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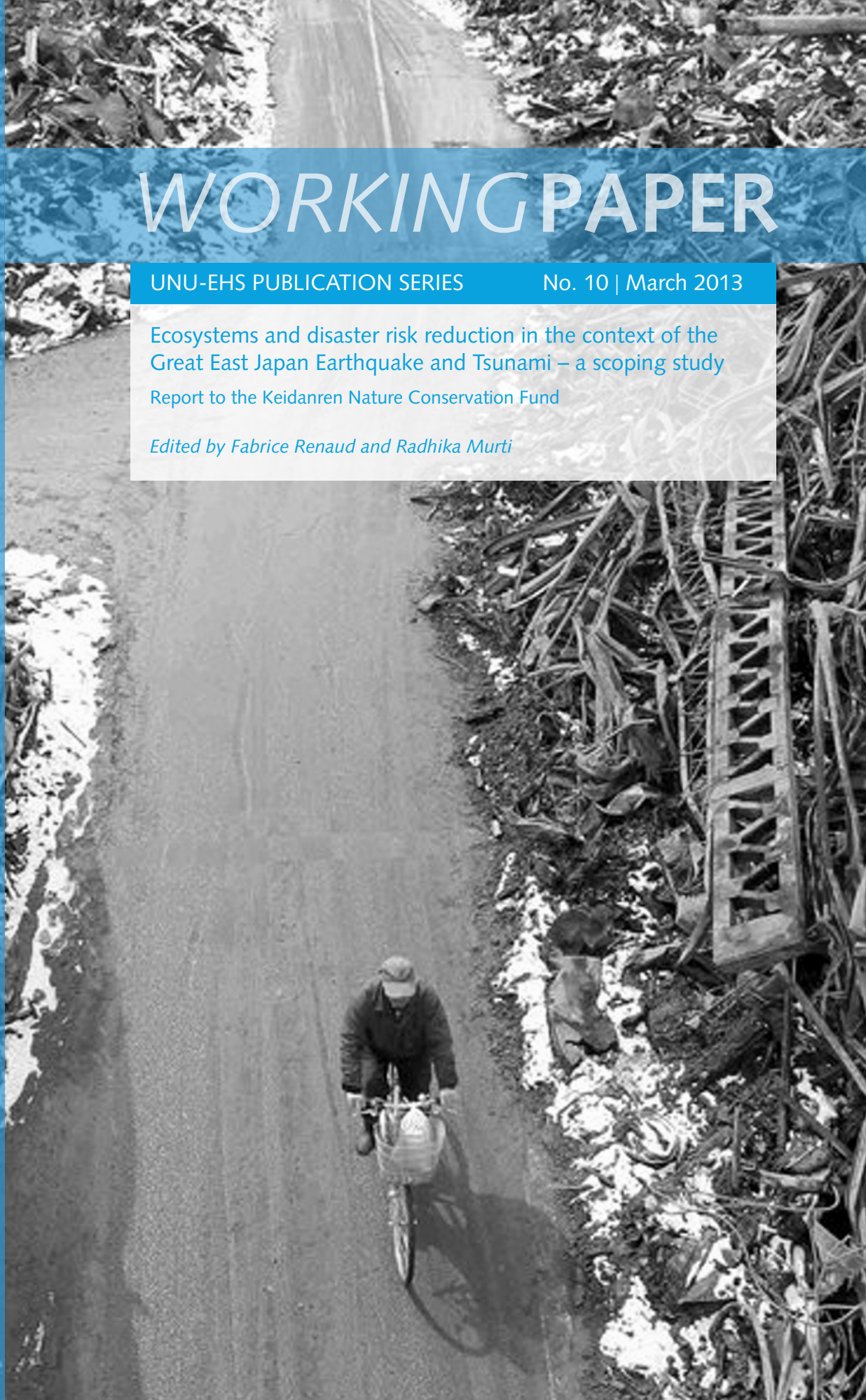
WORKINGPAPER

UNU-EHS PUBLICATION SERIES No. 10 | March 2013

Ecosystems and disaster risk reduction in the context of the Great East Japan Earthquake and Tsunami – a scoping study

Report to the Keidanren Nature Conservation Fund

Edited by Fabrice Renaud and Radhika Murti



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N0. 10 | March 2013

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Report to the
Keidanren Nature Conservation Fund

Edited by Fabrice Renaud and Radhika Murti

Introduction

Radhika Murti[1] and Fabrice Renaud[2]

1 International Union for Conservation of Nature (IUCN); 2 United Nations University Institute for Environment and Human Security (UNU-EHS)

The Hyogo Framework for Action (HFA) Priority for Action 4 on 'reducing the underlying risk factors' advocates the 'sustainable use and management of ecosystems, including through better land-use planning and development activities to reduce risk and vulnerabilities' (UNISDR, 2005). A mid-term review on the progress countries are making for the implementation of HFA was conducted during 2010-2011. The review states that Priority for Action 4 reported the least progress. Moreover it reports that 'there was little mention of' sustainably managing natural resources to successfully reduce risks, by countries.

The supporting, provisioning, regulating and cultural functions of ecosystems can provide valuable services to reduce the risks posed by and recover from disasters. Regulating services, in particular, such as climate regulation, water purification and flood regulation (MEA, 2005), can contribute significantly to disaster risk reduction (DRR). Ecosystem based DRR, therefore, is defined by PEDRR (2010) as "Sustainable management, conservation and restoration of ecosystems to provide services that reduce disaster risk by mitigating hazards and by increasing livelihood resilience."

A major barrier to successful incorporation of ecosystem-based disaster risk planning remains the limited amount of synthesized and compiled knowledge on evidence-based science, economic valuation and best practices on the role that ecosystems play in hazard mitigation. There is an increasing demand for organizations who are working in areas of climate change adaptation, disaster risk reduction and environmental management to establish a knowledge base that would support and enhance the implementation of ecosystem based disaster risk reduction (DRR). This demand has also led to the establishment of coordination mechanisms such as The Partnership for Environment and Disaster Risk Reduction (PEDRR)[1]. Generation and dissemination of such knowledge can enhance the capacity of countries in implementing sustainable management of ecosystems to reduce risks and vulnerabilities to disasters.

