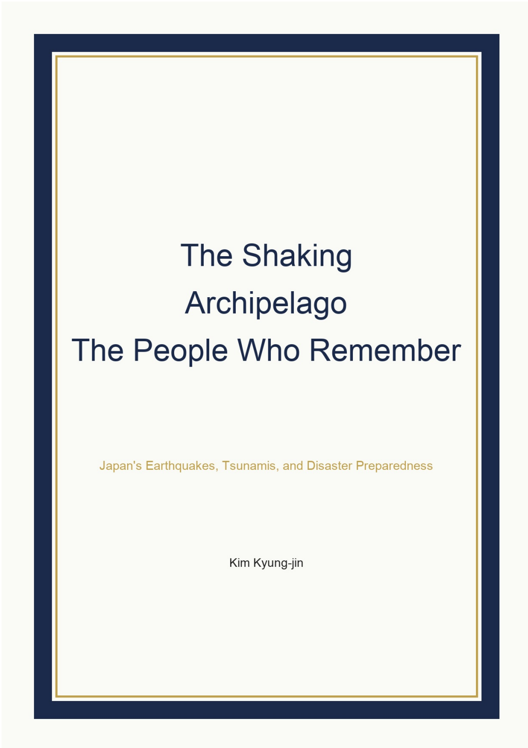

The Shaking Archipelago, The People Who Remember

Japan's Earthquakes, Tsunamis, and Disaster Preparedness

Kim Kyung-jin

Table of Contents

Preface

When the ground begins to shake, people in Japan first count. One, two, three. A long, continuous shaking portends a serious earthquake; short, abrupt tremors mean the waves have traveled from afar. For generations, this country has etched into its body the art of living alongside the trembling earth.

The Japanese archipelago sits at the meeting point of four tectonic plates: the Pacific Plate, the Philippine Sea Plate, the Eurasian Plate, and the North American Plate (or Okhotsk Plate). Along the Japan Trench, the Pacific Plate slides beneath the North American Plate at a rate of roughly 8 centimeters a year—about as fast as a human fingernail grows. Meanwhile, along the Nankai Trough, the Philippine Sea Plate pushes beneath the Eurasian Plate. As these plates collide and press against one another, stress accumulates until, pushed past its limit, the earth gives way and recoils in a split second. Consequently, Japan experiences over 1,500 earthquakes every year, with one-tenth of all earthquakes worldwide occurring around this narrow chain of islands.

The memory of these tremors remains preserved in ancient geological strata and in the spoken accounts of the people: the recurring megathrust earthquakes of the Nankai Trough, the massive waves that struck Tohoku on March 11, 2011, the tireless struggle of scientists striving to read movement deep beneath the earth, and Mount Fuji, whose next awakening remains unknown. Yet what we must follow to the end is not the earthquakes themselves, but the stories of the people who endured them, recorded them, and passed those lessons down to succeeding generations.

Japan’s earthquake research has accumulated over more than a century. This knowledge was not built by seismographs and satellites alone. A few brief lines of record in official histories such as Nihon Shoki and Shoku Nihongi, the namazu-e (catfish prints) drawn by Edo-period artists satirizing earthquakes, stone monuments erected where tsunamis swept through, and, in recent years, the volunteer efforts of citizens transcribing ancient manuscripts character by character have all served as raw material for this reservoir of understanding. Documents recording the 869 Jogan earthquake matter-of-factly noted the screams of the people, collapsing buildings, fractured earth, and more than a thousand deaths. More than a millennium later, that record served as a yardstick to gauge the scale of the immense waves that surged off the coast of Tohoku in 2011.

This work, known as historical seismology, is not accomplished by individuals working in isolation. At Kyoto University, the historical earthquake research group brings together seismologists, historians, geographers, chemists, and digital humanities scholars to decipher ancient texts and cross-reference them with geological evidence. For eras before written records existed, traces left deep in the earth speak in their place. Tsunami deposits found in coastal wetlands and lake beds—unfamiliar layers of sand mixed with seashell fragments and bits of wood—bear quiet witness to unrecorded megathrust earthquakes. Through such deposit research, the reality of events missing from official chronicles, such as the 1498 Meio Nankai earthquake, has been confirmed.

This knowledge has not remained confined to experts. Through a project called "Minna de Henkaku" (Transcription for Everyone), ordinary citizens stepped forward to decipher old manuscripts written in cursive script. In the thousand days following its release in January 2017, over 6.18 million characters were transcribed, with more than 5,300 registered users taking part. Among them were participants who, while deciphering old disaster records from their own neighborhoods, were stunned to learn that a tsunami had struck the very spot where their homes stand today. In this way, disasters of the past cease to be someone else's story and become one's own.

Yet this knowledge does not offer precise predictions of the future. Before March 11, 2011, forecasts indicated a 99 percent probability of a magnitude 7.5 earthquake occurring off the coast of Miyagi. The earthquake that actually struck measured magnitude 9.0, far surpassing all expectations. After that day, Japanese society was forced to reexamine the phrase sōteigai ("beyond anticipation"). It meant not that the event was inherently beyond prediction, but that society had drawn the boundaries of expectation too narrowly. Although some scholars had previously pointed out that the 869 Jogan earthquake and its resulting tsunami were comparable in scale to the 2011 disaster, their warnings were not widely heeded. There is always a gap between what science uncovers and the speed at which society absorbs it.

The most recent case is the earthquake that struck the Noto Peninsula on January 1, 2024. From January 11 to 20 of that year, the Japan Meteorological Agency conducted field surveys of tsunami traces, confirming a run-up height reaching 5.8 meters at Funami Park in Joetsu City, Niigata Prefecture. The Cabinet Office’s 2025 Disaster Management White Paper states that the lessons drawn from this earthquake are being incorporated into discussions on responding to a Nankai Trough megathrust earthquake and a directly under-Tokyo earthquake. Whether addressing ancient disasters or recent catastrophes, Japan never stops turning past experience into material for future preparedness.

The megathrust earthquakes of the Nankai Trough, the waves that devastated Tohoku in 2011, observation technologies reading deep underground dynamics, and the eruptive potential of Mount Fuji are not isolated occurrences. They form a single, continuous subterranean motion, and only by understanding that motion can human preparedness find its true footing.

At the 107th Assessment Committee meeting held on July 7, 2026, the Japan Meteorological Agency announced that no anomalous changes indicating a higher-than-usual likelihood of a large-scale earthquake around the Nankai Trough had been observed. Nevertheless, the agency explained that the probability of such an earthquake occurring within 30 years remains high under normal conditions, and that nearly 80 years have already passed since the 1946 Showa Nankai earthquake and the 1944 Showa Tonankai earthquake, underscoring a deep sense of urgency. Pinpointing an exact date is quite different from preparing in the language of probability. What matters more than an exact date is understanding that language of probability and translating it into daily readiness.

Sources for This Chapter

- The Modern History of Managing Seismic Risk in Japan

- 2021 Geology Day Online Public Lecture Series

- Japans Mega Earthquake | Earthquake and Tsunami - Amazing Documentary TV

- 【EARTHQUAKE】The 62nd TIEC Cross-Cultural Seminar〈The History of Japan Shaped by Earthquakes〉

- SRC-PDF-045_Evaluasi_Kegagalan_Sistem_Mitigasi_Tsunami_Studi_Kasus_Tohoku_2011.pdf

- How Earthquake Phenomena Can Cause Disasters 10

- Digital Scholarship in the Study of Historical Japanese Earthquakes

- SRC-PDF-009_Researches_on_the_tsunami_deposits_along_the_Nankai_Trough.pdf

- "Participation of Non-experts in Historical Earthquake Research Seen in 'Minna de Henkaku'" by Yasuyuki Kano - 1st SPARC Japan Seminar 2019

- Kyoto University Shunju Lectures "Looking Back at Heisei Earthquake Disasters: What We Learned and What We Pass On" by Professor Sumio Seino (Graduate School of Engineering), September 29, 2019

- SRC-PDF-054_CONSIDERATION_OF_RELATIONSHIP_BETWEEN_TSUNAMI_MONUMENTS_TSUNAMI_INUNDATION_AREA_AND_HUMAN_.pdf

- SRC-PDF-032_Formation_processes_of_tsunami_deposits_following_the_2011_Tohoku_oki_earthquake_in_the_es.pdf

- Kazuki Koketsu, "Why Is Earthquake Prediction Difficult?" - Public Lecture "Predictable Futures and Unpredictable Futures," 2019

- Numerous citations without reference numbers or source names (applies to a significant number of citations in U003 materials)

- Japan Meteorological Agency, Nankai Trough Earthquake Information (107th Assessment Committee, July 7, 2026): https://www.data.jma.go.jp/eew/data/nteq/index.html

- Japan Meteorological Agency, 2024 Noto Peninsula Earthquake Tsunami Field Survey: https://www.jma.go.jp/jma/press/2401/26a/20240126_tsunamichousakekka.pdf

- Cabinet Office, 2025 Disaster Management White Paper (English Version): https://www.bousai.go.jp/en/documentation/white_paper/pdf/2025/R7_hakusho_english.pdf

Attorney Kyung-jin Kim

Chapter 1 Opening

Chapter 1: The Nankai Trough, A Plate Boundary That Has Never Slept

The Restless Archipelago

Japan's frequent seismic activity is a direct consequence of its complex tectonic setting.

The Japanese archipelago is positioned at the convergence of four major tectonic plates: the Pacific, Philippine Sea, Eurasian, and North American (or Okhotsk) plates. The constant interaction and subduction of these plates beneath Japan accumulate immense stress, which is released as earthquakes.

Four Plates

Chapter 1: The Nankai Trough, A Plate Boundary That Has Never Slept

Beneath the sea south of the Kii Peninsula, at a depth of four thousand meters, lies a valley where human feet will never tread, extending approximately 700 kilometers from the waters east of Kyushu to Suruga Bay in central Japan. Known as the Nankai Trough, this valley marks the boundary where the Philippine Sea Plate subducts beneath the Eurasian Plate. The plate slides inward at a rate of 40 to 55 millimeters per year. Though imperceptible to humans, this persistent sliding steadily accumulates strain energy along the plate boundary. When the stored energy exceeds the limit the rock can withstand, the plate suddenly rebounds, triggering a massive earthquake. Earthquakes of this kind are called trench-type earthquakes, or megathrust earthquakes.

For convenience of research, this vast boundary is divided into several segments named Tokai, Tonankai, and Nankai. In some earthquakes, these segments rupture all at once, while in others, they rupture sequentially with time lags between them. Scholars estimate that between 684 CE and 1336 CE, nine major earthquakes occurred in this region, exhibiting an average recurrence interval of 150 years. Another method of calculation yields thirteen events over a span of 1,262 years, with an average interval of 105 years. Whichever calculation is used, the conclusion remains the same: this seafloor is never quiet.

On October 28, 1707, one of the largest among these earthquakes shook the Japanese archipelago. Known as the Hoei earthquake, with an estimated moment magnitude of 8.6 or higher, it was an event in which almost all segments from Tokai to Nankai ruptured simultaneously. Strong shaking was observed across nearly the entire archipelago except Hokkaido, and vast regions from Shizuoka to northern Kyushu suffered damage. Along the Pacific coast, tsunamis exceeding 5 meters washed ashore, with waves reaching 6 to 10 meters reported in the Osatsu area of Toba City, Mie Prefecture. The traces of this earthquake even reached a volcano. Forty-nine days after the quake, Mount Fuji erupted. Carried by the wind, volcanic ash flew as far as Edo—present-day Tokyo—blanketing the city to a depth of 2 to 4 centimeters. Crops were buried and urban functions ground to a halt. Three hundred years ago, people experienced firsthand the reality that major earthquakes and volcanic eruptions could stem from the same root.

In December 1854, 147 years after the Hoei earthquake, a new disaster struck. On December 23, the Ansei Tokai earthquake (moment magnitude 8.6) occurred, followed just 32 hours later on December 24 by the Ansei Nankai earthquake (moment magnitude 8.5 to 8.7). The two earthquakes left damage across a wide swath from the Kii Peninsula to Kyushu, and people later collectively referred to them as the "Ansei Earthquakes." The following year, stone monuments commemorating this catastrophe were erected at Taishobashi and Shitennoji in Osaka. Carved into the stones was the fact that 350 people who attempted to evacuate by boat after the earthquake were swept away by the tsunami and lost their lives, along with a warning never to flee by boat again. For generations, the carved stones remained in place, speaking to posterity.

After another 92 years passed, on December 21, 1946, the Showa Nankai earthquake (moment magnitude 8.0) occurred. Coming two years after the Showa Tonankai earthquake (magnitude 7.9) of December 7, 1944, both quakes were examples where the entire Nankai Trough did not rupture all at once, but rather split and ruptured sequentially with a time lag. Seismologist Ando analyzed the 1944 and 1946 earthquakes as the result of the same plate boundary slipping at different points in time. This view called into question the long-dominant concept of the "characteristic earthquake"—the idea that the same fault segment repeatedly ruptures in the exact same manner. In 2012, seismologist Seno argued that the rupture zones of the 1854 Ansei Tokai earthquake and the 1944 Showa Tonankai earthquake did not overlap, but were instead complementarily partitioned. This implies that how the Nankai Trough ruptures next may be redrawn anew each time.

These three earthquakes—Hoei, Ansei, and Showa—remain preserved in records from different eras. Records of the Hoei earthquake were compiled during the Edo period, making them far more detailed and reliable than those of earlier times. By contrast, records for older earthquakes remain fragmentary, leaving uncertainties in estimating their magnitude and rupture extent. Research on tsunami deposits found at Ryujin-ike lagoon in Oita Prefecture estimated that great earthquakes occurred in 684, 1361, and 1707 on a 450-year cycle, but separate tsunami simulation results concluded that this estimate could not be accepted as is. When geological evidence and computer models yield conflicting answers, bridging that gap remains the task of ongoing research.

Faced with this repeating pattern, Japan now confronts a single question: When will the next earthquake strike? The Headquarters for Earthquake Research Promotion presents the potential magnitude of a future Nankai Trough earthquake as class 8 to 9, classifying its probability rating for trench-type earthquakes at the highest rank, Rank III. Depending on the calculation method, the probability of occurrence within 30 years ranges from 60 to 90 percent, or from 20 to 50 percent, but the headquarters explains that disaster prevention measures must be designed with the higher range in mind—a principle of "when in doubt, act." According to the long-term evaluation summary published by the Headquarters for Earthquake Research Promotion, the 30-year probability of a magnitude 8 to 9 class Nankai Trough earthquake was calculated at 60 to 70 percent as of January 2013, but was recalculated as Rank III—roughly 80 percent—as of January 2025. The rise in probability is not because a new hazard suddenly emerged, but simply because that much more time has elapsed.

At the 107th Assessment Committee meeting held on July 7, 2026, the Japan Meteorological Agency stated that no changes had been observed around the Nankai Trough to suggest that the likelihood of a massive earthquake was higher than usual. Even so, it added that the urgency remains high, given that the 30-year probability in this region is elevated even under normal conditions and nearly 80 years have already passed since the Showa Tonankai and Showa Nankai earthquakes. On August 8, 2024, the Japan Meteorological Agency also issued its first "Nankai Trough Earthquake Extra Information (Major Earthquake Warning)." This system is not a device for predicting the future. It is a mechanism designed to evaluate whether risk has risen above normal levels following an actual earthquake, informing society on how to exercise caution during that period. Japan's official stance today is to approach this earthquake not in the language of predicting exact dates, but in the language of probability and preparedness.

Sources for This Chapter

- SRC-PDF-026_Status_of_historical_seismology_in_Japan.pdf

- SRC-PDF-008_Uncertainty_quantification_of_tsunami_inundation_in_Kuroshio_Kochi_Prefecture_Japan_using_.pdf

- SRC-PDF-002_Traces_of_paleo_earthquakes_and_tsunamis_along_the_eastern_Nankai_Trough_and_Sagami_Trough.pdf

- SRC-PDF-009_Researches_on_the_tsunami_deposits_along_the_Nankai_Trough.pdf

- SRC-PDF-025_Amplification_of_tsunami_heights_by_delayed_rupture_of_great_earthquakes_along_the_Nankai_.pdf

- SRC-PDF-015_Tsunami_Deposits_of_Tokai_Earthquakes_Preserved_in_a_Coastal_Marsh_Sequence_at_Osatsu_Toba.pdf

- SRC-PDF-061_Great_Earthquakes_along_the_Nankai_Trough_A_New_Idea_for_Their_Rupture_Mode_and_Time_Serie.pdf

- SRC-PDF-067_Examination_of_Giant_Nankai_Japan_Earthquakes_Suggested_by_Tsunami_Deposits_in_the_Ryujin_.pdf

- SRC-PDF-079_Time_difference_between_the_1854_CE_Ansei_Tokai_and_Ansei_Nankai_earthquakes_estimated_fro.pdf

- SRC-PDF-097_The_possibility_of_deeper_or_shallower_extent_of_the_source_area_of_Nankai_Trough_earthqua.pdf

- [Deepest Japan] Nankai Trough Earthquake: Tsunami Reached Osaka 10 Minutes Later and Swept People Away (4K UHD [Cruel Tomorrow])

- [Japanese podcast] Be Prepared! Nankai Trough Earthquake & Mt. Fuji Eruption

- 2021 Geology Day Online Public Lecture

- 03 Nankai Trough Great Earthquakes and Tsunamis: Latest Research Results and Government Thinking - Manabu Hashimoto: Kyoto University Disaster Prevention Research Institute Public Lecture (25th)

- Tokai Earthquake

- Digital Scholarship in the Study of Historical Japanese Earthquakes

- Japan Meteorological Agency, Nankai Trough Earthquake-Related Information (107th Assessment Committee, July 7, 2026): https://www.data.jma.go.jp/eew/data/nteq/index.html

- Japan Meteorological Agency, August 8, 2024 Nankai Trough Earthquake Extra Information: https://www.jma.go.jp/jma/press/2408/08e/202408081945.html

- Headquarters for Earthquake Research Promotion, Earthquakes Occurring in the Nankai Trough: https://www.jishin.go.jp/regional_seismicity/rs_kaiko/k_nankai/

- Headquarters for Earthquake Research Promotion, Partial Revision of the 2nd Edition of the Long-Term Evaluation of Seismic Activity in the Nankai Trough: https://www.jishin.go.jp/evaluation/long_term_evaluation/subduction_fault/summary_nankai/

- Headquarters for Earthquake Research Promotion, Nankai Trough Long-Term Evaluation Summary PDF: https://www.jishin.go.jp/main/chousa/25sep_nankai/nankai_gaiyou2_3.pdf

Chapter 1 Closing

Chapter 1: The Nankai Trough, A Plate Boundary That Has Never Slept

Nankai Trough: An Inevitable Threat

The Nankai Trough represents a persistent and high-probability seismic threat requiring continuous vigilance.