As lessons are learnt from the March 2011 (3/11) earthquake, tsunami and nuclear disaster in Japan, it is critical that analysis and documentation of the role of ecosystems is carried out in order for the world to better understand how ecosystems can help or hinder during disasters. Seasonal celebrations of nature, such as cherry blossom-viewing and moon-viewing are a testament to the close relationship between the Japanese people and nature. This relationship is also reflected in the way Japan protects itself from disasters (see Chapter 3). Coastal forests have been used for centuries to reduce the impacts of a variety of coastal hazards. Japanese experts advise and support other countries on how to use ecosystems as green infrastructure to reduce risks to disasters through international cooperation initiatives.

With a disaster of such magnitude, Japan can offer the much needed lessons learnt on the role of ecosystems in DRR as well as the limitations of ecosystems. Additionally, analysis of the reconstruction plans can also provide insights on how to better integrate nature as infrastructure with engineered infrastructure for complementary solutions. It is also an opportunity to document lessons on how to ensure that the victims of such events are also an integral part of the decision making processes as ultimately it's their lives and livelihoods that have been dramatically impacted.

This report presents results from a research initiative carried out under a grant to The International Union of Conservation of Nature (IUCN) from The Keidanren Nature Conservation Fund (KNCF) and was led by the United Nations University Institute for Environment and Human Security and Tohoku University. The research focused on the perceptions of communities on the role of ecosystems for DRR, particularly in the context of

1 www.pedrr.net

the 3/11 tsunami. The research was carried out in the region of Sendai (described in detail in Chapter 2) over a two months period in July and August 2012. A desk-based study was also carried out to review the institutional setup and mechanisms for Japan's risk reduction, reconstruction and land use planning. This also includes insights on the specific policies designed to support ecosystem management in the reconstruction phase (Chapter 3). Chapter 4 proceeds to present the key experiences and perspectives of some of the best 'experts' on the effects of the 3/11 events – the local communities. It provides insights on peoples' experiences of how ecosystems are perceived, understood and how they witnessed the role of ecosystems during the 3/11 events. The document concludes by highlighting some research gaps and recommendation for further analyses as well as the valuable lessons Japan is learning, that can assist other countries to help build resilient communities.

2. Geographical Background

Philipp Koch[1, 2], Ogata Koichi[3], Najwa Obeid[1], and Fabrice Renaud[1]

[1] United Nations University Institute for Environment and Human Security (UNU-EHS); [2] University of Bonn; [3] Tohoku University

2.1 Research Area

The research was conducted in the coastal area near Sendai city, Japan (Figure 1). Sendai city is located in the northeast of Japan´s Honshu Island. It is the largest city in the Miyagi prefecture of the Tohoku region with a population of around one million. Sendai lies 300 km north of Tokyo and 50 km from Fukushima city. It is bordered by the Ōu mountain range in the north and west, and extends to the east and south into the Sendai plain. The urban center of Sendai is located approximately 2 km inland from the Sendai bay coastline. The Sendai plain is divided by three major rivers: Nanakita, Natori (including Hirose running through Sendai), and Abukuma (being the largest). Historically, these rivers carried deposits from the Ōu mountain range and formed an alluvial plain with most of the area being below 5 m amsl (Matsumoto 1981:158). Sandy beaches and shallow water characterize Sendai plains while Northern Sendai Bay and the Sanriku coastline have rocky shores.

Sendai has an annual mean temperature of 12.4°C and an annual precipitation of 1254 mm for the period 1981-2010 (30 year normal) (Japan Meteorological Agency, 2013; Figure 2).

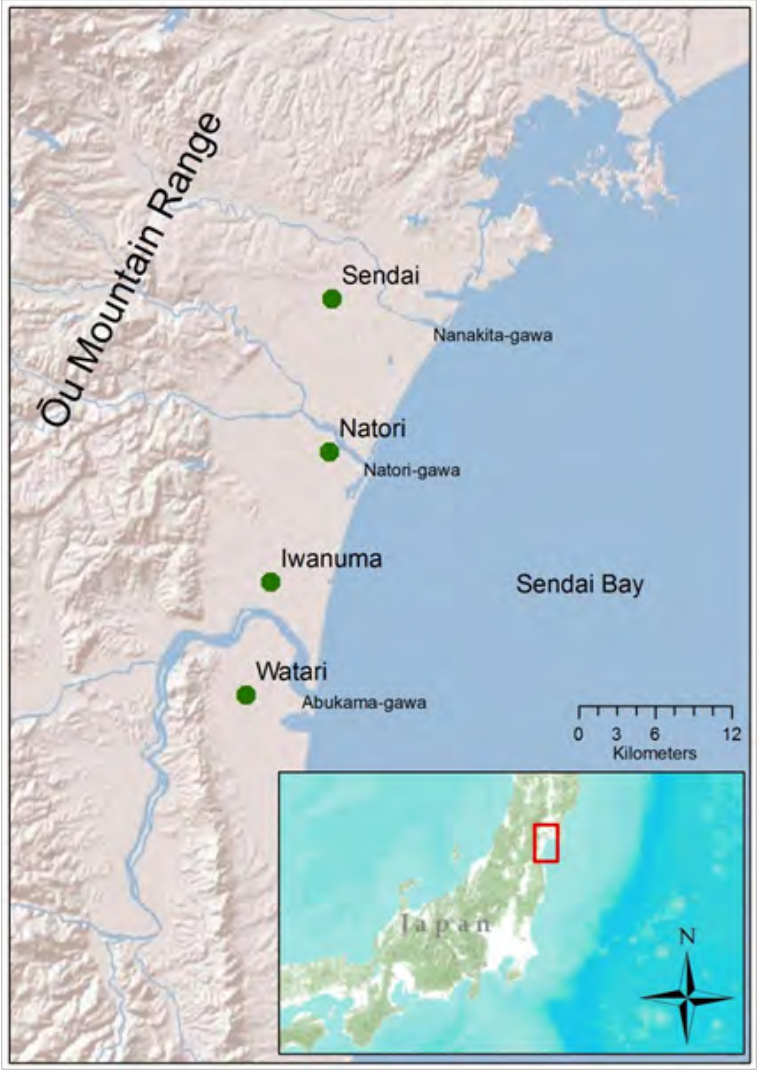


Figure 1: Sendai Bay (Source: by authors)