Major earthquakes along the Nankai Trough have recurred with estimated cycles ranging from 105 to 150 years, indicating its ongoing seismic potential. As of January 2025, the probability of a magnitude 8-9 Nankai Trough earthquake occurring within 30 years is estimated at 80%, a figure that has increased over time.

80%
Probability

Chapter 2 Opening

Chapter 2: March 11, 2011, Tohoku

2011 Tohoku: A Redefining Moment

> The 2011 Tohoku earthquake was a colossal event that fundamentally altered the understanding of seismic risks in Japan.

On March 11, 2011, a magnitude 9.0 earthquake struck off the Pacific coast of Tohoku, causing an exceptionally long and intense ground shaking. The earthquake's rupture zone spanned approximately 400 kilometers north-south and 200 kilometers east-west, leading to significant ground displacement, including the Oshika Peninsula shifting 5.3 meters eastward.

Magnitude 9.0

Chapter 2: March 11, 2011, Tohoku

At 2:46 p.m. on March 11, 2011, Japan Standard Time, the strain that had accumulated between the Pacific Plate and the North American Plate (or the Okhotsk Plate) was released all at once deep off the coast of Miyagi Prefecture in the Pacific waters off Tohoku. The shaking was prolonged. People who lived through that moment in offices, schools, and homes later remembered the earthquake as "a long shaking with no end in sight." The rupture zone extended approximately 400 kilometers north-to-south and 200 kilometers east-to-west, with a moment magnitude of 9.0.

The earthquake moved the earth itself. The Oshika Peninsula shifted 5.3 meters eastward within three minutes of the earthquake's onset. Across the Japanese archipelago, horizontal displacements of 4 to 5 meters and land subsidence of 0.4 to 1.2 meters were observed. Plate movements that had been invisible were, at that moment, newly drawn onto the map.

Following the earthquake, the ocean responded. Tsunamis exceeding 10 meters were observed across vast regions including Iwate, Miyagi, and Fukushima Prefectures, while Kamaishi recorded a breaking wave height of up to 21 meters and an inundation depth of 18 meters. In low-lying terrain like the Sendai Plain, the waves surged several kilometers inland from the coastline. Deaths and missing persons from the tsunami surpassed 15,000, and more than 12.3 million people were evacuated. Debris accumulated to over 19.2 million cubic meters—weighing more than 13 million tons—blocking recovery efforts and giving rise to sanitation issues. Disaster-prevention facilities built to withstand disasters of earlier eras, such as Kamaishi's 12-meter-high seawall, stood in city after city, but this wave overwhelmed most of them.

The Japan Meteorological Agency issued a tsunami warning just three minutes after the earthquake occurred. However, the initial announcement underestimated the earthquake's magnitude at M7.9. Only after 28 minutes had passed was the magnitude revised to M9.0, prompting a drastic upward adjustment in the expected tsunami height. In the interim, the sea was already engulfing the coast. Learning from this lesson, the Japan Meteorological Agency later overhauled its system: when an earthquake exceeding magnitude 8 strikes, initial warnings use qualitative terms such as "Huge (巨大)" or "High (高い)" instead of specific numbers, followed by revised numerical forecasts after detailed analysis 20 to 30 minutes later.

The greatest hazard materialized not along the shoreline, but at a nuclear power plant. At the Fukushima Daiichi Nuclear Power Plant, the reactors shut down automatically due to the earthquake's intense shaking, but the tsunami that swept in afterward inundated the emergency power generators and cooling systems. Stripped of cooling capability, the reactors suffered meltdowns and hydrogen explosions, leading to widespread soil and marine contamination. The situation was grave enough that evacuation scenarios for residents within a 250-kilometer radius were brought under review.

Yet another nuclear power plant struck by a tsunami of equal magnitude met a strikingly different outcome. The Onagawa Nuclear Power Plant, situated closest to the epicenter, shut down without any major incident. Behind this result stood an engineer named Yanosuke Hirai (平井弥之助). Serving as vice president and director of Tohoku Electric Power, he had drawn upon historical records of the 869

Jogan earthquake and its massive tsunami during the site selection and disaster-prevention design phases for the Onagawa plant. Though met with pushback at the time for being overly cautious, he insisted that key facilities be placed not along the low-lying shore, but on elevated ground 14.8 meters above sea level. On March 11, 2011, a tsunami of approximately 13 meters crashed into Onagawa, but because the site elevation was above the surge, vital equipment remained untouched by water. Consequently, even though Onagawa was closer to the epicenter than Fukushima Daiichi, it shut down safely and served as a shelter for displaced residents in its gymnasium. An International Atomic Energy Agency inspection team also noted that the site suffered minimal damage despite experiencing severe seismic motion and tsunami waves.

There is a reason why this disaster weighed so heavily on the collective memory. In the year 869, the Tohoku region had already experienced a colossal earthquake and tsunami known as the Jogan (貞観) earthquake. The historical chronicle Nihon Sandai Jitsuroku recorded that Tagajo Castle on the Pacific coast of Miyagi Prefecture collapsed and over a thousand people were swept away and drowned. For centuries, this account was viewed as little more than an ancient legend; however, tsunami deposits discovered in low-lying river mouths across multiple areas, including the Odaka district, provided physical evidence confirming that the Jogan tsunami had driven far inland. The inundation extent of these deposits, verified through radiocarbon dating, overlapped with the actual flooding pattern seen in 2011. Prior to 2011, several scientists had highlighted this parallel and issued warnings, yet the prevailing view remained that earthquakes off the Sanriku coast would max out at around magnitude 7.5. Modern seismology's predictive models had failed to accord sufficient weight to a record from a thousand years ago.

Why this occurred can be attributed to several factors. A written record spanning 1,300 years is far too short a window to measure abnormally massive earthquakes that operate on cycles of several centuries or millennia. Pre-modern records were sparse to begin with, and surviving accounts varied wildly in precision. Furthermore, human memory breaks down as it crosses generations. With disasters that have long recurrence intervals, the belief that "this place is safe" easily takes root, often fostering an overreliance on structures like seawalls. Indeed, even after experiencing the Sanriku tsunamis of the Meiji and Showa eras, those lessons failed to be fully passed down to subsequent generations, leading to repeated large-scale loss of life.

Following 2011, Japan began managing tsunamis under a two-tiered framework. L1 tsunamis refer to waves occurring on a 100-year cycle that can be warded off by hard infrastructure like seawalls. L2 tsunamis refer to rare waves occurring once every few centuries or millennia, such as the 2011 Tohoku earthquake; against these, a consensus took hold that prompt evacuation plans and community disaster awareness must take precedence over structural defenses. Areas where L2 tsunami inundation depths exceed 2 meters began to be designated as virtually uninhabitable. Recognizing the limits of prediction while remaining prepared for the worst-case scenario became the foundational pillar of Japan's post-disaster prevention policy.

Sources for This Chapter

- SRC-PDF-001_STUDY_ON_PREDICTION_OF_TSUNAMI_INUNDATION_DUE_TO_TOKAI_TONANKAI_AND_NANKAI_MASSIVE_EARTHQU.pdf

- SRC-PDF-058_The_Paper_for_the_2011_Japan_Association_for_Quaternary_Research_Academic_Award_Research_r.pdf

- SRC-PDF-045_Evaluasi_Kegagalan_Sistem_Mitigasi_Tsunami_Studi_Kasus_Tohoku_2011.pdf

- SRC-PDF-004_Distribution_and_physicochemical_properties_of_tsunami_deposits_generated_by_the_2011_Grea.pdf

- SRC-PDF-012_Inundation_areas_and_deposits_of_the_2011_off_the_Pacific_coast_of_Tohoku_and_the_869_Joga.pdf

- SRC-PDF-032_Formation_processes_of_tsunami_deposits_following_the_2011_Tohoku_oki_earthquake_in_the_es.pdf

- SRC-PDF-056_Radiocarbon_Dating_Historical_Tsunami_Deposits_from_the_Sendai_Plain_Northeastern_Japan_Pr.pdf

- SRC-PDF-035_Analysis_and_Verification_of_the_2011_Tohoku_Earthquake_Tsunami_at_Nuclear_Power_Plant_Sit.pdf

- SRC-PDF-013_ISSUES_OF_ORGANIZATION_AND_LAW_REGULATION_OF_MASSIVE_EARTHQUAKE_AND_TSUNAMI_DISASTER_mdash.pdf

- SRC-PDF-054_CONSIDERATION_OF_RELATIONSHIP_BETWEEN_TSUNAMI_MONUMENTS_TSUNAMI_INUNDATION_AREA_AND_HUMAN_.pdf

- Digital Scholarship in the Study of Historical Japanese Earthquakes

- EGU2011: The 11 March 2011 Tohoku (Sendai) Earthquake and Tsunami

- Impact of Huge Tsunamis: Did Researchers Anticipate It? | Galileo X Episode 4

- The 3.11 Miracle That 99% of People Don't Know: Behind Fukushima, the Story of 'Another Nuclear Plant' That Protected 364 Residents from Tsunami

- The Meiji Sanriku Tsunami That Swallowed 20,000 People - Why Didn't People Flee? The Monster Born from 'Science's Blind Spot' [Edo Dark Tales]

- FY2023 [Shikoku Region ③] 'How to Face the Inevitable Nankai Trough Earthquake: 10 Years Since the Release of Nankai Trough Earthquake Damage Estimates, and the Future'

- Multiple unindicated citation numbers and source names (applies to a significant number of citations in U007 material)

- Japan Meteorological Agency, 2024 Noto Peninsula Earthquake Portal: https://www.jma.go.jp/jma/en/2024_Noto_Peninsula_Earthquake/index.html

- Japan Meteorological Agency, Earthquake and Tsunami Information Commentary PDF: https://www.jma.go.jp/jma/kishou/books/jishintsunami/en/jishintsunami_en.pdf

Chapter 2 Closing

Chapter 2: March 11, 2011, Tohoku

Beyond Expectation: Lessons from Tohoku

The 2011 Tohoku disaster underscored the critical limitations of existing predictions and defenses, leading to profound policy shifts.

Initial tsunami warnings significantly underestimated the earthquake's actual magnitude, and existing coastal defenses were largely overwhelmed by the colossal waves, exposing a gap between prediction and reality. This experience introduced the concept of "Soteigai" (beyond assumptions) and led to a re-evaluation of disaster preparedness, including the adoption of L1/L2 tsunami classifications.

Soteigai

Chapter 3 Opening

Chapter 3: Technologies for Reading Beneath the Earth

Earth's Pulse: Advanced Monitoring

Japan utilizes an extensive and sophisticated network of sensors to monitor seismic and tsunami activity in real-time.

The country is equipped with approximately 2,000 seismic observation points, including land-based seismometers operated by the Japan Meteorological Agency (JMA) and NIED (Hi-net), alongside a significant increase in seafloor observation networks like S-net and DONET after 2011. This dense network enables the "Urgent Earthquake Broadcast" system, which detects initial P-waves to issue warnings to areas yet to be hit by stronger S-waves, providing crucial seconds for safety measures.

2,000
Sensors

Chapter 3: Technologies for Reading Beneath the Earth

At the Japan Meteorological Agency's earthquake control center, not a single day passes in quiet. On land, seismographs are densely embedded at roughly 700 locations operated by the agency and around 850 locations in the High Sensitivity Seismograph Network (Hi-net) run by the National Research Institute for Earth Science and Disaster Resilience. Since the 2011 Great East Japan Earthquake, seafloor observation networks have expanded by nearly 200 sites, so that today approximately 2,000 stations across land and sea transport data in real time. It is this dense network that makes possible the warning system known as Earthquake Early Warning.

When an earthquake strikes, the nearest seismograph captures the first weak wave to arrive—the P-wave. Based on these data, the epicenter and magnitude are automatically estimated, and warnings are dispatched to areas where the strong shaking (S-wave) has not yet arrived. This entire process unfolds in under a second, simultaneously transmitting to television, radio, smartphone applications, and factory or railway control systems. The time remaining for people is little more than a minute to a minute and a half, but that brief window is enough to duck low and prop doors open.

Monitoring beneath the sea began much later than on land. After 2011, Japan laid a new seafloor observation network named S-net along the Japan Trench. Completed in March 2017, this system installed both seismographs and pressure gauges at 150 seafloor observation stations, linking them via fiber-optic submarine cables. In the Nankai Trough region, another seafloor network called DONET took root, reading subsea movements that land-based observations alone could hardly detect. The pressure gauges measure changes in water pressure on the seafloor to detect the generation and propagation of tsunamis in real time. Back in 2011, a single water pressure gauge installed on the seabed recorded the moment the sea level rose alongside the seismic waves—the very moment the tsunami began.

No matter how sophisticated observation technology becomes, determining precisely when an earthquake will strike remains a different matter altogether. While seismology understands how faults move well enough to reproduce their mechanics in laboratories, accurately pinpointing short-term predictions—when, where, and how large an earthquake will be—in the face of Earth's actual complexity remains virtually impossible today. What scholars can state with confidence is only a long-term cycle of 100 to 150 years, not an exact timeframe. The 2011 Tohoku earthquake stands as the most painful illustration of this limitation. Offshore Miyagi, a magnitude 7.5-class earthquake had been forecast with a 99 percent probability, but the earthquake that actually occurred far exceeded expectations at magnitude 9.0.

In recent decades, a phenomenon has drawn new attention. Known as slow earthquakes or episodic aseismic slip, this movement involves fault surfaces sliding slowly and releasing energy without generating strong seismic waves. Humans cannot feel this shaking, yet GPS observation networks have captured long-term slow slip lasting from several months to years in the Bungo Channel and Tokai regions. High-sensitivity seismograph networks have identified short-term slow slip occurring over several days, along with deep low-frequency tremors and shallow very-low-frequency earthquakes, in areas such as the Nankai Trough. The very discovery of these phenomena is thanks to the densification of observation networks. Movements whose very existence was once unknown have only now come into view, but how these slow earthquakes relate to megathrust earthquakes remains an actively researched question.

Subsurface changes also leave traces in groundwater. Beneath the Japanese archipelago lie numerous cracks large and small, their fissures filled with groundwater. Stress changes caused by earthquakes can alter the flow of this underground water. During the 1923 Great Kanto Earthquake, water gushing from the ground was observed in parts of Tokyo's Honjo Ward, a phenomenon interpreted as related to groundwater shifts during or immediately after the earthquake. In research analyzing ionospheric total electron content using GPS networks, anomalous signals were observed in the ionosphere following earthquakes exceeding magnitude 6, such as the one in 2011. However, these signals appear after the earthquake has occurred, meaning they have not yet reached the stage of being usable as precursory indicators for predicting earthquakes in advance.

The Tokai earthquake of the past is a symbolic case that demonstrates the limits of prediction. Although specific observation equipment was installed and slow slip phenomena were observed, it did not culminate in a major earthquake, earning it the longstanding moniker of the "phantom earthquake." This case demonstrated firsthand that heightened activity does not necessarily lead to a major quake.

The inability to predict does not mean an inability to prepare. In 2012, when the Central Disaster Management Council published its Nankai Trough megathrust earthquake model, it simulated the entire fault surface by dividing it into 5,773 subfaults, each measuring 5 kilometers by 5 kilometers. The 2011 Tohoku earthquake was modeled using forty 50-kilometer by 50-kilometer subfaults and eight 50-kilometer by 30-kilometer subfaults—48 subfaults in all—and according to these calculations, the largest slip concentrated in the shallow portion near the Japan Trench, reaching a maximum of 70 to 80 meters. Tsunami simulations overlap grids measuring 1,350 meters, 450 meters, 150 meters, and 50 meters to calculate open ocean and nearshore areas at varying degrees of precision. The calculation that seismic energy increases 2.82-fold when earthquake magnitude grows from 8.7 to 9.0 also emerged from this work.

Not all of these simulations portray the future flawlessly. Research continues to emerge challenging the characteristic earthquake model long regarded as established theory, such as Seno's new interpretation of rupture zones. Nevertheless, this work remains a central tool for disaster prevention. If exact dates cannot be determined, visualizing the worst-case scenario in advance and preparing seismic retrofitting, disaster mitigation facilities, and evacuation drills accordingly is the path Japan has chosen today.