[2] In the strictest sense, a "normal" of a particular variable (e.g., temperature) is defined as the 30-year average (NOAA, 2011)

The main administrative units along the Sendai plain coastline are Sendai city, Natori city, Iwanuma city, and Watari town (see Figure 1). Apart from urban infrastructure, industry and smaller settlements, the plain in this area is largely used for agriculture (mainly rice paddies). Sendai airport is located in Natori city, approximately 500 m from the coast (Figure 3). The coastal infrastructure consists of Sendai harbor as well as several smaller fishing harbors along the coastline (such as Yuriage). One special feature in this area is the freshwater Teizan channel that runs parallel to the coastline. It was constructed (starting in 1597) by Date Masamune as a transportation route for rice. It is now used as a drainage channel and for recreational purposes.

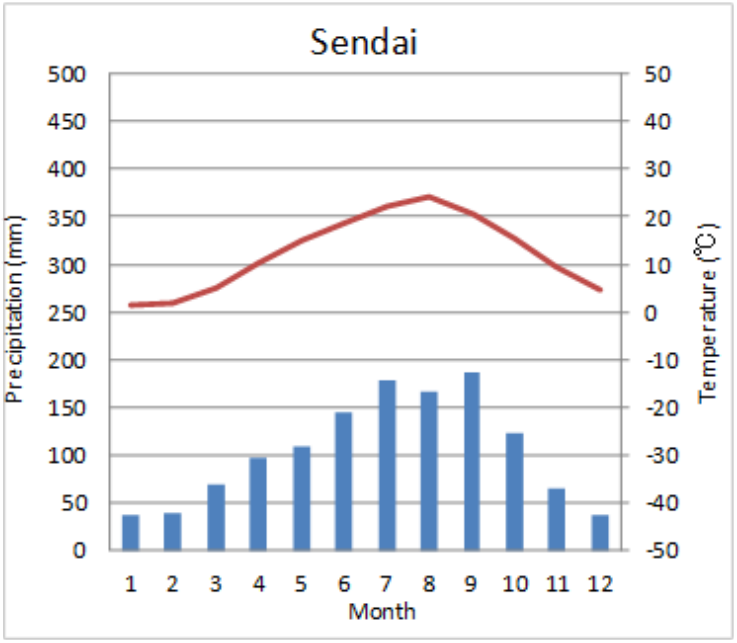


Figure 2: Climate Diagram of Sendai, Japan (Data: GHCN and CLIMAT 1981- 2010 - Source: Japan Meteorological Agency, 2013)

2.2 The 3/11 Chain of Events

On Friday March 11, 2011 at 02:46:23 PM JST time a magnitude 9.0[3] (M_w) earthquake occurred at the level of the Japan Trench, approximately 130 km east from Sendai and at a depth of 32 km (USGS, 2011a). The quake resulted from movements in the subduction zone east. The Pacific plate is moving towards Japan (83 mm/year) and is being subducted under the Japan plate, causing tension (USGS, 2011a). Since 1973 nine magnitude 7+ events have taken place in the Japan Trench, causing several deaths and injuries. The largest of those was the 1994 magnitude 7.8 earthquake (USGS, 2011b). The more recent earthquakes have not caused a significant tsunami. However, tsunamis are historically recorded for the northeast of Japan, especially the Sanriku coast that features a tsunami enhancing bathymetry due to deep coastal embayments (in 1611; 1896: magnitude 7.6; 1933: magnitude 8.6). The only devastating tsunami for the Sendai area happened on 13July 869 (based on sediment analysis and written records, see below) (USGS, 2011b). This so-called Jogan earthquake (estimated at magnitude 8.4) was the last major earthquake that triggered a "giant tsunami" hitting the Sendai plain (AFERC, 2011). The 3/11 earthquake was therefore unusually strong for the southern Japan Trench, particularly considering the last millennia.