Sources for This Chapter

- 2021 Geology Day Online Public Lecture

- 03 Nankai Trough Megathrust Earthquakes and Tsunamis: Latest Research Results and Government Thinking, Manabu Hashimoto: 25th Public Lecture, Disaster Prevention Research Institute, Kyoto University

- Mechanisms of Earthquake Phenomena That Can Cause Disasters 10

- Headquarters for Earthquake Research Promotion 30th Anniversary Special Symposium "Tackling Earthquakes: 30 Years of Progress and the Future"

- 20230529 UPLAN Katsuhiko Ishibashi "Linear Chuo Shinkansen Weakening Japan and Exacerbating the Nankai Trough Megathrust Disaster" (Tentative Title)

- Katsuhiko Ishibashi, Professor Emeritus, Kobe University (Seismology) 2011.11.29

- SRC-PDF-014_Detailed_Seismic_Intensity_Distribution_due_to_the_1923_Kanto_Earthquake_in_Tokyo_Metropol.pdf

- SRC-PDF-116_The_resonant_response_of_the_ionosphere_imaged_after_the_2011_off_the_Pacific_coast_of_Toh.pdf

- SRC-PDF-035_Analysis_and_Verification_of_the_2011_Tohoku_Earthquake_Tsunami_at_Nuclear_Power_Plant_Sit.pdf

- SRC-PDF-061_Great_Earthquakes_along_the_Nankai_Trough_A_New_Idea_for_Their_Rupture_Mode_and_Time_Serie.pdf

- 2011/07/24(3) Great East Japan Earthquake Forum, Lecturer Yukinobu Okamura "Recreating the Jogan Tsunami: Unutilized Research Findings", Lecturer Masateru Murosaki "The Great Hanshin Earthquake, the Great East Japan Earthquake, and Urban Disaster Prevention"

- "Unraveling the Mysteries of Earthquakes" - 11th Kyoto University-Inamori Foundation Joint Kyoto Prize Symposium, Aitaro Kato, February 8, 2025

- Japan Geoscience Union Meeting 2021 Top Seminar: Prof. Kenji Satake "Progress in Earthquake and Tsunami Research over the 10 Years Since the Great East Japan Earthquake"

- Numerous citations missing citation numbers or source names (many citations within U010 materials fall under this category)

- Headquarters for Earthquake Research Promotion, Partial Revision of the Second Edition of the Long-Term Evaluation of Seismic Activity Along the Nankai Trough: https://www.jishin.go.jp/evaluation/long_term_evaluation/subduction_fault/summary_nankai/

Chapter 3 Closing

Chapter 3: Technologies for Reading Beneath the Earth

Unpredictable Depths: New Insights

Despite technological advancements, precise short-term earthquake prediction remains elusive, but new discoveries like "slow earthquakes" enhance understanding.

While seismology understands fault movements in laboratory settings, accurately predicting the exact timing, location, and magnitude of real-world earthquakes on a short-term basis is still largely impossible due to the Earth's inherent complexity. Recent decades have seen the identification of "slow earthquakes" or "intermittent non-seismic slips," which are slow-motion fault movements that release energy without generating strong seismic waves, prompting ongoing research into their relationship with major seismic events.

Slow Earthquakes

Chapter 4 Opening

Chapter 4: Mount Fuji, the Sleeping Giant

Mt. Fuji: The Sleeping Giant's Threat

Japan's beloved Mt. Fuji, despite its long silence, remains an active volcano with a history of frequent eruptions and connections to major earthquakes.

Mt. Fuji has been dormant since the Hoei eruption in 1707, but its historical record reveals approximately 100 eruptions over the last 3,200 years, averaging roughly one every 30 years. Historical evidence, such as the Hoei eruption occurring 49 days after a major Nankai Trough earthquake, suggests a strong possibility that large seismic events can trigger or exacerbate volcanic activity.

30-Year Cycle

Chapter 4: Mount Fuji, the Sleeping Giant

Japan's most beloved mountain is also the volcano that has remained silent the longest. Mount Fuji has been quiet for more than 300 years since the Great Hoei Eruption of 1707. Yet this silence should not be read as evidence of safety. Over the past 3,200 years, Mount Fuji has erupted roughly 100 times—an average of once every 30 years. Although there is no way to pinpoint exactly when the next eruption will occur, it is precisely this record of ancient repetition that leads experts to warn that it could erupt at any time.

Like earthquakes, volcanic hazards are difficult to predict. From lava flows, pyroclastic flows, debris avalanches, and volcanic ash to lahars (volcanic mudflows) and volcanic gases, the hazards Mount Fuji can produce vary in form, arrival time, and duration. Accurately predicting the timing, scale, and type of an eruption in advance remains a difficult challenge to this day.

History shows that Mount Fuji and great earthquakes have not been unrelated. The Great Hoei Eruption of 1707 occurred 49 days after a megathrust earthquake in the same year—the Hoei earthquake, in which the entire Nankai Trough ruptured all at once. Scholars believe it is highly likely that the great earthquake stimulated the magma beneath the volcano, increasing its instability. A similar chain of events followed the shock of the 2011 Great East Japan Earthquake, a moment magnitude 9.0 event. Seismic activity increased beneath twenty volcanoes across Japan, and Mount Fuji was judged to be among those in an unstable state. A similar cascade occurred in the ninth century. Citing the sequence of the 869 Jogan earthquake, the 878 Southern Kanto earthquake, and the 887 Nankai Trough earthquake, some have even proposed scenarios suggesting that following 2011, a Southern Kanto earthquake could strike in the 2020s, followed by a Nankai Trough earthquake in the 2030s.

If Mount Fuji were actually to erupt, the element that would impact the broadest area for the longest time is not lava, but volcanic ash. During the 1707 eruption, ash drifted as far as Edo—present-day Tokyo—accumulating to a thickness of two to four centimeters. Crops were smothered and the city's functions ground to a halt. Because prevailing winds in Japan generally blow from west to east, an eruption of Mount Fuji would likely drop more ash on the Greater Tokyo Area than on Shizuoka Prefecture, which is closer to the mountain. This means that what Tokyo experienced 300 years ago could be repeated in the Tokyo of today.

Composed of microscopic shards of glass, volcanic ash is fatal to computer systems. In an era where every industry and infrastructure relies on computers, this reality goes beyond mere inconvenience. Transportation networks could be paralyzed as ash-covered roads, railways, and airports—including Haneda and Narita—suspend operations. Power grids could suffer widespread blackouts as ash accumulating on power lines causes short circuits or infiltrates generation facilities, triggering failures. Water supply systems could face prolonged outages as ash contaminates water sources and degrades the function of purification facilities. Should telecommunications and municipal gas networks falter as well, the paralysis of the capital region would ripple through the economy and society of all of Japan.

Damage from volcanic ash does not end on the spot; it can also trigger subsequent disasters. During the 1707 eruption, massive volumes of ejecta flowed into the Sakawa River, raising the riverbed. When heavy rains fell the following year, flood control levees collapsed, subjecting the Ashigara Plain to a second catastrophe from severe flooding. In 1792, a landslide and tsunami occurred together at Mount Unzen (Unzendake), claiming more than 4,600 lives. Volcanic eruptions do not arrive separate from earthquakes or tsunamis; they can approach as complex, compound disasters, intertwined and overlapping.

In the face of this risk, the path Japan has chosen is monitoring rather than prediction. The Japan Meteorological Agency maintains 24-hour observation of 50 of the country's 111 active volcanoes, focusing on capturing ground vibrations produced as magma ascends near the surface—namely, low-frequency earthquakes. In certain areas, technology is being developed to detect these low-frequency earthquakes with a sensitivity ten times greater than the agency's baseline. However, because of the time lag between earthquakes and eruptions, some researchers view the connection between the two as coincidental. Studies comparing the composition of volcanic ejecta with past eruptive history, along with research into flank eruption history using trench investigations and tephra analysis, are also underway to help map Mount Fuji's volcanic hazards.

During the summer, roughly 300,000 climbers gather on Mount Fuji. If a large-scale eruption were to occur, safely evacuating so many people from the mountain would be a formidable challenge in itself. The government and local authorities advise protecting eyes and respiratory tracts with masks and goggles, planning travel routes in advance for potential train and flight cancellations, and stockpiling drinking water for extended outages. For foreign tourists, multilingual disaster prevention apps and multilingual disaster information services such as NHK WORLD-JAPAN are provided. In regions living alongside volcanoes, such as Sakurajima in Kagoshima, ash disposal and evacuation drills have already become a routine part of daily life. Beneath a mountain that could awaken at any moment, people live their days preparing in just this way.

Sources for This Chapter

- 【Japanese podcast】 Be Prepared! Nankai Trough Earthquake & Mt. Fuji Eruption

- FY2020 3rd Term Course: Earthquakes, Volcanoes, and Disaster Prevention You Should Know in Shizuoka

- 【Volcano Headquarters Regional Lecture in Kagoshima】 Living with Volcanoes: The Frontlines of Volcanic Research and Disaster Prevention (February 1, 2026)

- SRC-PDF-057_History_and_Future_of_Volcanic_Disasters_in_and_around_the_Tokyo_Metropolitan_Area_Central.pdf

- 【Disaster Prevention Lecture】 Kyoto University Professor Emeritus Hiroki Kamata: Knowledge and Mindset for the Nankai Trough Megathrust Earthquake—Surviving Wisely by Learning 'Earth Science'

- Earthquake Precursor Research Forum 2022: Preparing for Megathrust Earthquakes

- 【Keynote Lecture】 Kyoto University Professor Emeritus Hiroki Kamata: How to Avoid Hazards of Earthquakes, Volcanoes, and Meteorological Disasters in an 'Age of Crustal Movement'—Preparing Wisely for a Mount Fuji Eruption and Nankai Trough Megathrust Earthquake

- Japan, Land of Earthquakes and Volcanoes: Learning from Historical Earthquakes and Protecting Ourselves from Disasters—Masanori Ueno, Specially Appointed Lecturer, Hyogo Inamino Gakuen

- 【Deepest Japan】 Tsunami After Nankai Trough Earthquake Reached Osaka in 10 Minutes and Swept People Away (4K UHD 【Tomorrow's Harsh Disaster】)

- SRC-PDF-120_Foreword_Special_Volume_on_accurate_eruptive_history_of_Fuji_Volcano_Japan_using_trench_su.pdf

- SRC-PDF-135_Tephrochronology_of_coastal_terraces_and_their_tectonic_deformation_in_South_Kanto.pdf

- 【For Sleep】 Summarizing the History of Great Earthquakes 【Yukkuri Commentary】

- Katsuhiko Ishibashi, Professor Emeritus of Kobe University (Seismology), November 29, 2011

Chapter 4 Closing

Chapter 4: Mount Fuji, the Sleeping Giant

Fuji's Ash: A Widespread Impact

A Mt. Fuji eruption's most far-reaching and lasting impact would be from volcanic ash, threatening critical infrastructure and daily life across a wide region.

Should Mt. Fuji erupt, volcanic ash, rather than lava, is the primary concern, capable of reaching and severely disrupting the Tokyo metropolitan area, similar to the 1707 event. Volcanic ash, composed of fine glass fragments, can cripple transportation networks, cause widespread power outages by shorting transmission lines, contaminate water supplies, and disrupt communication systems, posing a severe threat to the capital's functionality.

Volcanic Ash

Chapter 5 Opening

Chapter 5 Personal and Household Preparedness

Personal Preparedness: Foundation of Safety

> Because precise earthquake prediction is currently impossible, continuous personal and household preparation is the most critical element of disaster readiness.

The probability of a magnitude 8-9 Nankai Trough earthquake within 30 years has been reassessed to approximately 80% as of January 2025, highlighting the urgent need for preparedness despite the inability to pinpoint an exact date. Essential household preparations include securing at least a 7-day supply of water (2-3 liters per person per day) and food, utilizing a "rolling stock" method where everyday items are rotated for freshness.

7-Day Supply

Chapter 5 Personal and Household Preparedness

Before an Earthquake Strikes

Even with today's science, it is impossible to accurately predict when, where, or at what magnitude an earthquake will strike. The only thing scientists can calculate is long-term probability spanning decades. Taking the Nankai Trough earthquake as an example, the probability of a megathrust earthquake with a magnitude between 8 and 9 occurring within the next 30 years reached around 80% as of January 2025. In January 2013, this figure was between 60 and 70%, meaning that as time passes, the probability is continually recalculated upward. At the 107th Assessment Committee meeting of the Japan Meteorological Agency held on July 7, 2026, officials stated that no unusual changes indicating a higher risk than normal were observed around the Nankai Trough. At the same time, however, the agency explained that nearly 80 years have already passed since the Showa Tonankai earthquake and the Showa Nankai earthquake, creating a pressing situation where the next megathrust earthquake could strike at any time. No one knows whether an earthquake will strike tomorrow or next week, but the fact that it will inevitably come试验 is already certain. Therefore, the surest way to face an earthquake is not prediction, but preparation.

The first things to prepare at home are water and food. If roads and railways are severed, the supply of goods is cut off as well. In the past, authorities recommended stockpiling a three-day supply, but in widespread disasters like a Nankai Trough earthquake, even relief efforts by the Self-Defense Forces may be delayed, so experts now advise preparing at least a seven-day supply. Emergency food also used to evoke images of hardtack or instant cup noodles, but nowadays the practice of daily stockpiling—storing the food one normally eats—has taken hold. Staple grains like rice are easy to manage in terms of expiration dates, and familiar flavors help soothe people's minds. Using the rolling stock method—consuming items closest to their expiration date first and replacing them with fresh supplies—spares the trouble of managing stockpiles separately. Since one person requires two to three liters of water per day, households should maintain at least a three-day supply based on family size. When water service is cut, it is not just thirst that becomes an issue, but toilets as well. If water and sewage systems collapse, there will not even be water to flush toilets, making it wise to prepare portable toilets in advance for use during outages.

Securing furniture is directly linked to saving lives. During the 1995 Great Hanshin-Awaji Earthquake, approximately 90% of those who died were crushed beneath collapsing wooden houses. Even if a building is sturdy, falling bookshelves or wardrobes inside a room can injure people or block doorways, making escape difficult. A professor at Kyoto University reduces indoor hazards by reinforcing bookshelves alongside seismic retrofitting and moving heavy books from the second floor to the first floor whenever possible. Such small adjustments significantly reduce the risk of injury when an earthquake strikes.

Families must also decide on ways to contact one another before an earthquake strikes. Immediately after an earthquake, communication networks are prone to congestion and paralysis, and if power cuts occur, smartphones can shut down within one to three minutes. Therefore, confirming safety within the brief window right after shaking stops is vital, and establishing shared channels afterward—such as messaging apps like LINE or disaster message board services—is recommended. Once everyone's safety is confirmed, simply being mentally prepared to endure in safe locations separately for three days to a week while waiting to reunite significantly reduces anxiety.

One should also become familiar in advance with how to receive information. In Japan, when an earthquake of seismic intensity 1 or higher occurs, the Japan Meteorological Agency immediately releases relevant information. Earthquake Early Warnings give advance warning before major shaking arrives, while tsunami warnings and advisories prompt evacuation by announcing expected wave heights. Although the first tsunami warning is issued within three minutes of an earthquake, this initial information can carry a large margin of error, so more precise information is reissued 20 to 30 minutes later. Coastal residents do not have the luxury of waiting these 20 to 30 minutes. Because a tsunami can reach the coast within 20 minutes, the moment the first warning is heard, people must move immediately to high ground or designated evacuation sites. Pre-installing services such as Safety tips—a multilingual disaster prevention app for foreign travelers—or NHK WORLD-JAPAN will also prove helpful.

There are also differences in the time it takes for essential lifelines like electricity, water, and gas to be restored. It is often said that electricity is restored in a day, water in three days, and gas in a week, but this applies only to average situations. In disasters with widespread damage like a Nankai Trough earthquake, restoring electricity can take a week, water one month, and gas up to three months. Such delays actually occurred during the 1995 Great Hanshin-Awaji Earthquake and the 2011 Great East Japan Earthquake. Residents of high-rise buildings must also be prepared for situations where elevators remain stopped for more than three days, forcing them to walk up and down stairs as high as the 20th floor.

Preparation is not something that is finished once done. Participating in local disaster preparedness drills and maintaining ongoing discussions among family and friends must continue steadily. As such preparations accumulate, they become the strength that enables people to act calmly without being overwhelmed by fear when an earthquake actually strikes.

Sources for This Chapter

Extracted reference sources: 2011/07/24(3) 東日本大震災フォーラム Yukinobu Okamura・ Yoshiteru Murosaki lecture (Jogan tsunami and urban disaster preparedness of the Hanshin and Great East Japan earthquakes), 【Japanese podcast】 Be Prepared! Nankai Trough Earthquake & Mt. Fuji Eruption, 2020年度 第3期講座「静岡で知っておきたい地震と火山と防災」, SRC-PDF-031 し尿処理における大規模地震災害対応に関する研究 (Nankai Trough earthquake case study), 「地震の謎に迫る」 Kyoto University–Inamori Foundation Kyoto Prize Symposium Aitaro Kato (February 8, 2025), 南海トラフ巨大地震講演会 How to Prepare for the Nankai Trough Earthquake, Japan Faces 9.0 Megaquake and Giant Tsunami, 2017/11/23 「地震短期予測と防災体制」 Toshiyasu Nagao (Tokai University), 創立70周年記念講演会 『2035年±5年に起きる南海トラフ巨大地震に備える』, 地震と火山の国 日本 Masanori Ueno, 災害に強いまちづくり講座(II), 【オンライン自習室】東日本大震災から9年, How to Save Tokyo from

Earthquakes and Floods, 「変動する日本の大地と地震」 Takuya Nishimura, 【巨大地震注意】日本列島の活断層, 【最深日本】地震特輯 (1981 new seismic standards and 1995 Hanshin earthquake), Kyoto University Symposium Series 「大震災後を考える」 Masumi Yamada, 令和4年度北海道防災気象講演会.

Latest official sources: Japan Meteorological Agency Nankai Trough Information (https://www.data.jma.go.jp/eew/data/nteq/index.html), Headquarters for Earthquake Research Promotion Nankai Trough Earthquake Overview (https://www.jishin.go.jp/regional_seismicity/rs_kaiko/k_nankai/), Headquarters for Earthquake Research Promotion Long-Term Evaluation Revision (https://www.jishin.go.jp/evaluation/long_term_evaluation/subduction_fault/summary_nankai/), Long-Term Evaluation Summary PDF (https://www.jishin.go.jp/main/chousa/25sep_nankai/nankai_gaiyou2_3.pdf).

The Moment an Earthquake Strikes

The moment shaking begins, the first thing to do is protect yourself. If you are indoors, you should move close to an interior wall near the core of the building or take cover under a sturdy table. This follows the commonly known principle of Drop, Cover, and Hold On, and in Japan, people are taught from childhood to get under a desk immediately when shaking occurs. Covering your head with a cushion or bag to protect against falling objects is also crucial. Unsecured bookshelves, wardrobes, or items on shelves can topple or fall, injuring people and blocking escape routes. The fact that approximately 90% of the victims in the 1995 Great Hanshin-Awaji Earthquake were crushed to death by collapsing wooden houses underscores that indoor furniture safety is just as decisive for survival as the seismic performance of the building itself. Even after shaking stops, do not move immediately; check for falling debris or collapsed structures first. If you were in the kitchen, turning off the gas stove is the priority, an action recommended to be completed within one to one and a half minutes. You must also stay far away from objects at risk of falling, such as signboards or window glass.