[3] All magnitudes are measured in the Moment magnitude scale, denoted as M_w

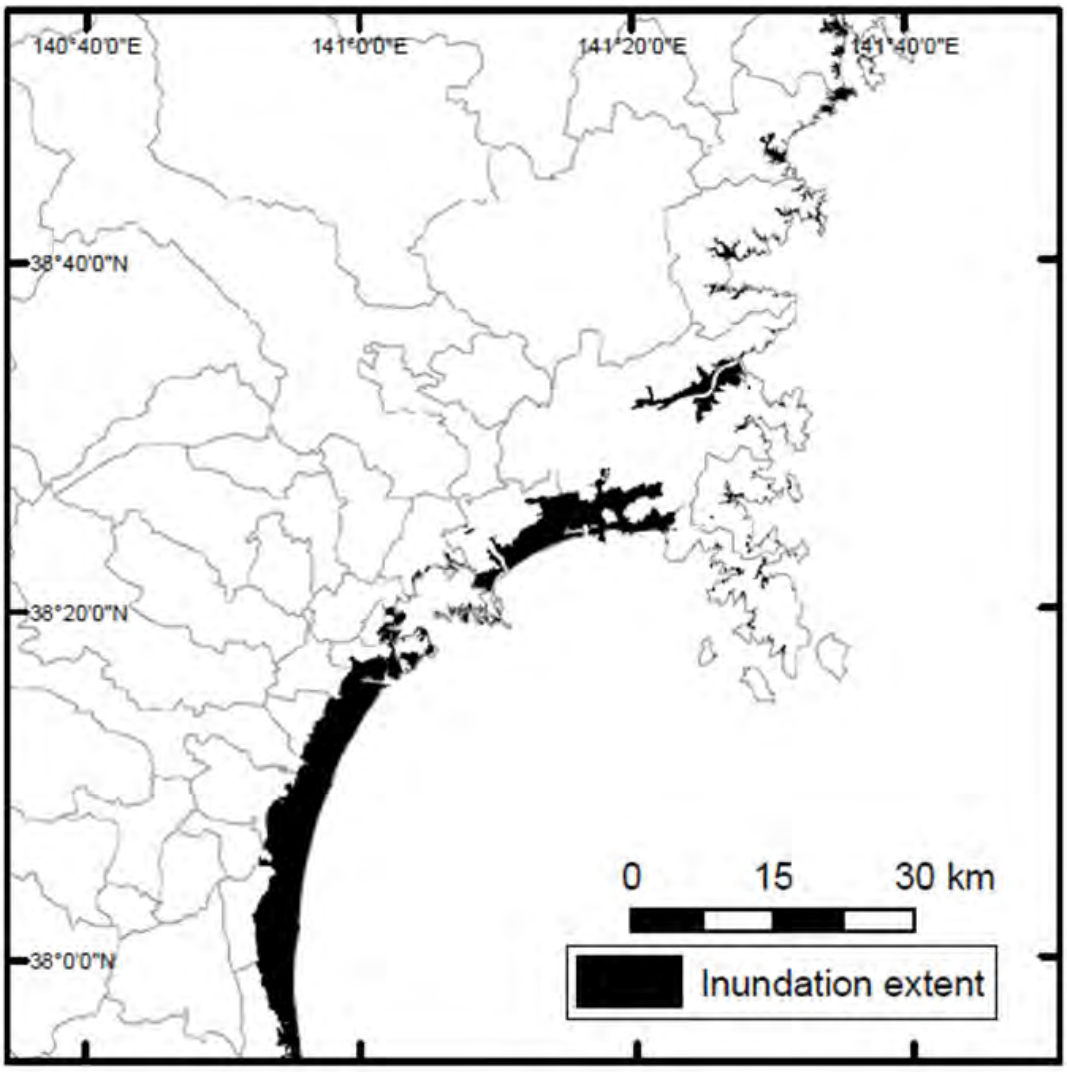


Figure 3: Tsunami inundation map (Source: Gokon and Koshimura, 2012).

As the 3/11 earthquake originated from a depth of only 32 km, the seafloor was uplifted (approx. 30-40 m; USGS, 2011a) and caused a major tsunami, inundating 516 km² of the eastern coastline of Japan (GSI, 2012). In total the Earthquake and Tsunami resulted in around 15,000 deaths, 2,800 missing people and approximately 300,000 people being evacuated (ADRC, 2012). According to Table 1 below, Miyagi Prefecture suffered the most in terms of numbers of casualties and infrastructure damage. Figure 3 above shows inundation caused by the Tsunami in the area of Sendai Bay, with Matsushima Bay in the north and Soma-city in the south. The number of households situated in the inundated areas that were destroyed were 2,735 out of 3,974 in Natori and 699 out of 2,337 in Iwanuma (Suppasri, 2012, based on December 1, 2011 data from Miyagi Prefecture). The fatality rates differ as well; the highest rate is 11.8% in Onagawa city, on the Oshika peninsula east to Sendai, followed by 8.1% in Natori city and 2.3% in Iwanuma. These differences are caused by the settlement patterns of the two cities which are discussed in chapter 4.

A third element in the chain of disasters after the earthquake and tsunami was and continues to be the Fukushima Daiichi nuclear disaster. Several nuclear power plants shut down immediately due to the earthquake. The earthquake-triggered tsunami hit the coastal nuclear power plant in Fukushima; it damaged or destroyed critical structure necessary for the cooling of the reactors and ultimately led to three reactor meltdowns (Norio et al., 2012). The total economic damage of the 3/11 chain of disasters is estimated around 16 to 25 trillion yen (194 to 304 billion USD) (Kantei, 2011).

	Human casualties			Building damages	
Prefecture	Killed	Missing	Total collapse	Half collapse	Partially damaged
Aomori	3	1	308	701	958
Iwate	4,671	1,192	19,199	5,043	8,784
Miyagi	9,530	1,337	85,331	151,768	224,124
Akita	-	-	-	-	3
Yamagata	2	-	37	80	
Fukushima	1,606	211	21,034	72,110	162,491

Table 1: Casualties and damages from the 2011 Earthquake and Tsunami (as of Nov 21st 2012) (Source: excerpt from National Police Agency of Japan, 2012).

2.3 Coastal protection forests in Japan

This research focused on the role of ecosystems for disaster risk reduction. Of particular interest was the effects of coastal vegetation in the context of the 3/11 tsunami. Japan has a coastline that measures approximately 34,000 kilometers. There are 1,640 km2 of forested green belts distributed along Japan's sandy coast and these green belts have been maintained for over four centuries. Composed mainly of Japanese black pine, the green belts function to reduce the impact of coastal hazards such as sand storms, salty winds, high tides and tsunamis (Shaw et al., 2012). The 200 to 400 meter wide pine forests in the Sendai Plains of Miyagi Prefecture have mitigated disasters and provided beautiful scenery for the past four centuries. The Takatamatsubara coastline of Rikuzentakata City, Iwate Prefecture, was also very famous for its 21-hectare coastal forest, 2 kilometers long and 200 meters wide, consisting of some 70,000 pine trees (Shaw et al., 2012). The forest was completely destroyed except for one tree after the 3/11 Tsunami.

The next chapter of this report addresses institutional issues linked to disaster risk reduction in Japan, with a focus on the role of ecosystems.

3. Institutional Aspects of Disaster Risk Reduction

Najwa Obeid[1], Fabrice Renaud[1], Daniel Brink[1], and Naoya Furuta[2]

[1]United Nations University Institute for Environment and Human Security (UNU-EHS); [2] International Union for Conservation of Nature

3.1 Introduction

For effective disaster management, national Government, local governments and wide range of relevant partners develop disaster management plans and carry them out appropriately, based on the Disaster Countermeasures Basic Act. At national level, various government agencies including the Cabinet Office, National Police Agency, Fire and Disaster Management Agency, Ministry of Land, Infrastructure and Transport, Meteorological Agency, Ministry of Education, Culture, Sports, Science and Technology, Ministry of Health, Labor and Welfare, and Ministry of Defense are sharing responsibilities of disaster management in Japan. Central Disaster Management Council is in charge of developing large-scale disaster management plans at national level.

Following the Tohoku disaster of March 11, 2011 (3/11), the Japanese government established a disaster headquarters, a reconstruction design council, a reconstruction agency, and a special zone for reconstruction (Tanaka et al., 2012a). These agencies are in charge of planning and developing regulatory guidelines and policy for recovery and reconstruction. The main policies passed after 3/11, are "Towards Reconstruction – hope beyond the disaster" and its seven principles; the Great East Japan Earthquake Reconstruction Act; and the "Basic Guidelines for the Reconstruction in Response to the Great East Japan Earthquake (herein after referred to as Basic Guidelines). These policies promote the shaping of disaster resilience during the reconstruction process.

One of the most important lessons that the Japanese learned following 3/11 was that no amount of preparation can completely allow them to avoid the destruction caused by disasters of this magnitude. As such, a paradigm shift in disaster management policy that moves away from an almost exclusive reliance on structural countermeasures and moves towards strengthening disaster risk reduction measures is being encouraged. This comprises more comprehensive tsunami management countermeasures that emphasize approaches such as escape strategies, land use planning/management and establishing multiple defenses.

According to the Basic Guidelines, reconstruction will take place for a period of ten years with concentrated efforts taking place during the first five years. The communities affected by the tsunami will face significant challenges during the redevelopment process – one being the need to rebuild quickly while generating a consensus amongst local stakeholders about how best to reconstruct. For example, local fishing and farming communities, whose livelihood depends on low-lying coastal zones for agriculture and fishing, oppose the government's proposition to build new safer housing on hills away from coasts and to consolidate smaller fishing towns into large industrial fishing ports (Figure 4) (Barrett, 2011). In order to accelerate the rebuilding process, a special zone for reconstruction was introduced in December 2011, with a special financial support system. Additionally, the Reconstruction Agency was established in February 2012 with the aim of providing flexibility and expediting government procedures in relevant ministries.

Furthermore, The Basic Guidelines emphasize a bottom-up process and point out the crucial role that municipalities play in the reconstruction process. Barrett (2011) suggested that the experience of the Transition Movement – a movement founded by Rob Hopkins in 2005, where communities aim to reduce their ecological footprint, live more sustainably, and build resilience in response to climate change and diminishing supplies of energy - could be helpful in guiding reconstruction efforts and in particular, fostering a bottom-up, rather than a top-down approach. Since the end of August 2012, 42 out of 43 municipalities have finalized their reconstruction plans, which include major land use restructuring.