If you feel an earthquake on the coast, the greatest threat is a tsunami. In a megathrust earthquake like a Nankai Trough earthquake, wave heights can exceed 10 meters, and waves can reach the shore within 20 minutes. In some areas, it is estimated that a tsunami could arrive in just two minutes after the earthquake occurs. The Japan Meteorological Agency issues its first tsunami warning three minutes after an earthquake, but this initial warning can underestimate the earthquake's magnitude and carry a large margin of error. During the 2011 Great East Japan Earthquake, the initial announcement stated a magnitude of 7.9, but it was actually 9.0. Because more precise information is only released 20 to 30 minutes later, coastal residents cannot afford to wait for it. Rather than waiting for sirens or broadcasts, people should run to nearby high ground or designated evacuation sites as soon as shaking stops. In Japan's Sanriku region, the tradition of tsunami tendenko has been passed down. Meaning 'protect your own life yourself,' it is an ancient wisdom advising people to evacuate immediately based on individual judgment without waiting even for family. When evacuating, it is better not to use cars. Abandoned vehicles block emergency transit and exacerbate traffic congestion. The spirit of mutual aid (kyojo)—helping the elderly or children during evacuation—is also considered vital.

The reason for identifying two or three different evacuation routes in advance is that usual roads may collapse or become blocked after a major earthquake. A tsunami does not end with a single wave and can surge repeatedly, with no guarantee that the first wave will be the largest. Therefore, one must never return home until all warnings are completely lifted. Weak shaking is no cause for relief either. Some earthquakes, such as outer-rise earthquakes, produce massive tsunamis despite causing relatively mild shaking. In the 1896 Meiji Sanriku earthquake, more than 20,000 people lost their lives even though the shaking was not particularly strong.

Smartphones are vital tools immediately after an earthquake for checking family members' safety and obtaining information. Japan's Earthquake Early Warning system sends alert notifications 5 to 10 seconds before major shaking arrives. Pre-installing apps such as Yurekuru Call or Yahoo! Disaster Alert and setting notification thresholds to a seismic intensity of 4 or higher allows users to receive alerts before shaking begins. However, immediately after an earthquake, communication networks are easily congested and paralyzed, and if power cuts occur, smartphones can shut down within one to three minutes. Hence, confirming safety within the first few minutes is paramount, and designated tools like the Disaster Message Board Service 171, mobile disaster message boards, or LINE should be agreed upon in advance. Once everyone's safety is confirmed, family members gain peace of mind, knowing they can endure on their own for three days to a week while waiting to reunite. It is crucial to always keep in mind that initial earthquake information and tsunami warnings may carry significant error. While precise information issued by the Japan Meteorological Agency 20 to 30 minutes later serves as a reference, taking safe actions first before then remains the wiser course.

Sources for This Chapter

Extracted reference sources: 2011/07/24(3) 東日本大震災フォーラム (Yukinobu Okamura・ Yoshiteru Murosaki), 「変動する日本の大地と地震」 Takuya Nishimura, Japan Faces 9.0 Megaquake and Giant Tsunami, 2023年度【四国地区③】 How to Face the Nankai Trough Earthquake, 南海トラフ巨大地震講演会 How to Prepare for the Nankai Trough Earthquake, 「地震の謎に迫る」 Aitaro Kato, 南海トラフ地震対策啓発ドラマ「その日、その時･・・」(Kochi Prefecture), 【最深日本】地震特輯 (1981 new seismic standards and 1995 Hanshin earthquake), 【Japanese podcast】 Be Prepared!, 【超衝撃】怖すぎて眠れなくなる地震の話, SRC-PDF-045 Evaluasi Kegagalan Sistem Mitigasi Tsunami (2011 Tohoku case study), 令和4年度北海道防災気象講演会, [Great East Japan Earthquake] 「大切な人に届けこの想い」 documentary, 創立70周年記念講演会 『2035年±5年に起きる南海トラフ巨大地震に備える』, 【3/11WEB防災セミナー】南海トラフ巨大地震を迎え撃つ, 【2026年3月下旬】日本を襲う最大級の巨大地震が来る (urban legend channel), 【日本の震災と地震研究 - 予測可能性 - 】 Naoshi Hirata, ＜未公開映像追加＞南海トラフ地震に備える (JAMSTEC), 03南海トラフの巨大地震と津波 Manabu Hashimoto (Disaster Prevention Research Institute, Kyoto University), 2020年度第3期講座「静岡で知っておきたい地震と火山と防災」, 「地震の日本史ー関西を中心にー」 Part 3, Kyoto University Spring/Autumn Lecture Series 「平成の地震災害を振り返る」 Junji Kiyono, Japan Geoscience Union 2021 Meeting Kenji Satake, 東海地震.

Latest official sources: Japan Meteorological Agency August 8, 2024 Nankai Trough Earthquake Extra Information (https://www.jma.go.jp/jma/press/2408/08e/202408081945.html), Japan Meteorological Agency Earthquake and Tsunami Information Explanation PDF (https://www.jma.go.jp/jma/kishou/books/jishintsunami/en/jishintsunami_en.pdf).

Life After a Disaster

Once an earthquake has passed, another battle begins immediately. This is because essential lifelines like electricity, water, and gas remain disrupted for long periods. It is often said that electricity returns in a day, water in three days, and gas in a week, but during the 1995 Great Hanshin-Awaji Earthquake, the 2011 Great East Japan Earthquake, and the Kumamoto Earthquake, restoration actually took much longer. Water outages lead directly to toilet problems. According to research, about half of the population experiencing water and power outages lose the ability to use toilets, and it can take around 30 days for toilet facilities to be fully restored, with delays extending even longer if replacement parts cannot be procured. In high-rise buildings, it is common for elevators to remain out of service for more than three days, adding the hardship of climbing up and down stairs.

Many disaster survivors continue living in evacuation centers, but the environment there is far from easy. A study examining people evacuated due to the Fukushima nuclear accident during the 2011 Great East Japan Earthquake reported that they experienced high stress across ten categories, including financial hardship, health, concerns about radiation exposure, children's education, housing, isolation, loss of community and family, and anxiety about the future. In the ten months following March 11, the number of people requiring long-term care across 42 municipalities increased by 12,140, or 12.7%, a growth rate 3.7 times higher than that of the same period prior to the disaster. Sitting or lying in cramped and uncomfortable evacuation centers for extended periods impairs leg blood flow and can lead to deep vein thrombosis—so-called economy class syndrome—which is cited as a major cause of disaster-related deaths. Disaster-related deaths refer not to lives lost directly to an earthquake or tsunami, but to cases where people pass away later as stress from evacuation life, aggravation of pre-existing conditions, injuries, poor sanitation, and psychological distress accumulate.

The quality of evacuation centers varies significantly by country. In Italy, post-earthquake evacuation centers are operated complete with containerized toilets, shower facilities, washing stations, mobile kitchen trucks serving hot meals cooked on-site, and beds. Italian disaster response experts point out that the very concept of 'disaster-related death' in Japan stems from unnecessary deaths caused by poor evacuation center environments. The fact that Italy, whose gross domestic product was lower than Japan's as of 2022, provides far superior evacuation center environments prompts reflection on Japanese society's long-standing perception that enduring hardship at evacuation centers is only natural.

Not everyone needs to head to an evacuation center. If you live in a house with superior seismic performance, such as reinforced concrete construction, staying at home may actually be safer than moving to a shelter. This is known as sheltering in place at home, and adopting this approach requires maintaining at least a one-week supply of water, food, emergency medicine, and portable toilets. The 72 hours immediately following an earthquake are known as the golden window, during which survival rates drop precipitously. Because public rescue efforts by fire departments, police, and the Self-Defense Forces often cannot reach everyone during this timeframe, self-help (jijo) and mutual assistance (kyojo) among neighbors become paramount.

During the 2011 Great East Japan Earthquake, in businesses that opened their doors as temporary evacuation shelters in devastated areas, local residents, employees, and facility users lived together, dissolving pre-existing barriers and naturally fostering relationships of mutual assistance. The realization that even when material things cannot be relied upon, people can rely on each other became the root of social welfare, with individuals previously viewed as vulnerable—such as children and the elderly—finding their own roles. The firsthand account that what disaster survivors fear most is coming to a complete standstill explains why it is vital to create environments where people can keep moving forward, even in small steps, and focus on what can be gained rather than what has been lost.

The ability to handle information is also a driving force sustaining life after a disaster. People must acquire accurate information using disaster apps and disaster message board services on smartphones, while also staying attentive to municipal disaster prevention administrative radio networks, satellite communication networks, and alert apps. Population aging and decline cast a shadow over this entire recovery process. In some regions, the working-age population falls below 40% or the population under age 15 accounts for less than 20%, raising fundamental questions about whether recovery would truly be possible if a major disaster were to strike such areas. Issues such as difficulty procuring materials, aging infrastructure, and rising rates of disaster-related deaths underscore why disaster preparedness systems must be continually reassessed and reformed.

Sources for This Chapter

Extracted reference sources: 2020年度 第3期講座「静岡で知っておきたい地震と火山と防災」, 【Japanese podcast】 Be Prepared!, SRC-PDF-031 し尿処理における大規模地震災害対応に関する研究, 災害に強いまちづくり講座(II), SRC-PDF-028 東日本大震災における原子力災害後の避難者· 帰還者のメンタルヘルスと支援およびメディアの役割, SRC-PDF-017 高齢者と東日本大震災, 【第１部：講演】 Japan Medical Association Symposium 「関東大震災発災から100年」, 地震と火山の国 日本 Masanori Ueno, 【オンライン自習室】東日本大震災から9年, Science Council of Japan Sponsored Symposium (9th) First Half, SRC-PDF-081 大規模地震被災地域におけるコミュニティ形成の現状と課題, 【南海トラフ地震と首都直下地震】 (PIVOT Official Channel), SRC-PDF-007 Examining Causes of Dwellings in the Lowlands, Kyoto University Spring/Autumn Lecture Series 「平成の地震災害を振り返る」 Junji Kiyono, 地震調査研究推進本部 30th Anniversary Special Symposium, 2023年度【四国地区③】 How to Face the Nankai Trough Earthquake, 名取市東日本大震災映像記録, SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, SRC-PDF-014 Detailed Seismic Intensity Distribution (1923 Great Kanto Earthquake), SRC-PDF-040 東日本大震災 現地調査の軌跡 (Obuchihama, Ishinomaki City), SRC-PDF-065 NEWSPAPER REPORTS ON EAST JAPAN GREAT EARTHQUAKE, 【防災講演会】 Hiroki Kamata (Professor Emeritus, Kyoto University), 後方カメラ映像· 令和8年6月23日講演会「首都直下地震への対応」, [東日本大震災]

「大切な人に届けこの想い」.

Latest official sources: Cabinet Office 2025 Disaster Management White Paper English Edition (https://www.bousai.go.jp/en/documentation/white_paper/pdf/2025/R7_hakusho_english.pdf).

Chapter 5 Closing

Chapter 5 Personal and Household Preparedness

Immediate Actions: Safeguarding Lives

Knowing how to react during an earthquake and having a communication plan are vital for immediate safety and post-disaster recovery.

The immediate priority during an earthquake is personal safety: dropping, covering, and holding on to sturdy furniture, or bracing against an interior wall to protect oneself from falling objects and structural damage. Post-earthquake, communication networks are often overwhelmed, making it crucial for families to pre-determine alternative contact methods and understand that essential services like electricity, water, and gas may be disrupted for extended periods.

Drop, Cover, Hold On

Chapter 6 Opening

Chapter 6 Disaster Prevention in Cities and Infrastructure

Urban Resilience: Seismic Engineering

> Japan consistently innovates in seismic engineering to ensure its urban infrastructure can withstand frequent and powerful earthquakes.

Seismic design in Japan encompasses three main approaches: quake-resistant structures (taishin) built for strength, vibration-damping structures (seishin) that absorb energy with devices like dampers, and base-isolated structures (menshin) that decouple the building from ground motion. The introduction of the 1981 seismic building code marked a significant turning point, though the 1995 Great Hanshin-Awaji Earthquake tragically revealed the vulnerability of older, non-compliant wooden houses that pre-dated this standard.

Menshin Structures

Chapter 6 Disaster Prevention in Cities and Infrastructure

Seismic Design and Construction

When the shaking of an earthquake coincides with a building's natural period, a phenomenon called resonance occurs, dramatically amplifying the damage. Seismic design is therefore not merely a matter of constructing sturdy buildings, but an undertaking that considers the complex properties of such shaking. In Japan, earthquakes measuring seismic intensity 6 Lower or higher on the Shindo scale have occurred on average twice a year since 2000, leaving seismic technology as an ongoing challenge that must continuously evolve and be applied. Buildings withstand earthquakes primarily through three structural approaches. Earthquake-resistant (seismic-resistant) structures withstand shaking by building the structure itself sturdily; vibration-damping structures incorporate devices such as dampers inside the building to absorb vibrational energy; and base-isolation structures place special devices between the building and the ground to decouple them, preventing ground motion from transferring directly to the building and keeping even objects inside from shaking violently. In practice, there have been numerous confirmed cases where hospitals incorporating base-isolation structures suffered only light damage even during major earthquakes.

The new seismic code established in 1981 marked a major turning point in Japan's architectural history. This standard focused on preventing buildings from collapsing during major earthquakes of seismic intensity 6 or higher to protect human lives. However, the 1995 Great Hanshin-Awaji Earthquake exposed the blind spots of this new standard. Roughly 90% of those killed in the earthquake died inside their homes after being crushed under collapsed buildings, a significant portion of which were wooden houses built under the pre-1981 code. While buildings built under the new standard generally sustained lighter damage, the fact that many structures built earlier fell short of the new code led to widespread devastation. The earthquake served as a stark reminder that no matter how much laws are strengthened, the danger remains unless existing buildings are actually retrofitted.

The vulnerability of aging buildings remains a major challenge in Japan's urban disaster prevention today. During the 1923 Great Kanto Earthquake, wooden houses in Tokyo collapsed extensively on soft ground due to long-period ground motion, and among them, densely populated low-lying areas known as Shitamachi suffered immense damage exacerbated by fires. Even now, out of 52.5 million ordinary residential homes nationwide, 2.5 million fail to meet the new seismic standards. Among 440,000 high-occupancy facilities such as schools, department stores, and hospitals, 20,000 fall short, and out of 15,000 buildings subject to mandatory seismic inspections, 4,000 remain non-compliant. As of 2020, the target rate for seismic reinforcement of high-occupancy buildings was 95%, but 20,000 structures failed to reach this goal.

Because schools and hospitals serve as hubs for evacuation and relief operations when disasters strike, the seismic performance of these facilities is paramount. After the 1995 Great Hanshin-Awaji Earthquake, the government designated local government offices, police stations, hospitals, and schools as operational bases for emergency use and mandated their proper management. Yet, not all schools and hospitals fully meet the latest standards, and smaller facilities in regional areas face greater difficulties carrying out seismic retrofitting.

Seismic retrofitting requires money. Investing around 1 million yen can significantly boost a building's seismic performance, whereas a 500,000-yen reinforcement might feel less visibly effective, and inconvenience daily life as pillars thicken or braces are placed in awkward locations. In bustling commercial districts like Ginza where buildings are tightly packed together, securing space for construction is difficult, and with businesses having to pause operations during construction alongside rent burdens, cases of delayed retrofitting continue to be reported. Such circumstances leave workers and passersby exposed to danger when an earthquake occurs.

Urban planning and reconstruction are also inseparable from seismic architecture. Following the 1923 Great Kanto Earthquake, Tokyo enacted a new Urban Planning Act, formulated a reconstruction plan, and was restored in seven years. However, due to budget shortages, densely built wooden residential areas were left unattended, which later caused flames to spread extensively during World War II air raids. Even after the 2011 Great East Japan Earthquake, measures restricting land use or prohibiting residential construction in tsunami-inundated areas delayed the establishment of recovery plans and complicated disaster victims' stabilization of daily life and return to work. Ishinomaki Municipal Hospital was initially supposed to be rebuilt on its original site, but opposition from citizens led to a policy change relocating it elsewhere, delaying recovery. Earthquake motion affects buildings differently depending not only on intensity but also on duration and period. Long-period ground motion can resonate with high-rise buildings, causing them to sway heavily for extended periods. Thus, the government pushes forward seismic strengthening through various methods, such as braces, dampers, hoop reinforcement, slope stabilization, and underground pipe reinforcement.

Sources for This Chapter

Extracted sources: Kyoto University Shunju Lecture "Reflecting on Heisei Earthquake Disasters" Junji Kiyono, "Approaching the Mysteries of Earthquakes" Aitaro Kato, SRC-PDF-139 Senior Housing with Nursing Care Prepared for Increasingly Severe Natural Disasters (Challenges and Solutions in Promoting Base Isolation), 【Deepest Japan】 Earthquake Special (1981 New Seismic Code and 1995 Hanshin Earthquake), SRC-PDF-069 DAMAGE RATES OF VARIOUS KINDS OF STRUCTURES (1923 Great Kanto Earthquake), SRC-PDF-122 OVERVIEW OF THE 1995 HYOGO-KEN NANBU EARTHQUAKE, SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, FY2020 3rd Term Course "Earthquakes, Volcanoes, and Disaster Prevention to Know in Shizuoka", 【Disaster Prevention Lecture】 Kyoto University Professor Emeritus Hiroki Kamata, 20230529 UPLAN Katsuhiko Ishibashi, 【Super Shock】 Earthquake Stories Too Terrifying to Sleep, 2011/07/24(3) Great East Japan Earthquake Forum, 【Japanese podcast】 Be Prepared!, Japan: A Country of Earthquakes and Volcanoes Masanori Ueno, The Impending Nankai Trough Megathrust Earthquake.

Urban Planning

The 2011 Great East Japan Earthquake clearly exposed the limitations of existing disaster prevention systems and predictive models. It revealed that disasters can strike at scales and in manners exceeding pre-conceived scenarios—what is called *sajōgai* (unforeseen) in Japanese. Consequently, urban planning must become a long-term, flexible strategy encompassing everything from routine land use, facility placement, and resident education to real-time response during a disaster and subsequent recovery.

In coastal areas, how quickly residents access evacuation routes determines life or death. In one simulation, if evacuation began 5 minutes after an earthquake, everyone could evacuate before the tsunami reached land; however, after 10 minutes, one person was lost; after 15 minutes, a significant number were swept away; and after 20 minutes, nearly everyone was engulfed by the tsunami. This result reaffirms that people must immediately head for higher ground without waiting for sirens or broadcasts. In regions like Minami Town in Tokushima Prefecture, local plans tailored to regional circumstances are being implemented, with residents maintaining evacuation routes themselves and creating and distributing personal cards detailing when, where, and how to evacuate.

When a major earthquake strikes an urban center, traffic paralyzes in an instant. An earthquake in the Tokyo metropolitan area could block major roads with abandoned vehicles and damaged road infrastructure, triggering severe congestion. To secure routes for emergency vehicles, police are preparing measures to block vehicles entering the city center and ban general traffic on emergency transport routes. The plan known as the 'Eight-Direction Operation' aims to secure emergency thoroughfares into the city center within 48 hours, focusing on routes expected to suffer relatively lighter damage. However, narrow backstreets in residential areas remain vulnerable to blockages by obstacles, potentially delaying rescue teams, hindering supply delivery, and making passage entirely impossible for wheelchair users.

Relocating villages to higher ground is a flagship tsunami countermeasure long employed by Japan. Following the 1933 Showa Sanriku Tsunami, more than 100 villages in Iwate and Miyagi Prefectures relocated to higher ground. Yet during the 2011 Great East Japan Earthquake, severe damage recurred in several of these relocated villages as houses were swept away. This occurred because the 2011 tsunami was far larger than the Showa-era tsunami, and over the 80 years since relocation, people had begun reoccupying the former inundation zones. As memories of the disaster faded, structures like seawalls fostered a false sense of security, luring people back into dangerous lowlands. Consequently, modern urban planning is moving beyond moving entire villages to prioritizing the relocation of core facilities—such as hospitals and preschools—to higher ground first. In Minami Town, the hospital and preschool were relocated to high ground based on the reasoning that if children are already in a safe place, parents will evacuate directly rather than venturing into dangerous areas to retrieve them. Checking hazard maps in advance to confirm anticipated damage and evacuation destinations for each area is also emphasized.

Ports and coastal regions are vulnerable to tsunamis and liquefaction. Prior to 2011, the Sanriku Coast had 10-meter-high seawalls designed based on major tsunamis from the Meiji and Showa eras, whereas seawalls along Sendai Bay and the Joban Coast were built to heights of only about 6 meters based on typhoon storm surges. The 2011 tsunami exceeded all these projections, causing widespread devastation. Following this experience, Japan introduced a two-tiered tsunami concept designated L1 and L2. L1 tsunamis are relatively frequent tsunamis occurring once every several decades to a century, which hard infrastructure like seawalls aims to block. L2 tsunamis are megathrust tsunamis occurring once in roughly 1,000 years, like the one in 2011; recognizing that facilities alone cannot completely block them, the goal shifts to minimizing loss of life through soft measures like comprehensive urban planning and rapid evacuation.

Densely populated metropolises like Tokyo face compound risks. During the 1923 Great Kanto Earthquake, wooden houses in Tokyo collapsed extensively on soft ground due to long-period ground motion, while densely populated low-lying areas like Shitamachi suffered immense damage compounded by fires and flooding from liquefaction. Even today, Tokyo's so-called zero-meter zones face risks of catastrophic flooding should river dikes collapse. The fact that concealed blind fault lines lie buried beneath thick sedimentary layers also remains a potential risk factor in heavily populated areas.

Rebuilding a city after a disaster involves an intricate web of administrative, financial, and social challenges. After the 1923 Great Kanto Earthquake, Tokyo was restored in seven years, but due to budgetary constraints, some densely built wooden areas were left untouched, later contributing to the spread of fires. After the 2011 Great East Japan Earthquake, recovery plans were frequently delayed due to sectionalism—where ministries operated in silos—and localized optimization. Large-scale disasters exacerbate structural social issues like population decline and aging, and smaller municipalities face severe hardship due to a lack of manpower and resources necessary for recovery. Addressing these issues requires pre-disaster recovery planning, where residents participate before a disaster occurs to envision the post-disaster city in advance.

Sources for This Chapter

Extracted sources: SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, Connection Point Between the Great East Japan Earthquake and the Nankai Trough Earthquake (JSCE note), FY2022 Hokkaido Disaster Prevention Weather Lecture, 【3/11 Web Disaster Prevention Seminar】 Confronting the Nankai Trough Megathrust Earthquake, Rear Camera Video: June 23, 2026 Lecture 'Response to a Capital Inland Earthquake', SRC-PDF-007 Examining Causes of Dwellings in the Lowlands, [Great East Japan Earthquake] 'May This Feeling Reach My Loved Ones', ＜Unreleased Footage Added＞ Preparing for the Nankai Trough Earthquake (JAMSTEC), Kyoto University Shunju Lecture 'Reflecting on Heisei Earthquake Disasters' Junji Kiyono, SRC-PDF-012 Inundation areas and deposits of the 2011 and 869 Jogan tsunamis, SRC-PDF-065 NEWSPAPER REPORTS ON EAST JAPAN GREAT EARTHQUAKE, SRC-PDF-014 Detailed Seismic Intensity Distribution (1923 Great Kanto Earthquake), 【Super Shock】 Earthquake Stories Too Terrifying to Sleep, 【Megathrust Earthquake Warning】 Active Faults of the Japanese Archipelago, 【Deepest Japan】 Earthquake Special, SRC-PDF-091 Catastrophic Disasters and Earthquake Insurance, SRC-PDF-138 Overcoming the Dual Structure of Reconstruction (30-Year Verification of Hanshin-Awaji Earthquake and Nankai Trough Earthquake), 20230529 UPLAN Katsuhiko Ishibashi.

Pre-Disaster Recovery Planning

Large-scale disasters deal a massive shock to society as a whole due to their unpredictable nature and compound complexity. Accurately predicting the exact timing and magnitude of earthquakes and tsunamis on a short-term basis remains impossible even with today's science and technology, a limitation that underscores the critical importance of pre-disaster recovery planning to reduce post-disaster chaos and expedite recovery. Following the 2011 Great East Japan Earthquake, Japan acutely realized the limitations of its existing disaster prevention system and felt the painful necessity of a comprehensive disaster management system spanning the entire process from pre-disaster preparation to recovery.

When a disaster occurs, the immediate challenge encountered is the disruption of essential lifelines like electricity, water, and gas. Although there is a rule of thumb of 'one day for electricity, three days for water, and one week for gas,' restoration during the 1995 Great Hanshin-Awaji Earthquake took one week for electricity, three weeks for water, and up to two months for gas, with similar delays observed in the 2011 Great East Japan Earthquake. Water outages lead to sanitation crises; nearly half of the population experiencing water and power outages lose access to usable toilets, and fully restoring toilet facilities can take approximately 30 days.

Disaster recovery does not end with merely rebuilding what collapsed. Tsunami deposits generated during the Great East Japan Earthquake amounted to between 5.16 million and 8.26 million cubic meters. Processing such immense volumes of waste directly impacted the pace of recovery, with early delays stemming even from securing temporary storage sites. Japan's Ministry of the Environment and Ministry of Land, Infrastructure, Transport and Tourism established guidelines and standards to reuse this waste and deposit material as foundation material for recovery projects rather than simply discarding it. When restoring public facilities, debates arose between original-form restoration—rebuilding structures exactly as they were—and disaster-avoidance improved restoration, which rethinks a facility's purpose and function to mitigate future risks. Ishinomaki Municipal Hospital stands as a prominent example where recovery was delayed because the plan shifted from rebuilding on its original site to relocating elsewhere following opposition from residents.

One of the largest obstacles during the recovery process is the issue known as sectionalism (vertical administration). Because various central government ministries executed projects applying different laws and regulations, projects collided and coordination stalled even within the same region. For instance, regarding high-ground relocation alone, the Disaster Prevention Collective Relocation Project managed by the Ministry of Land, Infrastructure, Transport and Tourism and the Fishing Village Disaster Prevention Function Enhancement Project managed by the Ministry of Agriculture, Forestry and Fisheries ran separately, adding confusion on the ground. Such localized optimization slowed recovery speeds and eroded residents' trust. To resolve this, proposals emerged to consolidate recovery tasks between the central government and local municipalities, creating a recovery support organization with unified authority, funding, and personnel.

In many cases, local municipalities cannot cope with major disasters on their own strength alone. Small to medium-sized municipalities with populations under 200,000 have small average staff sizes—1,030 for cities and 260 for towns and villages—risking total organizational paralysis if a major disaster occurs. During the Great East Japan Earthquake, many municipalities suffered severe setbacks in initial response and recovery operations due to administrative paralysis and personnel losses. Under these circumstances, a wide-area cooperation framework is essential, where the national government and prefectural authorities actively intervene from the outset to perform municipal duties and dispatch experts and resources.

Pre-disaster recovery planning, where residents directly participate in formulating recovery plans before a disaster occurs, serves as the key to preserving both recovery speed and public trust. Regions like Kochi and Tokushima Prefectures are working alongside residents to envision the kind of town they want to build in preparation for a Nankai Trough earthquake. In Minami Town, the hospital and preschool were moved to higher ground before any disaster hit, securing children's safety in advance so parents could evacuate with peace of mind.

Disaster recovery in Japan has long exhibited a dual structure that prioritizes institutional recovery—such as infrastructure reconstruction, urban planning, and economic revitalization—while relegating human-centered recovery—such as rebuilding residents' livelihoods, restoring communities, and offering psychological support—to the background. This imbalance, where roads and buildings are quickly re-erected while residents' lives and communities suffer over prolonged periods, is sometimes termed a 'secondary disaster of recovery.' Observers pointed out that this familiar dual structure repeated itself during the 2024 Noto Peninsula Earthquake. The Japanese government stated in its 2025 White Paper on Disaster Management that lessons from the Noto Peninsula Earthquake are being incorporated into discussions on responding to a Nankai Trough megathrust earthquake and a Tokyo metropolitan inland earthquake, and a verification team for the 2024 Noto Peninsula Earthquake operated to identify strengths and areas for improvement in emergency response. This aligns with Japan's long-standing practice of using past disasters as material to prepare for the next.

Population decline and aging add new hurdles to recovery. In regions where the working-age population is under 40% or the population under age 15 is under 20%, a major disaster leaves such a severe shortage of people needed for recovery that questions arise as to whether recovery is truly possible. Facing the potential future emergence of hundreds of thousands to one million long-term evacuees, critics point out that the traditional linear model—moving from temporary housing to recovery housing and then to permanent housing—is no longer viable. Proposed as an alternative, the concept of temporary urban areas goes beyond merely distributing temporary housing; it builds temporary urban spaces equipped with urban functions like schools, hospitals, shops, and parks, supporting residents so they can maintain stable urban lives even during extended displacement. However, establishing the legal and institutional framework to back this concept remains incomplete.

Sources for This Chapter

Extracted sources: SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, November 23, 2017 'Short-Term Earthquake Prediction and Disaster Prevention System' Toshiyasu Nagao, SRC-PDF-031 Research on Large-Scale Earthquake Disaster Response in Human Waste Treatment, ＜Unreleased Footage Added＞ Preparing for the Nankai Trough Earthquake (JAMSTEC), SRC-PDF-004 Distribution and physicochemical properties of tsunami deposits(2011), SRC-PDF-007

Examining Causes of Dwellings in the Lowlands, FY2023 【Shikoku Region ③】 How to Confront the Nankai Trough Earthquake, SRC-PDF-138 Overcoming the Dual Structure of Reconstruction, Connection Point Between the Great East Japan Earthquake and the Nankai Trough Earthquake, 【3/11 Web Disaster Prevention Seminar】 Confronting the Nankai Trough Megathrust Earthquake, 【Part 1: Lecture】 Testimonies and Records of the Great Earthquake (Iwaki City Official) / Japan Medical Association Symposium, Norio Maki 'Thinking About Recovery from Nankai Trough Earthquake Disasters' Kyoto University Disaster Prevention Research Institute Open Lecture.

Latest official data: Cabinet Office 2025 Disaster Management White Paper English Version (https://www.bousai.go.jp/en/documentation/white_paper/pdf/2025/R7_hakusho_english.pdf), Disaster Management White Paper Chapter 2 (https://www.bousai.go.jp/en/documentation/white_paper/pdf/2025/01_chap_02.pdf), Japan Meteorological Agency 2024 Noto Peninsula Earthquake Portal (https://www.jma.go.jp/jma/en/2024_Noto_Peninsula_Earthquake/index.html), Noto Peninsula Earthquake Tsunami Field Survey PDF (https://www.jma.go.jp/jma/press/2401/26a/20240126_tsunamichousakekka.pdf).

Chapter 6 Closing

Evolving City Planning: New Standards

Urban planning strategies must adapt to the evolving understanding of disaster scale, moving beyond mere physical defenses to embrace comprehensive, flexible approaches.

The 2011 Tohoku earthquake exposed the limitations of previous urban planning assumptions, leading to the adoption of L1 and L2 tsunami classifications: L1 for more frequent, smaller tsunamis manageable with hard infrastructure, and L2 for rare, massive tsunamis requiring land-use restrictions and rapid evacuation. Significant challenges persist in retrofitting older buildings, especially in dense urban areas, and addressing the complexities of post-disaster recovery that are often hindered by segmented administrative processes.

L1/L2 Classification

Chapter 7 Opening

Chapter 7: Disaster Response in an Aging Society

Aging Society: Vulnerable Evacuation

Elderly and disabled individuals, categorized as "care-dependent persons," face heightened risks and unique challenges during disaster evacuations.

The reduced mobility of elderly and disabled individuals makes rapid evacuation, especially during tsunamis with short warning times, physically much more difficult compared to the general population. Historical events, like the Tohoku earthquake, exposed how the proximity of many elder care facilities to coastlines and the lack of accessible transportation severely hampered timely and safe evacuations, leading to high casualties.

Reduced Mobility

Chapter 7: Disaster Response in an Aging Society

Evacuation of the Elderly and People with Disabilities

Large-scale disasters are difficult for anyone, but for people categorized as vulnerable—such as the elderly and people with disabilities—they pose a direct threat to survival itself. As noted earlier, a tsunami can reach the coast within 20 minutes, yet taking shelter within this brief timeframe is physically far more challenging for the elderly and disabled. According to a study measuring evacuation speeds, individuals with hemiplegia move at 0.63 meters per second, half the speed of the average person, while pregnant women move at 0.95 meters per second, 20% slower than average. This difference means vulnerable individuals require significantly more time to escape a tsunami, which consequently results in a distinctly lower chance of survival.

During the Great East Japan Earthquake, many elder care facilities were located near the coast and were directly exposed to the tsunami. Even though a senior facility in Ofunato City, Iwate Prefecture, sat on high ground 14 meters above sea level, delayed action due to not receiving timely tsunami information resulted in the loss of 54 out of 67 residents with mobility difficulties. At a care facility in Kesennuma City, Miyagi Prefecture, the tsunami engulfed up to the second floor, claiming the lives of 47 residents; staff members faced extreme difficulty moving wheelchair-bound users to the first floor and then transporting them to an evacuation shelter past collapsed levees and damaged roads. At the time of the Fukushima nuclear accident, an elderly care facility lacked suitable vehicles like tour buses or trucks to evacuate its 141 residents, causing delays during which many suffered or passed away amid the risk of radiation exposure. In winter, evacuation routes can freeze over or become covered in snow, further slowing evacuation speeds and necessitating cold-weather measures. If an earthquake occurs directly beneath the Tokyo metropolitan area, main roads could be blocked by abandoned vehicles and damaged pavement, while narrow side streets could be obstructed even more easily, making access difficult for rescue teams and rendering movement impossible for wheelchair users.

Maintaining health after a disaster also weighs far more heavily on the elderly and people with disabilities. For patients relying on electricity-dependent medical devices such as ventilators, hemodialysis machines, or sleep apnea therapy devices, a power outage is directly a matter of life and death. Emergency power supplies and oxygen delivery systems can currently sustain operation for only about three days. Sitting or lying down for extended periods in cramped, uncomfortable shelters can cause deep vein thrombosis, which serves as a major cause of disaster-related deaths. General shelters—commonly school gymnasiums—lack sufficient heating, offer little privacy, have an inadequate number of restrooms, and sometimes provide meals yielding around 1,340 kilocalories across two meals a day, falling short of the national recommended daily intake of 2,000 kilocalories, rapidly deteriorating the health of elderly residents. At a shelter in Sendai City, 60% of elderly occupants experienced difficulty walking or standing up after one month, and in Minamisanriku, 41.8% of elderly residents who had not previously been certified for long-term care encountered greater difficulty with activities of daily living than before the disaster. For patients suffering from dementia, unfamiliar surroundings, separation from family, and a lack of information heightened confusion and anxiety, leading to incidents of wandering or getting lost. One patient even remarked that evacuation meant death. To address these issues, the role of welfare shelters that provide medical care and support tailored to the elderly and disabled is increasingly emphasized. In these facilities, bedsores and skin conditions are treated, warm meals prepared by nutritionists are served, medical social workers intervene, and rehabilitation therapy is offered, protecting the health of vulnerable individuals.