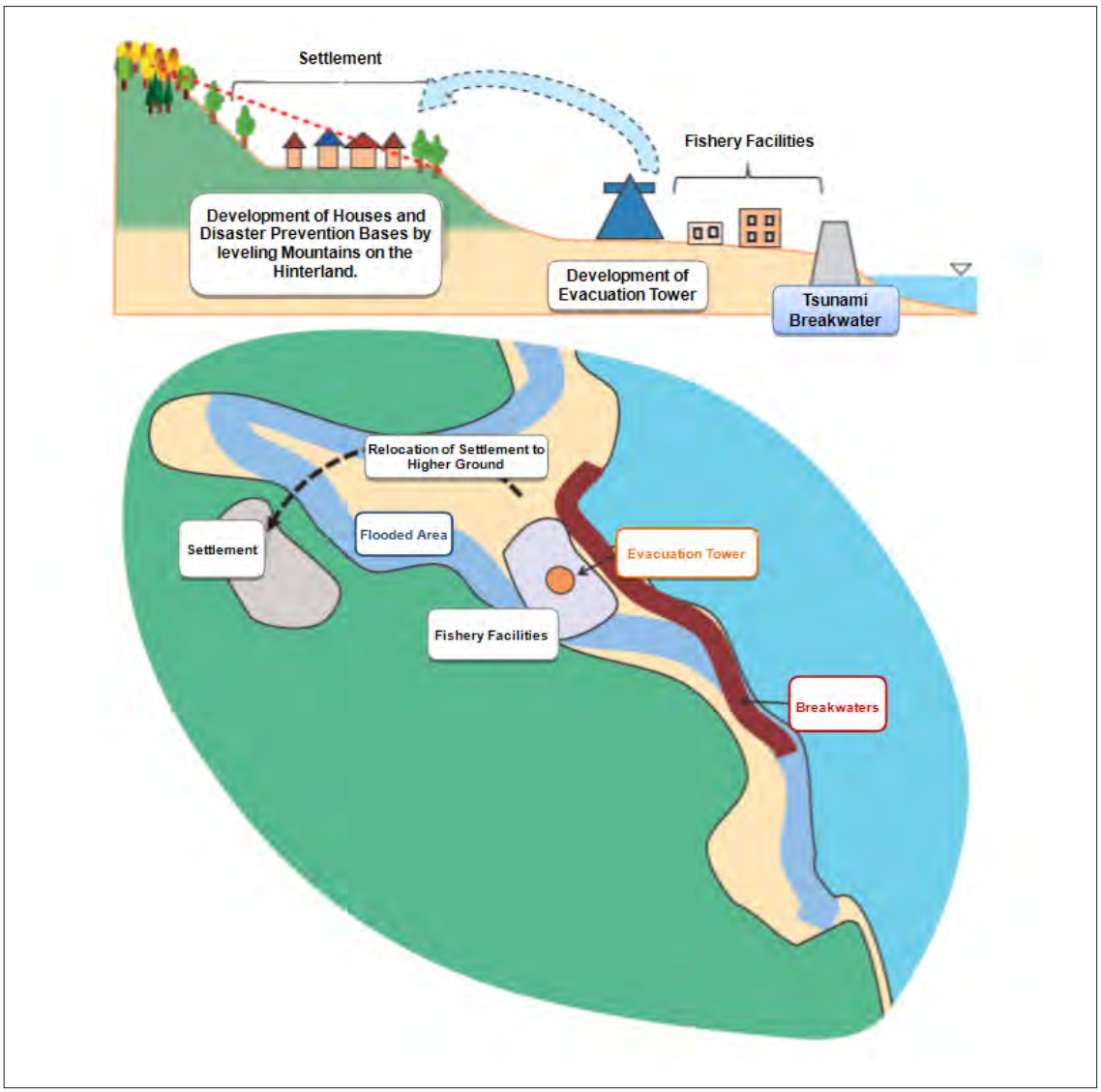


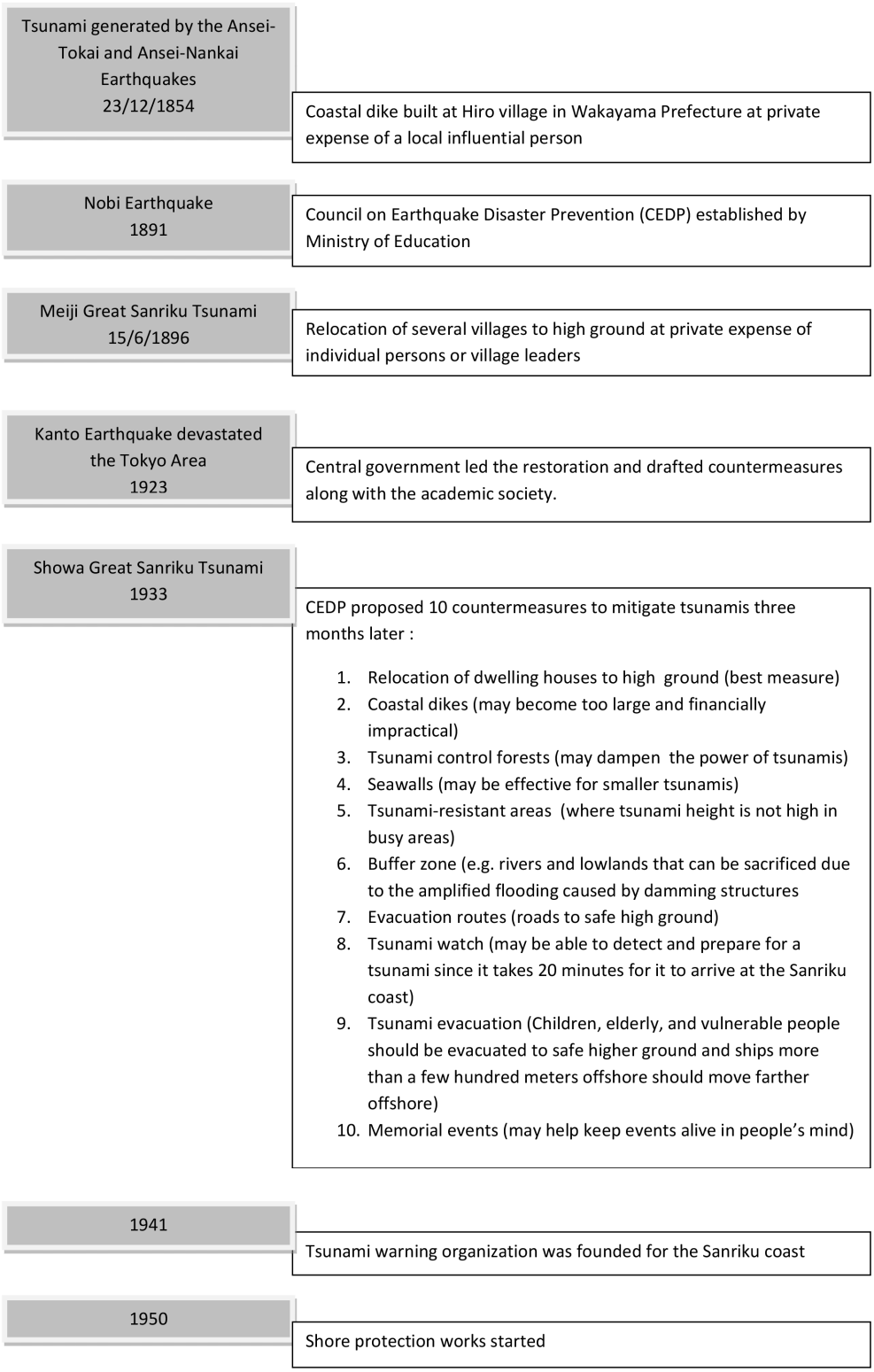
Figure 4: Regions built on hills running down to the coast with few low-lying areas and settlements (Towards Reconstruction, 2011)

One of the measures that The Basic Guidelines promote is the use of disaster-prevention forests for reconstruction in coastal areas. This chapter focuses on describing ecosystem-based countermeasures that were in place before the Tsunami. It also documents the planned countermeasures based on ecosystems, following the Tsunami. Relevant engineered countermeasures are also included in order to demonstrate how, when they are combined with ecosystem-based countermeasures, they provide superior protection against tsunamis than if used on their own. Policies put in place after 3/11 regarding the use of ecosystem services for disaster risk reduction are also described followed by a few strategies that some municipalities are taking during the reconstruction process.

3.2 History of Tsunami countermeasures in Japan

Tsunami science and engineering originated in Japan largely in response to the Meiji Great Sanriku Tsunami of 1896, which claimed 22,000 lives. The idea of comprehensive tsunami countermeasures was introduced after the 1933 Showa Great Sanriku Tsunami which led to the relocation of dwellings to higher ground. In 1941, Tsunami forecasting began and following the extensive damage to the Japanese Pacific coast caused by

the Chilean Tsunami of 1960, elaborate engineered coastal structures were built. The current comprehensive disaster prevention that consists of defense structures, tsunami-resistant town development, and evacuation based on warning were put in place in 1993, after the Hokkaido Nansei-Oki Earthquake Tsunami. The timeline below (Figure 5) provides a brief history of tsunamis and subsequent policies and countermeasures put forth in Japan (Shuto et al., 2009; Forestry Agency, 2012; Tanaka et al., 2012a).