Aging and population decline also impose a heavy burden on securing caregiving personnel during a disaster. Following the Great East Japan Earthquake, 104 care workers and nursing staff members across 35 facilities in Fukushima Prefecture resigned or left their posts due to evacuation and other reasons, deepening staff shortages and leading to an increase in disaster-related deaths. Before the disaster, invisible walls sometimes existed between welfare facilities and local residents; however, when facilities opened their doors as evacuation shelters during the Great East Japan Earthquake, these walls broke down and new bonds formed as staff, facility users, and local residents lived together. It was demonstrated that those considered vulnerable, such as the elderly and children, could also find social roles. In Ofunato City, retired elderly men engaged in activities to teach children woodworking skills, local folklore, dialect, and traditional cooking, regaining a sense of social connection and vitality. After the Great East Japan Earthquake, maintaining the continuity of welfare services emerged as a major challenge. To achieve this, efforts were made to establish support centers providing comprehensive counseling, home nursing, meal delivery, and community interaction spaces within temporary housing areas, as well as to construct welfare temporary housing—a lesson drawn from the experience during the Niigata Chuetsu Earthquake, where building care hubs alongside temporary housing helped prevent solitary deaths and the worsening of care-need levels.

Sources for This Chapter

Extracted source evidence: FY2020 3rd Term Lecture "Earthquakes, Volcanoes, and Disaster Prevention You Should Know in Shizuoka", FY2022 Hokkaido Disaster Prevention Weather Lecture, SRC-PDF-017 The Elderly and the Great East Japan Earthquake, Rear Camera Video / June 23, 2026 Lecture "Response to an Earthquake Directly Beneath the Tokyo Metropolitan Area", Nankai Trough Megathrust Earthquake Lecture How to Prepare for the Nankai Trough Earthquake, [Online Study Room] 9 Years Since the Great East Japan Earthquake, FY2023 [Shikoku Region ③] How to Face the Nankai Trough Earthquake, SRC-PDF-081 Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes, SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, SRC-PDF-007 Examining Causes of Dwellings in the Lowlands, SRC-PDF-028 Evacuees After the Nuclear Disaster in the Great East Japan Earthquake, SRC-PDF-031 Large-Scale Earthquake Disaster Response in Night Soil Treatment, SRC-PDF-065 NEWSPAPER REPORTS ON EAST JAPAN GREAT EARTHQUAKE, SRC-PDF-139 Senior Housing with Nursing Care Facilities Preparing for Intensifying Natural Disasters, [Great East Japan Earthquake] "Deliver This Feeling to My Loved Ones", "Why Were So Many People Delayed in Evacuating?" 13 Years Since the Great East Japan Earthquake (ANNnewsCH Telementary), [3/11 WEB Disaster Prevention Seminar] Intercepting the Nankai Trough Megathrust Earthquake, [Nankai Trough Earthquake and Tokyo Metropolitan Directly Beneath Earthquake] (PIVOT Official Channel), Connecting Points Between the Great East

Japan Earthquake and the Nankai Trough Earthquake.

Recovery in Depopulated Areas

Large-scale disasters such as earthquakes and tsunamis are unpredictable and inflict compounding damage; in areas already experiencing population decline and aging, the recovery process faces even greater hurdles. In such regions, fundamental questions arise as to whether recovery is truly possible. Examining population trends in Iwate and Kochi Prefectures reveals a distinct demographic decline following major disasters, with population loss rates over 30 years in certain villages in Kochi Prefecture far exceeding those in Iwate Prefecture. Some areas have a working-age population under 40% or a youth population under age 15 below 20%, structural social shifts that severely impair disaster recovery capabilities.

Relocating tsunami-damaged villages to higher ground was a primary tsunami defense strategy, yet as memories of disaster faded over time, residents repeatedly returned to settle in hazardous lowlands. Even in more than 100 villages that had relocated to high ground following the 1933 Showa Sanriku Tsunami, severe damage recurred during the 2011 Great East Japan Earthquake as homes were washed away, because people had gradually reassembled in former inundation zones during the 80 years following relocation. A combination of factors drove this return to lowland areas: a sense of security conferred by disaster prevention infrastructure such as coastal dikes and tide-breaker forests, the fading of disaster memories and vigilance, the influx of new residents who had not experienced the disaster, financial constraints that prevented building new homes on high ground and led people to erect temporary dwellings on original lands, and social ties such as kinship and clan beliefs. Furthermore, the issue of vacant homes accumulating due to population decline has emerged as a crucial consideration when formulating post-disaster recovery plans.

The desire of disaster-affected residents to remain in their region and continue their livelihoods determines the community's future. If businesses fail to recover in the area after a disaster and relocate elsewhere, jobs disappear and the community itself can collapse. In a major disaster like a Nankai Trough earthquake, external assistance such as the Self-Defense Forces may not arrive immediately, reinforcing the awareness that such areas must prepare to sustain themselves independently for at least seven days. Along the coastal areas of Iwate and Miyagi Prefectures, the number of fishery workers had been declining even before the disaster; after the earthquake, an increasing number of people moved away or left the industry, making it even harder to maintain community ties.

The finances and administrative capacities of local governments are also far more vulnerable in depopulated regions. Municipalities with populations under 200,000 have small staffing levels—averaging 1,030 employees for cities and 260 for towns and villages—creating a high risk of organizational paralysis during a major disaster and forcing reliance on central government subsidies and assistance due to weak fiscal and organizational strength. When coupled with compartmentalized administrative silos, even a single high-ground relocation project can suffer heightened confusion on the ground as the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Agriculture, Forestry and Fisheries execute projects under conflicting laws and regulations. Heavy financial burdens associated with recovery projects can lead to budget cuts that shrink planned scales, while underinvestment in aging infrastructure combined with struggles in the local construction industry makes procuring materials and labor required for recovery difficult. Following the Fukushima nuclear disaster, concerns also emerged that the potential termination of medical and long-term care subsidies would further exacerbate burdens on already financially vulnerable residents.

Preserving community is the most prolonged challenge in the recovery of depopulated regions. Even after disaster victims transition from temporary housing to permanent housing, some become isolated or die alone because they fail to find an emotional anchor or community. As temporary housing is dismantled and connections between neighbors break, feelings of isolation deepen. Amid these hardships, there are grassroots movements where residents take initiative to rebuild community life. In Ofunato City, Iwate Prefecture, residents who had been distant before the disaster created spaces to cook meals together and engage in volunteer activities, maintaining supportive relationships as mutual sanctuaries. The recognition that those considered vulnerable, such as the elderly and children, can each find social roles serves as the foundation of welfare. In Minami Town, hospitals and daycare centers were relocated to high ground to secure children's safety first, enabling parents to evacuate with peace of mind. Regional approaches that transcend vertical administrative divisions and foster cooperation across broader regional scales are treated as vital, alongside institutional frameworks created to assist the private sector in autonomously launching relief activities during disasters.

Sources for This Chapter

Extracted source evidence: FY2023 [Shikoku Region ③] How to Face the Nankai Trough Earthquake, SRC-PDF-007 Examining Causes of Dwellings in the Lowlands, Connecting Points Between the Great East Japan Earthquake and the Nankai Trough Earthquake, Nankai Trough Megathrust Earthquake Lecture How to Prepare for the Nankai Trough Earthquake, Rear Camera Video / June 23, 2026 Lecture "Response to an Earthquake Directly Beneath the Tokyo Metropolitan Area", SRC-PDF-013 ISSUES OF ORGANIZATION AND LAW REGULATION, SRC-PDF-081 Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes, SRC-PDF-138 Overcoming the Dual Structure of Reconstruction, SRC-PDF-017 The Elderly and the Great East Japan Earthquake, SRC-PDF-014 Detailed Seismic Intensity Distribution (1923 Great Kanto Earthquake), SRC-PDF-028 Evacuees After the Nuclear Disaster in the Great East Japan Earthquake, SRC-PDF-031 Large-Scale Earthquake Disaster Response in Night Soil Treatment, SRC-PDF-040 Trajectory of Field Surveys in the Great East Japan Earthquake (Obuchihama, Ishinomaki City), SRC-PDF-065 NEWSPAPER REPORTS ON EAST JAPAN GREAT EARTHQUAKE, SRC-PDF-125 Detailed Seismic Intensity Distribution (1923 Great Kanto Earthquake Supplementary Material), SRC-PDF-139 Senior Housing with Nursing Care Facilities Preparing for Intensifying Natural Disasters, "100 Years Since the Great Kanto Earthquake" (3) Survey of Survivors and Fatalities, Itoko Kitahara, [3/11 WEB Disaster Prevention Seminar] Intercepting the Nankai Trough Megathrust Earthquake, [Yukkuri Commentary] Architectural Commentary on the Great Kanto Earthquake, [Nankai Trough Earthquake and Tokyo Metropolitan Directly Beneath Earthquake] (PIVOT Official Channel), Symposium "Japan and Asia as Seen from the History of Shimizu Port", Kyoto University

Shunju Lectures "Looking Back on Heisei Earthquake Disasters", Junji Kiyono, FY2022 Hokkaido Disaster Prevention Weather Lecture, Nankai Trough, Mount Fuji Eruption... The Worst-Case Scenario, Hiroki Kamata, Osaka Stratum Exploration from the Perspective of Earthquake Archaeology 1 "History of Nankai Trough Megathrust Earthquakes", Akira Samukawa, Science Council of Japan Sponsored Symposium (9th), <Additional Unreleased Footage> Preparing for the Nankai Trough Earthquake (JAMSTEC).

Chapter 7 Closing

Inclusive Recovery: Supporting the Most Vulnerable

Effective disaster response in an aging society necessitates specialized welfare facilities and robust community support to protect the health and well-being of its most vulnerable members.

Post-disaster health risks are exacerbated for the elderly and disabled, with issues ranging from life-threatening interruptions for those reliant on medical equipment to serious health declines in cramped, inadequate shelters. The development of "welfare evacuation centers" provides crucial specialized medical care, nutritious meals, and psychological support, while community initiatives help integrate vulnerable individuals, promoting social engagement and vitality during recovery.

Welfare Centers

Chapter 8 Opening

Chapter 8: Earthquakes Recorded in Ancient Records

Voices from the Past: Historical Seismology

> Ancient Japanese records serve as invaluable historical seismological data, providing critical context for understanding modern seismic risks.

Before the advent of seismometers, events like the 869 Jōgan earthquake were meticulously documented in official histories, aristocratic diaries, and local temple records, offering descriptions of ground cracking, sand eruptions, and tsunamis that bear striking resemblances to the 2011 Tohoku disaster. Historical seismology integrates these textual accounts with geological evidence, such as tsunami deposits and liquefaction traces, to reconstruct past earthquake patterns and magnitudes, uncovering events not explicitly recorded.

869 Jōgan Earthquake

Chapter 8: Earthquakes Recorded in Ancient Records

Ancient Manuscripts and Disaster Records

Even in an era without seismographs, the people of Japan left written records of the moments the ground shook. Diaries of nobles, official government documents, and ancient manuscripts preserved in temples and villages served this collective purpose. In the Nihon Sandai Jitsuroku (The True History of Three Reigns of Japan), which recorded the 869 Jogan earthquake, a passage remains: "People could not stand, buildings collapsed, the ground cracked with loud noises of erupting sand, and the land turned into sea, killing more than 1,000 people." This description shares many parallels with the damage patterns of the 2011 Great East Japan Earthquake, serving as a prime example of how ancient records offer tangible clues for modern earthquake research.

Records of the 1361 Shohei Nankai earthquake survive in the Banki, preserved at Horyu-ji temple, and in the Taiheiki. The Taiheiki notes that a massive tsunami struck the port of Yuki in Awa, submerging countless houses under the sea, and that after the sea off Namba temporarily receded dry, another tsunami surged in, claiming the lives of hundreds of fishermen. In Minami Town, Tokushima Prefecture, a stone monument erected in 1380 listing the names of tsunami victims still stands today, considered the oldest surviving inscription detailing tsunami damage from a Nankai Trough earthquake. Around the time of the 1596 Keicho-Fushimi earthquake and the 1854 Ansei Great Earthquakes, the extent of damage was detailed even in the diaries and letters of both nobles and commoners. During the Ansei Nankai earthquake, records note that the ground shook in the middle of a sumo match in Kochi Prefecture, causing widespread chaos. During the 1923 Great Kanto Earthquake, the Architecture Section of the Security Department under the Tokyo Metropolitan Police Department compiled collapse rates of wooden houses across Tokyo and even surveyed the ratio of overturned gravestones, using the data to reconstruct seismic intensity distribution.

The field of study that collects such materials to trace the timing, magnitude, and damage patterns of past earthquakes is known as historical seismology. Traces from eras where written records are lacking are sought underground. Earthquake archaeology, which confirms the existence of earthquakes by excavating sand dikes formed by liquefaction or ground fissures, gained its name in 1988 and established itself as an independent research discipline. However, records become scarcer the further back in time one goes, and earthquake accounts were often omitted depending on the purpose, as in domain governance records of daimyo families. The concentration of data in records from political centers also remains a challenge to overcome. To bridge these gaps, the Earthquake Research Group at Kyoto University launched a citizen science project called Minna de Honkoku (Transcribing Together). In this project, citizens transcribe cursive old script character by character into modern text, though the actual work relies heavily on a small number of dedicated participants.

Sources for This Chapter

- Nihon Sandai Jitsuroku, records of the 869 Jogan earthquake [EARTHQUAKE, The 62nd TIEC Cross-Cultural Seminar]

- Taiheiki, Banki, records of the 1361 Shohei Nankai earthquake [地震講座第2回, 寒川旭]

- 1380 Minami Town tsunami monument [Digital Scholarship in the Study of Historical Japanese Earthquakes]

- SRC-PDF-019, Study on historical sources of the 15th century Sagami Trough earthquake

- SRC-PDF-026, Status of historical seismology in Japan

- SRC-PDF-014·125, Study on the seismic intensity distribution of the 1923 Kanto earthquake

- 「「みんなで翻刻」にみる歴史地震研究への非専門家の参加」加納靖之, 2019

- Ansei Nankai Earthquake, 宇宙のすべての知識 プリンシピア

Kawaraban and Information Dissemination

When the earthquake struck on March 11, 2011, the Japan Meteorological Agency issued a tsunami warning in just three minutes. However, the initially announced earthquake magnitude was M7.9, a figure far below the actual M9.0. It was not until 28 minutes later that the predicted tsunami height was revised upward. Immediately after the event, the media focused on disaster coverage, with front pages of newspapers on March 12 featuring prominent photographs of tsunami damage in Natori City. As time passed, the focus of coverage shifted from the earthquake and tsunami to the Fukushima nuclear accident, and after two to three weeks, the number of articles on the nuclear accident exceeded those on the earthquake and tsunami. The French newspaper Le Monde focused on the indirect impacts of the nuclear accident rather than Japan's direct damage, while China's Wen Hui Bao reported on specific circumstances such as emergency generator failures and hydrogen explosions. Different countries, in effect, interpreted the same disaster from different angles.

When information broke down, human lives were also lost. Immediately following the 1923 Great Kanto Earthquake, false rumors spread rapidly claiming that "Koreans are poisoning wells and committing arson." Believing these rumors, vigilante groups led a massacre in which Japanese citizens killed and buried as many as 6,000 Koreans. Government records at the time stated that the military and police worked to suppress the rumors, but documents discovered later revealed circumstances indicating that the military actually aided and carried out the massacres. Even as the government issued an imperial edict for relief efforts, it mobilized the military and police to handle the "Korean issue" and established a temporary relief office.

People of the Edo period also shared news in their own ways. Woodblock-printed kawaraban were media broadsheets that carried illustrations and rumors related to earthquakes, and namazu-e (catfish prints), which will be examined in the next chapter, also spread widely through these kawaraban. Nagoya University Library currently provides digital access to prints of these kawaraban with their original vivid colors preserved. The power to manage information carries equal weight today. Displaced residents met in evacuation centers recalled realizing that the media "does not always report 100 percent accurately" and said they learned to discern and evaluate information for themselves. Early warnings from earthquake alert apps such as Yurekuru Call can also carry significant initial margins of error, making it necessary to form a habit of continuously verifying follow-up information.

Sources for This Chapter

- SRC-PDF-065, NEWSPAPER REPORTS ON EAST JAPAN GREAT EARTHQUAKE IN FOUR COUNTRIES

- Kyoto University Symposium Series, Practical Seismology: Warning of Earthquakes Before the Shaking, Masumi Yamada [京都大学シンポジウムシリーズ, 実用地震学：揺れる前に地震を知らせる, 山田真澄]

- Japan Geoscience Union Meeting 2021, Kenji Satake, "Progress of Research on Earthquakes and Tsunamis in the 10 Years Since the Great East Japan Earthquake" [日本地球惑星科学連合2021年大会, 佐竹健治「東日本大震災から10年間の地震・津波に関する研究の進展」]

- Japan's Crimes: Kanto Earthquake Massacre, Documentary English Subtitles(1997)

- "100 Years Since the Great Kanto Earthquake" (3) On the Survey of Survivors and Deceased, Itoko Kitahara, 2023 [「関東大震災100年」(3) 生存者と死亡者の調査について, 北原糸子, 2023]

- "Non-expert Participation in Historical Earthquake Research as Seen in 'Minna de Honkoku'" Yasuyuki Kano, 2019 [「「みんなで翻刻」にみる歴史地震研究への非専門家の参加」加納靖之, 2019]

- Learning Earthquake Measures from History: Focusing on the Ansei Great Earthquakes [Earthquake Measures Learned from History: Focusing on the Ansei Great Earthquakes]

- SRC-PDF-028, Mental Health and Support of Evacuees and Returnees after the Nuclear Disaster in the Great East Japan Earthquake and the Role Played by the Media [SRC-PDF-028, 東日本大震災における原子力災害後の避難者・帰還者のメンタルヘルスと支援およびメディアの果たした役割]

Chapter 8 Closing

Preserving Narratives: Community and Information

The collaborative preservation and analysis of historical records, including citizen-led initiatives, are crucial for comprehensive disaster understanding and public awareness.

Citizen science projects, such as "Minna de Honkoku" (Everyone Transcribes), actively engage the public in deciphering old handwritten documents, making historical disaster accounts accessible and fostering local awareness of past events. The critical evaluation and dissemination of information, even through historical mediums like "kawaraban" (woodblock prints), are continuous efforts to empower communities to make informed decisions in the face of natural hazards.