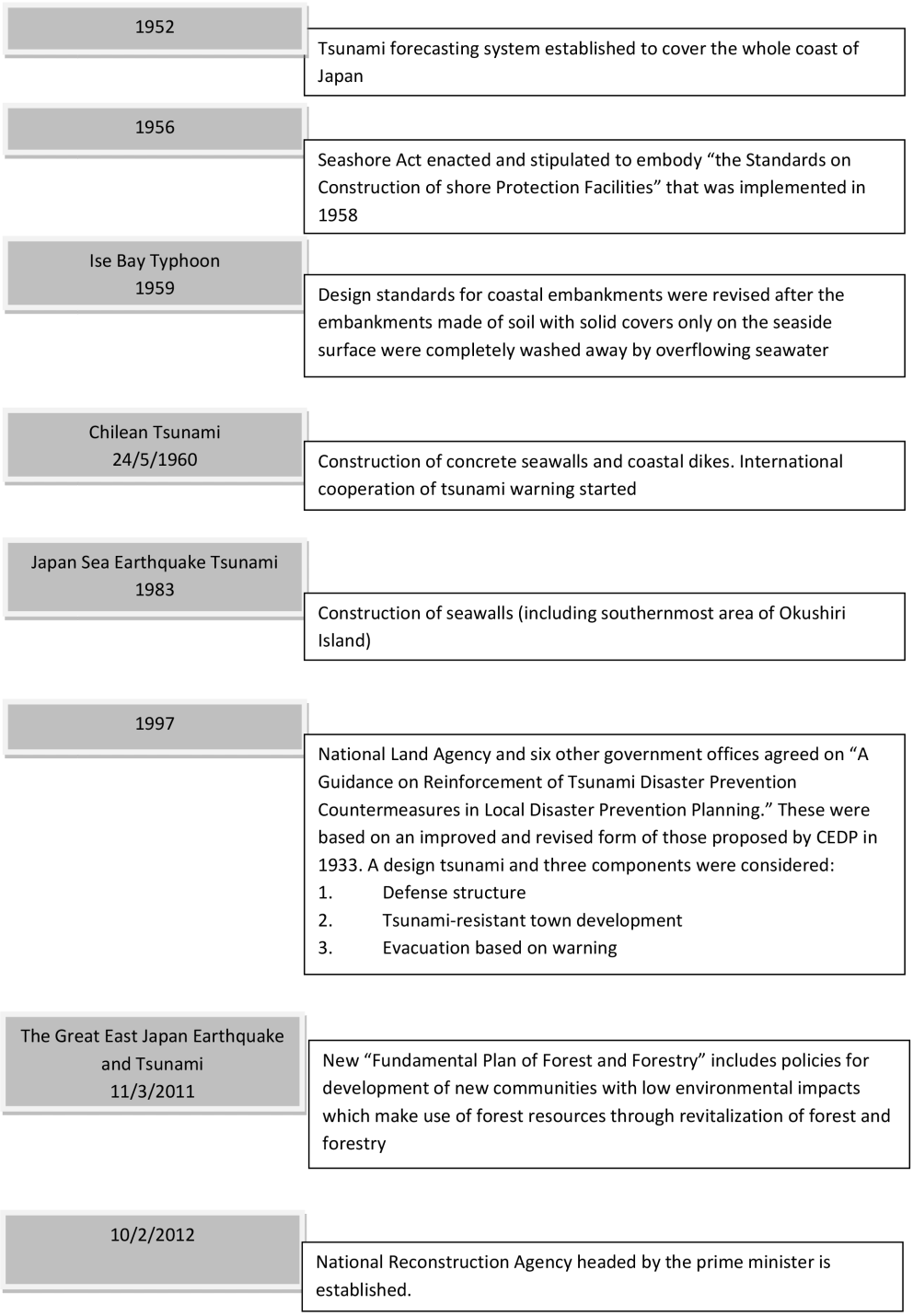


Figure 5: Brief history of tsunamis and subsequent policies and countermeasures put forth in Japan since 1854

3.3 Tsunami countermeasures before March 11, 2011

Japan has relied heavily on engineered countermeasures to protect its coastal areas against tsunamis. These hard, engineered countermeasures such as break waters, seawalls, dikes, and tide gates were designed to protect against a one in a hundred year tsunami and not the less frequent, more intense one in one thousand year tsunami of 3/11. Soft countermeasures such as disaster risk management (DRM) forests, green belts, and sand dunes have also been used historically, particularly for the ecosystem services they provide.

Coastal Forests

Japan's forest protection policies are a good example of how ecosystems should be used for reducing disaster risk. For instance, Japan's Forest Law requires that Disaster Risk Management (DRM) forests should be planted by the coast to prevent damages from blown sand and salt, high tides, and tsunamis (Shaw et al., 2012).

Japan introduced forest protection in the 15th and 16th centuries as a countermeasure to landslides. Since the 17th century coastal forests have been developed to prevent damage from strong winds, sand storms and salt winds in coastal areas. In 1897, the Japanese government passed the Forest Law in order to designate forests as Reserved Forests, to maintain their DRM function. In 1933 the green belt mitigated damages from the Syowa Sanriku tsunami. In 1935 the government started an afforestation program to mitigate tsunami damage and again promoted afforestation following the Chilean earthquake tsunami in 1960. The green belt became less important after the rapid economic growth of the 1970s, as other, arguably, more effective DRM measures were developed, and electricity and gas replaced wood as energy sources for people. The community's role in managing the green belt diminished and governments took over its maintenance (Shaw et al., 2012).

In coastal areas, erosion control forests have been planted and maintained for centuries due to the ecosystem services they provide. They protect against tidal surges, sand storms, and wind. They also mitigate tsunamis by 1) stopping drifts and debris, including ships, carried by the tsunami, 2) reducing tsunami energy and delaying the waves, 3) forming sand dunes protecting against tsunamis and high waves, and 4) catching people carried back to sea by the tsunami (Harada and Imamura, 2005). Therefore, the loss of these services from the forests will have significant consequences for people in Tohoku (Junko, 2012).