Minna de Honkoku

Chapter 9 Opening

Cultural Responses: Living with Fear

Japan's long history of earthquakes has fostered unique cultural and spiritual expressions to cope with the fear and uncertainty of seismic events.

The "Namazu-e" (catfish pictures) tradition, particularly popular after the 1855 Ansei Edo earthquake, depicted a giant catfish as the cause of earthquakes, often being restrained by the deity Kashima-Daimyojin. These artistic representations functioned as talismans and morale boosters, embodying a deep-seated cultural recognition of living alongside seismic activity and providing a mechanism to manage fear and maintain daily life.

Namazu-e

Chapter 9 How to Live with Fear

Namazu Worship

What people believed to be the cause of earthquakes varied from era to era. During the Kamakura period, it was believed that a giant dragon coiled around the Japanese archipelago thrashing its body caused the ground to shake. Entering the Edo period, a giant catfish—the namazu—took over this role. When the keep of Fushimi Castle collapsed during the Keicho-Fushimi earthquake of 1596, people began to wonder, "Could there be a connection between the namazu and earthquakes?" This was because the namazu, ordinarily a nocturnal fish, was observed thrashing violently in the water during the daytime right before an earthquake occurred. Although the namazu is indeed sensitive to electrical stimulation, considering that sharks or eels are even more sensitive, tying earthquakes specifically to catfish was an imagination unique to Japanese culture.

This imagination gained immense popularity following the 1855 Ansei Edo earthquake through woodblock prints known as namazu-e. In the center of these prints was a giant catfish, with a figure depicting Kashima Daimyojin—the god of Kashima, known as the deity of earthquakes—subduing it from above. At Kashima Shrine in Kashima City, Ibaraki Prefecture, lies a sacred stone called kaname-ishi, which was believed to pin down the underground catfish and prevent earthquakes. The geographical condition of Kashima City, situated along a coast where the Pacific Plate subducts and thus prone to frequent earthquakes, seems to have provided the backdrop for this belief to take root. Namazu-e did not merely depict the causes of earthquakes. They frequently employed the mitate technique, which reinterpreted disasters through contemporary cultural codes—such as prints portraying an earthquake and thunder competing in sumo with Kashima Daimyojin acting as referee. Some prints even satirized merchants carrying loads of rice sacks through ruined residential areas, sharply reflecting those who pursued profit even amidst calamity.

Sold like talismans, namazu-e provided people with peace of mind and inspired the courage to rebuild together. In a land with a deep-rooted awareness of living alongside earthquakes, symbols like Kashima Daimyojin and the kaname-ishi served as cultural devices for coping with fear and continuing daily life. The way people today check earthquake alerts on smartphones to assess information is, though different in form, no different from the people who created namazu-e in their desire to protect themselves before an unpredictable nature.

Sources for This Chapter

- 【EARTHQUAKE】The 62nd TIEC Cross-Cultural Seminar〈The History of Japan Shaped by Earthquakes〉
- 【Earthquake】The 62nd Tokyo International Exchange Center International Seminar〈The History of Japan Shaped by Earthquakes〉
- 2017/11/23 "Short-term Earthquake Prediction and Disaster Prevention System" Toshiyasu Nagao, Tokai University Institute of Oceanic Research and Development
- Osaka Strata Exploration 1 from the Perspective of Earthquake Archaeology, Akira Sangawa, 2018
- Shin Osaka-gaku Koto-hajime: "Japanese History of Earthquakes—Focusing on Kansai" Part 1
- 【For Sleep】A Summary of the History of Great Earthquakes

Places of Remembrance and Memory

At Taisho Bridge and Shitenno-ji in Osaka, there stand tsunami monuments erected in 1855. The inscription, "Record of the Tsunami at the Two River Mouths during the Great Earthquake," records that 350 people lost their lives to the tsunami caused by the 1854 Ansei Nankai earthquake. In 1707, when a tsunami struck the same location, many lives were lost while evacuating by boat; expressing regret over having forgotten that lesson, the inscription warns future generations: "Never evacuate by boat, no matter what." The characters on this inscription are repainted every year so they will not fade. Along with a 1380 stone monument in Minami Town, Tokushima Prefecture, such monuments served as a way across Japan to engrave the memory of tsunamis into stone and pass it on to the next generation.

A study surveyed 176 tsunami monuments along the coast of Iwate Prefecture. While 80 percent of the monuments erected after the 1896 Meiji Sanriku earthquake were memorial-type stones honoring the victims, 70 percent of those built after the 1933 Showa Sanriku earthquake shifted to lesson-type monuments containing specific directives, such as "Do not build houses below this point" or "If you hear of a tsunami, abandon your greed and flee." Notably, 73.9 percent of these stones were standing beyond the reach of the 2011 Great East Japan Earthquake tsunami, suggesting a strong likelihood that they served a practical function as evacuation targets. However, some point out that certain lesson-type monuments misdirected people to past inundation areas as evacuation points, potentially increasing danger, raising calls that monuments must be erected by considering the history of multiple tsunamis rather than a single event.

Stone monuments are not the only things preserving memory. The Ajiba Lodge Memorial Museum excavated the fault plane created during the earthquake to a depth of 4 meters and preserved it as is, allowing visitors to visually observe the shifted ground. In Ofunato City, Iwate Prefecture, Ibasho House became a community hub after the Great East Japan Earthquake where residents and visitors live together, focusing their minds not on "what was lost," but on "what can be gained." Shizugawa Elementary and Junior High Schools in Minamisanriku Town preserved the appearance of that day when the tsunami engulfed even their rooftops to convey the severity of the tragedy, while the site near the 1995 Kobe earthquake continues to remind visitors 30 years later that anywhere in a major city can be vulnerable to disaster. In Otsuchi Town, Iwate Prefecture, discussions are underway among residents to create a Forest of Requiem to honor the tsunami victims. In that the Great East Japan Earthquake struck just as generations were shifting after the Meiji and Showa Sanriku earthquakes, it serves as a case that questions anew how completely memory can be passed down to the next generation.

Sources for This Chapter

- 【Deepest Japan】Tsunami once reached Osaka in 10 minutes and swept people away after Nankai Trough Earthquake

- SRC-PDF-054, CONSIDERATION OF RELATIONSHIP BETWEEN TSUNAMI MONUMENTS TSUNAMI INUNDATION AREA AND HUMAN

- Kyoto University Disaster Prevention Research Institute 32nd Public Lecture, Yoshihisa Iio, "Earthquake Observation Supported by Local Citizens," 2021

- SRC-PDF-081, Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes

- 【3/11 (Thu) WEB Disaster Prevention Seminar】Confronting the Nankai Trough Megathrust Earthquake

- 【Deepest Japan】Earthquake Special: Kobe becomes heavily damaged area, 90% of deceased crushed to death at home

- SRC-PDF-113, Characteristics on Damages of 2011 Tohoku Tsunami in Iwate Coast

- Disaster Area Fukushima and Efforts for Passing Down Historical Culture

Chapter 9 Closing

Chapter 9 How to Live with Fear

Enduring Memory: Monuments and Lessons

Disaster monuments and collective memory play a critical role in educating future generations about past calamities and the importance of preparedness.

Tsunami monuments, such as the one in Osaka commemorating the 1854 Ansei Nankai earthquake, serve as stark reminders of past tragedies and explicitly warn against repeating mistakes, like seeking refuge by boat during a tsunami. Over time, these monuments evolved from purely commemorative stones to educational tools, providing practical instructions like "Do not build homes below this point," though their accuracy and effectiveness require continuous re-evaluation.

Tsunami Monuments

Chapter 10 Opening

Chapter 10: Those Who Preserve and Share Records

Preserving the Past: Disaster Archives

Comprehensive archiving of disaster data, encompassing historical documents, modern scientific records, and personal narratives, is vital for long-term preparedness.

Modern archives manage petabytes of seismic data, while initiatives like the "Minna de Honkoku" project digitize and translate thousands of historical documents, making past disaster records accessible for research and public engagement. Oral histories from affected communities, including children's drawings, capture the profound human impact of disasters, providing crucial insights that complement scientific data.

Petabytes

Chapter 10: Those Who Preserve and Share Records

Preservation of Photographs, Videos, and Testimonies

Just ten years ago, moving 300 gigabytes of earthquake data was something researchers could hardly dare to attempt; today, that information has been transformed into accessible material that flows freely within a one-petabyte archive. Work to transfer historical earthquake records into geographic information systems has also continued, including research that compiled 1,500 earthquake damage reports from 21 literature sources, identified the locations of 100 points among them, and structured them into data tables. The Minna de Honkoku project has run for more than 1,000 days since 2017, transcribing over 6.18 million characters from nearly 9,000 images, with around 8,200 of those images fully transcribed. However, because much of the transcribed material can only be viewed after logging in, researchers are searching for ways to make it as easily accessible to anyone as 'reading material on past disasters.'

The hands that preserve records do not stop at written documents. In Obuchihama, Ishinomaki City, interviews spanned several years, listening to elderly residents in their eighties about the history of the area and its fisheries, and to young fishermen about their lives after the disaster. To avoid forgetting those who were lost, survivors told stories to children and had them draw pictures; the children depicted the Great East Japan Earthquake tsunami not in the actual color of the sea, but in black like dark storm clouds or deep navy blue. These drawings vividly revealed the heavy weight the disaster had left on their hearts. At Ukedo Elementary School in Fukushima, almost all records were swept away by the tsunami, but water did not penetrate the principal's safe, preserving intact the school and community documents from the Meiji era to the Heisei era. Akasaki Hotto House in Ofunato City, Iwate Prefecture, serves as a welfare shelter replacing an aging community center and as a hub for local activities, created with resident participation from the design stage.

Privately held materials scattered throughout the region cannot be overlooked either. In the process of researching the history of Shimizu Port, a considerable amount of material was gathered in Shimizu City, yet a non-negligible number of documents—such as the Sawanogata documents—remain in private homes. Because of issues surrounding successors, there are moves to dispose of such materials, making continuous effort to discover and protect them essential. In Fukushima, even relatively recent materials—such as local newsletters or newspaper advertisements from just before the nuclear accident—are treated and preserved as valuable historical documents.

Sources for This Chapter

- 2017/11/23 "Short-Term Earthquake Prediction and Disaster Prevention System" Toshiyasu Nagao, Tokai University Institute of Oceanic Research and Development

- Digital Scholarship in the Study of Historical Japanese Earthquakes

- Symposium "Japan and Asia as Seen from the History of Shimizu Port"

- "Non-Expert Participation in Historical Earthquake Research as Seen in 'Minna de Honkoku'" Yasuyuki Kano, 2019

- SRC-PDF-040, Traces of the Great East Japan Earthquake Field Survey: Encounter with Obuchihama, Ishinomaki City

- [Live Stream] Children Who Listened to Vivid Personal Experiences of the Earthquake Disaster

- [Video Record] 15 Years Since the Great East Japan Earthquake: Prayers of Iwate, Miyagi, and Fukushima

- SRC-PDF-081, Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes

- Disaster-stricken Fukushima and Initiatives to Hand Down Historical Culture

Collaboration Between Experts and Citizens

Researching earthquakes is not the sole domain of professional researchers. Whether studying the recovery from the great fire in the Oshima area or filling in scarce records from the Fukushima nuclear disaster zone, researchers treated local residents not as subjects of study, but as colleagues working alongside them. In the Toni area of Kamaishi City, Iwate Prefecture, a volunteer group called 'Association for Telling Kamaishi's History' conducted questionnaires and hearing surveys, recording for themselves how residents perceived past tsunami damage, why they built houses in those locations, and how their lives changed after recovery projects. There are also observation projects in which citizens directly installed earthquake monitoring equipment and maintained observations for nearly 15 years, demonstrating that citizen science forms a pillar of academic inquiry rather than lingering on its periphery.

Although 5,322 people registered for the Minna de Honkoku project, the actual deciphering work relies heavily on a small number of dedicated participants. Even so, some participants took this activity as an opportunity to develop an interest in the disaster history of their own regions, making the deciphering work itself a channel for learning. Conveying knowledge accurately is another face of collaboration. It is necessary to make clear that a Nankai Trough earthquake "will definitely happen," and to emphasize that because its timing is unknown, one must always be prepared. It must also be candidly communicated that tsunamis differ from ordinary waves in both their mechanism of origin and energy scale, and that moving everyone to safety within a short evacuation window can be difficult. A volunteer in Miyagi Prefecture remarked, "No matter where you are, it is truly important to remain constantly aware of how to respond if a disaster occurs," emphasizing that the saying "if you are prepared, there is no worry" becomes a force that genuinely saves lives.

In Minami Town, residents create 'My Cards' to fill in their evacuation routes and timing, sharing hazard maps within the community and discussing recovery plans long before a disaster strikes. The police also state, "Police power alone cannot accomplish everything; cooperation with the private sector is required to generate greater strength." Each time expert knowledge meets the hands and feet of citizens, disaster preparedness grows thicker, step by step.

Sources for This Chapter

- SRC-PDF-040, Traces of the Great East Japan Earthquake Field Survey: Encounter with Obuchihama, Ishinomaki City

- Disaster-stricken Fukushima and Initiatives to Hand Down Historical Culture

- SRC-PDF-007, Examining Causes of Dwellings in the Lowlands

- SRC-PDF-081, Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes

- Kyoto University Disaster Prevention Research Institute 32nd Open Lecture, Yoshihisa Iio, 15 Years of the Manten Project

- "Non-Expert Participation in Historical Earthquake Research as Seen in 'Minna de Honkoku'" Yasuyuki Kano, 2019

- The Nankai Trough Megathrust Earthquake That Will Definitely Occur

- [3/11 (Thu) Web Disaster Prevention Seminar] Confronting the Nankai Trough Megathrust Earthquake

- Rear Camera Footage: Challenges Surrounding Responses to a Tokyo Metropolitan Earthquake, Focusing on Public-Private Partnership

Chapter 10 Closing

Collaborative Preparedness: Experts and Citizens

Effective disaster preparedness stems from a strong collaboration between scientific experts, administrative bodies, and informed citizens, translating knowledge into actionable community practices.

Researchers increasingly engage residents as active partners in disaster recovery studies, leading to community-led initiatives such as surveys on tsunami perception and citizen-driven earthquake monitoring programs. Educational efforts are designed to convey the inevitability of events like the Nankai Trough earthquake, focusing on preparedness over prediction, and promoting information literacy and critical thinking across all generations.

Citizen Science

Chapter 11 Opening

Chapter 11: Beyond the Unforeseen

Confronting "Soteigai": Failed Assumptions

The 2011 Tohoku earthquake revealed critical flaws in Japan's long-standing disaster assumptions and existing response systems.

Initial tsunami warnings and earthquake magnitude estimations for the 2011 Tohoku event were severely underestimated (M7.9 predicted vs. M9.0 actual), rendering existing coastal defenses inadequate against the unprecedented scale of the tsunami. Fragmented administrative responses, outdated building codes, and the vulnerability of critical infrastructure like nuclear power plants to unforeseen disaster magnitudes exacerbated the devastation.

Underestimated Magnitude

Chapter 11: Beyond the Unforeseen

Failed Assumptions

The 2011 Great East Japan Earthquake shattered the very premises of the disaster prevention system Japan had built up over many years. The Japan Meteorological Agency issued a tsunami warning just three minutes after the earthquake struck, but the initial magnitude was announced as M7.9, falling far short of the actual M9.0. Based on this prediction, tsunamis of 3 meters for Iwate Prefecture, 6 meters for Miyagi Prefecture, and 3 meters for Fukushima Prefecture were anticipated, yet the actual tsunami exceeded 10 meters. It was only after two days had passed that the earthquake magnitude was finalized as M9.0. Along the Sanriku Coast stood 10-meter-high seawalls built based on the massive tsunamis of 1896 and 1933, whereas the seawalls along Sendai Bay and the Joban Coast had been built much lower—at around 6 meters—taking storm surges as their benchmark. Neither seawall could withstand the force of an M9.0-class tsunami. Possessing a force fundamentally different from ordinary waves, a tsunami can obliterate entire wooden houses when its height reaches 2 meters, and even currents a few tens of centimeters deep can sweep a person away.

There were also points where administrative coordination faltered. Even for a single project to relocate to higher ground, the Ministry of Land, Infrastructure, Transport and Tourism and the Ministry of Agriculture, Forestry and Fisheries directed the work under different laws and regulations, adding to the confusion on the ground. At a moment when higher-level authorities such as the national government or prefectures should have gathered information quickly and handled necessary local adjustments, placing procedures and regulations first resulted in delayed responses. Building safety was no exception. During the 1995 Great Hanshin-Awaji Earthquake, roughly 90 percent of the victims lost their lives inside their homes, crushed under buildings. Older wooden homes that failed to meet the new seismic standards established in 1981 were at the core of this tragedy. Critics also point out an optical illusion: even if figures for seismic reinforcement rates appear high on the surface, the actual danger hiding behind them is far greater. Even in bustling commercial districts like Ginza in Tokyo, buildings remain with seismic performance reaching only half the current standards. At the Fukushima Nuclear Power Plant, emergency diesel generators lost functionality due to the earthquake and tsunami, leading to hydrogen explosions; around the Wakasa Bay nuclear power plants, seismic ground motion reached 2,000 gal, far exceeding the design basis of 800 gal. The fact that nuclear power plants line areas densely packed with active faults remains in itself a heavy assignment.

Sources for This Chapter

- SRC-PDF-045, Evaluasi Kegagalan Sistem Mitigasi Tsunami Studi Kasus Tohoku 2011

- 京都大学春秋講義, 清野純史「平成の地震災害を振り返る」2019

- 日本地球惑星科学連合2021年大会, 佐竹健治「東日本大震災から10年間の地震· 津波に関する研究の進展」

- SRC-PDF-012, Inundation areas and deposits of the 2011 off the Pacific coast of Tohoku and the 869 Jogan

- SRC-PDF-063, Fundamental Characteristics of Tsunami and Tsunami Disaster due to The 2011

- SRC-PDF-013, ISSUES OF ORGANIZATION AND LAW REGULATION OF MASSIVE EARTHQUAKE AND TSUNAMI DISASTER

- 【最深日本】地震特輯, 神戶成重災區死者中9成在家中遭壓死
- 『若狭湾原発震災』前夜の私たち, 地震学者· 石橋克彦さん

Flexible Response Systems

There was a time when people assumed a similar earthquake would recur in the near future. The 2011 Great East Japan Earthquake struck on a scale far surpassing those assumptions, leaving behind the awareness that we must now consider every scenario and maximum magnitude that science can conceive. A Nankai Trough earthquake is considered likely to occur with a probability of 70 to 80 percent, at magnitudes ranging from M8 to M9.1. Earthquakes do not arrive alone. The 1707 Hoei eruption occurred 49 days after a massive earthquake, suggesting the possibility that the Nankai Trough earthquake disturbed Mount Fuji's magma chamber and triggered the eruption. Immediately after the Great East Japan Earthquake, 20 percent of Japan's volcanoes showed signs of entering eruptive activity. Following the Great East Japan Earthquake, Japan established a two-tiered tsunami concept designated as L1 and L2. L1 tsunamis, occurring once every few decades to 100 years, are to be held back by hard infrastructure such as seawalls, whereas L2 tsunamis, occurring roughly once every 1,000 years, are deemed impossible to block with physical structures alone, prompting efforts to minimize loss of life through soft measures like land-use regulations and rapid evacuation. Plans are even under consideration to prohibit residency altogether in areas inundated by more than 2 meters during an M9.0-class earthquake.

Preparation exerts its strength only when repeatedly ingrained into one's body. If a Nankai Trough earthquake occurs, external aid such as the Self-Defense Forces may not arrive right away, so individuals are advised to maintain at least a seven-day supply of provisions. At Nakashima Glass Industry, workers repeatedly drill to evacuate outdoors within 20 to 30 seconds whenever an earthquake warning sounds via the "Digital Namazu" system. The response manual of the Tokyo Metropolitan Government has also evolved over time. Previously, it required 10 percent of staff to report to the scene within one hour, but now, if an earthquake of seismic intensity 6 or 7 or higher occurs, whoever is already on site must respond immediately. An attitude such as "I will evacuate after the teacher asks the Board of Education" is cited as the posture to be avoided most when facing a tsunami. This means that people on the scene must be capable of making decisions ahead of the manual. Some also point out that because disaster response headquarters are strictly defined by law, flexibility may actually suffer, sparking discussions that organizations with lighter rules—such as an information task force—can operate more effectively.

Sources for This Chapter

- 03南海トラフの巨大地震と津波, 橋本学, 京都大学防災研究所公開講座第25回
- 【Japanese podcast】Be Prepared! Nankai Trough Earthquake & Mt. Fuji Eruption
- 【基調講演】鎌田浩毅「大地変動の時代」に地震· 火山· 気象災害のハザードをどう避けるか
- 日本学術会議主催シンポジウム(第9回)前半
- 牧紀男「南海トラフ地震災害からの復興を考える」京都大学防災研究所公開講座20201005
- 南海トラフ巨大地震講演会, How to Prepare for the Nankai Trough Earthquake
- 2017/11/23「地震短期予測と防災体制」長尾年恭, 東海大学海洋研究所

- 東日本大震災と南海トラフ地震の接続点, 2020年9月9日

Chapter 11 Closing

Chapter 11: Beyond the Unforeseen

Adaptive Response: Learning from Catastrophe

Moving beyond "Soteigai" demands flexible, multi-layered disaster mitigation strategies, proactive community training, and continuous adaptation.

Following Tohoku, Japan adopted the L1/L2 tsunami concept: L1 tsunamis are addressed by hard infrastructure, while rare L2 tsunamis, which cannot be fully contained by facilities, necessitate comprehensive land-use planning and rapid evacuation to minimize casualties. Disaster training now prioritizes on-site judgment over rigid manuals, and individual preparedness emphasizes having at least a 7-day supply of essentials, acknowledging that external aid may be delayed in large-scale events.

L1/L2 Concept

Chapter 12 Opening

Chapter 12: Preparing for the Next Generation

Empowering the Future: Education and Judgment

Effective disaster education empowers the next generation with critical thinking and adaptability for real-time response.

The independent evacuation of Kamaishi Higashi Junior High School students during the 2011 tsunami, without waiting for instructions, highlights the crucial importance of on-site judgment beyond strict manuals. Disaster drills are evolving to include diverse scenarios like aftershocks and power outages, encouraging individual critical thinking and mutual aid among students to prepare for complex real-world situations.

On-Site Judgment

Chapter 12: Preparing for the Next Generation

Schools and Community Education

On March 11, 2011, students at Kamaishi Higashi Junior High School in Kamaishi City, Iwate Prefecture, did not wait for instructions from their teachers. They took the initiative to evacuate, holding the hands of nearby elementary school pupils as they ran together toward higher ground. As a result, every single student survived. By contrast, Okawa Elementary School had been designated a wide-area evacuation site, attracting local residents as the tsunami approached. The faculty, preoccupied with responding to residents and arranging for the children to return home, delayed their own evacuation, leading to the tragic loss of both staff and students. The contrasting fates of these two schools demonstrate the vital weight of making on-the-spot decisions rather than remaining trapped by manuals. Taking this lesson to heart, school disaster drills are changing. Where training once emphasized simply exiting buildings, current drills incorporate diverse scenarios—such as aftershocks, power outages, and waiting indoors—encouraging individual students to think for themselves about what to do and whether anyone nearby requires help.

In Hokkaido, a tsunami evacuation drill was conducted with participants equipped with GPS tracking devices. All participants who evacuated within five minutes of the earthquake reached safety, but as delays reached 10, 15, and 20 minutes, the number of individuals caught in the tsunami rose sharply. The study revealed that people with mobility impairments evacuated at half the speed of average individuals, while pregnant women saw their speed reduced by about 20 percent, underscoring the need for drills that practice assisting those nearby. Because even designated evacuation sites can become dangerous due to fires or blocked roads, it is safer to select multiple locations in advance. Residents of Minami Town wrote their evacuation routes and timing on personal cards, ensuring every family member knew their exact responsibilities. During the crucial 72 hours following a disaster—when professional rescue operations by the fire department, police, and Self-Defense Forces cannot immediately reach everyone—self-reliance to protect oneself and mutual assistance with neighbors become the decisive forces for survival.

Sources for This Chapter

- SRC-PDF-052, School education for disaster risk reduction in Japan after the 2011 Great East Japan Earthquake

- 【Urgent Warning】 Recurrence of the Same Earthquake Pattern as March 11, 2011, Urban Legend 999

- 【March 11 (Thu) Web Disaster Prevention Seminar】 Confronting the Nankai Trough Megathrust Earthquake

- FY2022 Hokkaido Disaster Prevention Meteorological Lecture, Megathrust Earthquakes along the Japan Trench and Kuril Trench and Disaster Prevention Measures

- Nankai Trough Megathrust Earthquake Lecture, How to Prepare for the Nankai Trough Earthquake

- SRC-PDF-081, Current Status and Challenges of Community Formation in Areas Affected by Large-Scale Earthquakes

- Japan, Country of Earthquakes and Volcanoes, Masanori Ueno, Hyogo Inamino Gakuen

Connecting Science and Administration

Seismographs do not move before an earthquake strikes. With current science and technology, accurately predicting the exact time, location, and magnitude of an impending earthquake in the short term remains impossible. Instead, seismologists focus their efforts on long-term forecasts spanning decades. These long-term projections serve as the essential foundation for preparing time-intensive measures, such as seismic retrofitting and sea wall construction. Communicating risk to the public presents another hurdle. Academically precise expressions like 'an 80 percent probability within 30 years' often fail to spur people into action. For this reason, some scholars argue that risk should be communicated in 'language that the public can understand and act upon, even if it might be scientifically imprecise.' This explains why the Japan Association for Earthquake Engineering puts extensive effort into outreach programs designed to plant research findings firmly into society rather than confining them to academic papers.

The experience of 2011 altered the core direction of disaster management in Japan. The center of gravity shifted from 'disaster prevention'—attempting to block damage entirely—to 'disaster mitigation,' which accepts the reality that while loss of human life must be prevented at all costs, property damage may be unavoidable. The integration of Level 1 (L1) and Level 2 (L2) tsunami concepts into policy grew out of this shift. Following the 1995 Great Hanshin-Awaji Earthquake, the Headquarters for Earthquake Research Promotion was established to lead programs aimed at reducing earthquake damage by bridging pure science and social sciences. Under the Ministry of Education, Culture, Sports, Science and Technology (MEXT), the Nankai Trough Earthquake Project brings together numerous universities and research institutions to analyze diverse damage scenarios and assist corporations in formulating business continuity plans. Only when the roles split among researchers, administrators, and citizens align into a unified effort does knowledge translate into tangible preparation.

At its 107th Assessment Committee meeting held on July 7, 2026, the Japan Meteorological Agency stated that no distinct anomalies indicating an imminent major earthquake around the Nankai Trough had been observed. Nevertheless, pointing out that nearly 80 years have passed since the Showa Tonankai and Showa Nankai earthquakes, officials emphasized the necessity of maintaining a constant sense of urgency in preparation. The Headquarters for Earthquake Research Promotion raised its estimate of the probability of a Nankai Trough earthquake occurring within 30 years from 60 to 70 percent in January 2013 to approximately 80 percent (Rank III) as of January 2025. On August 8, 2024, the government issued its first-ever 'Nankai Trough Earthquake Extra Information (Major Earthquake Advisory).' This system is not designed to predict the future, but rather to evaluate heightened risk following an observed seismic event and advise society to exercise caution.

Sources for This Chapter

- 2011/07/24(3) Great East Japan Earthquake Forum, Yukinobu Okamura "Reproduction of the Jogan Tsunami", Masateru Murosaki "The Great Hanshin Earthquake, the Great East Japan Earthquake, and Urban Disaster Prevention"

- "Japan's Dynamic Land and Earthquakes", Kyoto University–Inamori Foundation Joint Kyoto Prize Symposium, Takuya Nishimura, 2025

- 【Bound to Strike in the 2030s】 The Worst-Case Nankai Trough Scenario: 300,000 Deaths from a 34-Meter Tsunami, Hiroki Kamata

- Japanese Earthquake Researches for Seismic and Tsunami Disaster Risilience

- Tokai Region Disaster Mitigation Research Consortium 13th Symposium, Nobuhisa Hirayama, Nagoya University

- Science Council of Japan Sponsored Symposium (9th) First Half

- Japan Meteorological Agency, Nankai Trough Earthquake Information, https://www.data.jma.go.jp/eew/data/nteq/index.html

- Japan Meteorological Agency, August 8, 2024 Nankai Trough Earthquake Extra Information, https://www.jma.go.jp/jma/press/2408/08e/202408081945.html

- Headquarters for Earthquake Research Promotion, Earthquakes in the Nankai Trough, https://www.jishin.go.jp/regional_seismicity/rs_kaiko/k_nankai/

- Headquarters for Earthquake Research Promotion, Overview of the Long-Term Evaluation of the Nankai Trough, https://www.jishin.go.jp/main/chousa/25sep_nankai/nankai_gaiyou2_3.pdf

Turning Memory into Knowledge

Records accumulate in three distinct layers: ancient documents and letters; physical traces embedded in the earth, such as tsunami deposits and evidence of soil liquefaction; and real-time modern data transmitted from roughly 1,300 GPS observation stations alongside seafloor monitoring networks. Reliable historical accounts trace back approximately 400 years, with ancient capitals like Kyoto and Nara preserving records from 1,200 to 1,300 years ago, whereas Hokkaido's documentation largely dates only from the Edo period onward. Because the depth of memory varies by region, constructing a vision of the future based on records from a single location inevitably leaves blind spots. The MEXT Nankai Trough Project is developing real-time societal prediction models that overlay big data, such as power consumption patterns, onto earthquake damage assessments. Meanwhile, NHK and Oita University are connecting past disaster records to modern language through the Oita Prefecture Disaster Data Archive.

Accumulated records gain true force only when filtered through education. Disaster prevention training for elementary and junior high school students is vital, complemented by ongoing efforts to convey concepts to high schoolers through accessible media such as animation. Warnings carved into tsunami stone tablets—such as 'Do not build houses below this point'—serve as conduits for instilling a sense of crisis in generations that have never experienced a major tsunami. Information literacy—the ability to discern fact from fiction while recognizing that media coverage is not always 100 percent accurate—forms another crucial pillar of education. Engaging children by sharing disaster stories and encouraging them to draw pictures helps etch a deeper message into their minds: that confronting thoughts of mortality can empower one to live more resiliently. Discussing disasters at the dinner table and teaching children how to secure furniture represent small, practical steps that transform knowledge into everyday habits.

The ultimate stage to which records and education lead is action. Mindsets like 'preparedness prevents worry,' stockpiles for at least seven days, and pre-arranged family evacuation plans mark the first step. Further preparation involves school evacuation drills, workplace training, and addressing seasonal risks, such as those accompanying winter. On the policy and infrastructure fronts, this action is reinforced by the shift toward disaster mitigation, tsunami measures split into L1 and L2, corporate business continuity plans, and industry-academic-government-civil collaboration. The reality that aftershock activity can persist for more than a century—even a decade after March 11—reminds us that human time and nature's time flow along different scales. Transforming memory into knowledge, and that knowledge into ingrained readiness, is not a task completed by a single generation; it is a continuous responsibility to be carried forward until the next earthquake arrives.

Sources for This Chapter

- 2011/07/24(3) Great East Japan Earthquake Forum, Yukinobu Okamura "Reproduction of the Jogan Tsunami"

- SRC-PDF-009, Researches on the tsunami deposits along the Nankai Trough

- SRC-PDF-039, The Japanese tsunami deposit researches

- Digital Scholarship in the Study of Historical Japanese Earthquakes

- Japan Geoscience Union 2021 Meeting, Kenji Satake "Progress in Earthquake and Tsunami Research in the 10 Years Since the Great East Japan Earthquake"

- Disaster Prevention Research Institute, Kyoto University 32nd Public Lecture, Yoshihisa Iio, 15 Years of the MANTEN Project

- Tokai Region Disaster Mitigation Research Consortium 13th Symposium, Nobuhisa Hirayama, Nagoya University

- The Inevitable Nankai Trough Megathrust Earthquake

- "Non-Expert Participation in Historical Earthquake Research as Seen in 'Minna de Honkoku'", Yasuyuki Kano, 2019

- 【Japanese podcast】Be Prepared! Nankai Trough Earthquake & Mt. Fuji Eruption

Chapter 12 Closing

Chapter 12: Preparing for the Next Generation

Continuous Preparedness: A Legacy of Resilience

> Sustained disaster preparedness requires an integrated approach that connects scientific insight, administrative policy, and deeply ingrained community practices across generations.

Long-term scientific predictions guide substantial infrastructure investments like seismic reinforcement, while communication strategies are tailored to translate complex probabilities into actionable advice for the public. Japan's policy shift from pure "disaster prevention" to "disaster damage reduction (genzai)" and the integration of L1/L2 tsunami concepts reflect a continuous commitment to learning and adaptation, ensuring that knowledge is translated into ingrained preparation for future generations.

Gen-zai

(減災)

Epilogue

The Japanese archipelago rests upon land where four tectonic plates push and pull against one another. On this land, people have experienced tremors large and small with their own bodies, from the 869 Jogan earthquake to the 1361 Nankai earthquake, the 1854 Ansei Great Earthquakes, the 1923 Great Kanto Earthquake, the 1995 Great Hanshin-Awaji Earthquake, and the 2011 Great East Japan Earthquake. In times before seismographs existed, diaries, official records, and old documents from temples and villages captured those moments; as time passed, sand dikes within geological strata and tsunami deposits testified in place of memory from eras without written records. The imagination of people who believed a giant catfish shook the earth, and the devotion of repainting stone inscriptions year after year, ultimately stemmed from the same heart: a desire to protect people and villages when disaster strikes again.

Science has added precise language to this spirit. Predicting the exact time, location, and magnitude of an earthquake days in advance remains impossible even today. While stating at the 107th Assessment Committee meeting in July 2026 that no distinct changes had been observed around the Nankai Trough, the Japan Meteorological Agency also pointed out that nearly 80 years have passed since the last megathrust earthquake of the Showa era. The Headquarters for Earthquake Research Promotion estimates the probability of an M8 to M9 class earthquake occurring within the next 30 years at Rank III, roughly 80 percent. In August 2024, the Nankai Trough Earthquake Extra Information was issued for the first time, and the earthquake that struck the Noto Peninsula in January of that same year prompted the Cabinet Office's verification team to act once more, carving new lessons into the 2025 Disaster Management White Paper. Predicting an exact date and explaining risk through the language of probability and preparedness are fundamentally different endeavors. More important than guessing an exact date is understanding the risk and turning that risk into everyday readiness.

That preparation was never left solely to the government or academia. The moment when students of Kamaishi Higashi Junior High School ran on their own without waiting for their teachers' instructions, the evening when residents of Minami Town wrote down evacuation routes on their 'My Card,' and the late-night hours when volunteers for the Minna de Honkoku project transcribed ancient scripts all point in the same direction. It is a continuous flow of keeping records, teaching those records, and translating what is taught into ingrained practice. The resolve under the banner of disaster mitigation to accept property loss as long as human lives are saved, tsunami countermeasures divided into L1 and L2, Business Continuity Plans, and industry-academia-research-government collaboration all rest upon this very flow.

Aftershocks continued for more than a decade after 3.11, and they may persist for more than a century to come. Human time is short, while nature's time is long. Safeguarding memory from weathering amid this divergence, engraving knowledge into the bodies of the next generation, and translating that knowledge into today's readiness remain the oldest—and newest—task for those living on this land.

Support This AI Library Book

If this book was useful, you can support future translations, public editions, and open AI knowledge projects through PayPal.

PayPal

https://paypal.me/kimkjkj

Scan the QR code or open the link above.