Conservation forests and protected areas represent approximately 32% of total land area, or 12.02 million hectares (48% of total forest area) in Japan and play a vital role in the conservation of water resources as well as the natural environment and safeguarding biodiversity (Forestry Agency, 2012; PEDRR, 2010). Prior to 3/11, forest belts, as countermeasures for disaster-prevention, existed on about 3,300 kilometers of the nation's coastline. In Wakabayashi Ward, Sendai, coastal areas were struck by waves about seven meters high on March 11, 2011 but the waves were just 40 centimeters high by the time they reached the neighborhood located behind the forests, whereas areas near port facilities and other places without protection from forests suffered much greater damage (Yomiuri Shimbun, 2011).

Prior to 3/11, the Pacific coastlines of Aomori, Iwate, Miyagi, Fukushima, Ibaraki and Chiba prefectures (Figure 6) had a total of about 230 kilometers of disaster-prevention forests but the tsunami swept away about 140 kilometers of these forests. Some of the trees were planted in places where they could not develop deep root systems, which reduced their ability to withstand the tsunami (Yomiuri Shimbun, 2011; Cyranoski, 2012).

Sand Dunes

In addition to providing protection against tsunamis coastal forests also protect against sea winds and the blowing of sand. Blown sand accumulates due to the forests and forms dunes or increases the height of existing dunes along the coast (Harada and Imamura, 2005).

Sand dunes have the ability to act as a natural dike or barrier, providing protection against tsunamis and tidal surges. The 1983 tsunami that occurred with the Nihonkai-Chubu earthquake was prevented by 10 meter sand dunes on the coast of Aomori and Akita (Ishikawa, 1998; and Murai, 1983; cited in Harada and Imamura, 2005). Sand dunes can serve as an important natural buffer and should be considered as part of an integrated approach to tsunami mitigation.

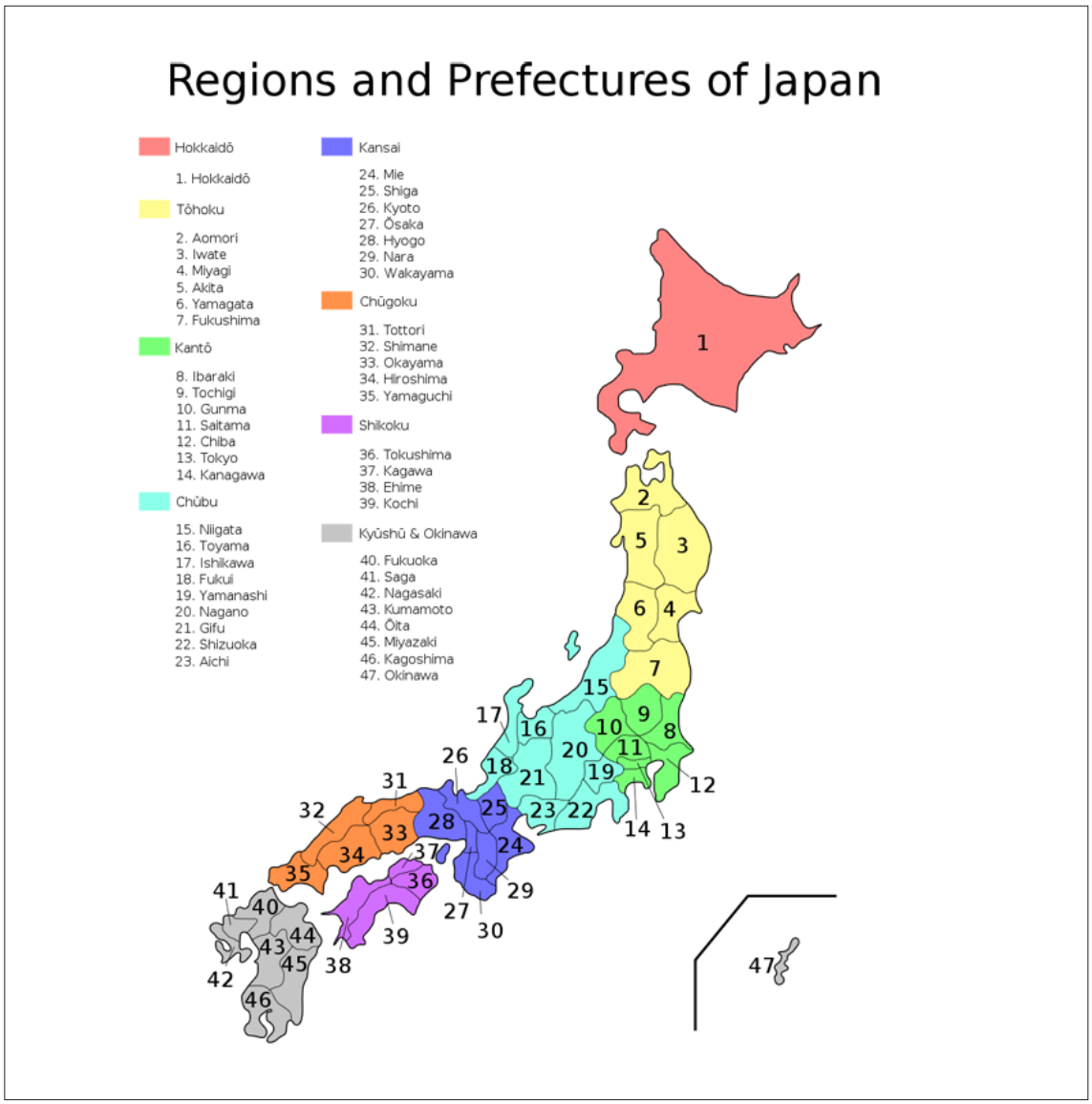


Figure 6: Regions and Prefectures of Japan (New Geography, 2011)

Sea Walls, Breakwaters, and Coastal Dikes

Sea walls and breakwaters (Figure 7a) surround nearly half of the country's 34,500 km of coastline (Cyranoski, 2012). Japan's Tohoku region built 3,000 kilometers of coastal defense structures over the course of 50 years. National and Local governments invested a total of $10 billion in building breakwaters and coastal structures at major ports in Tohoku (Ishiwatari and Sagara, 2012).

Large breakwaters were constructed at the mouths of Ofunato, Kamaishi, Miyako, and Kuji bays, in response to many large tsunamis that occurred in the past (1886, 1933, 1960, 1968). In kamaishi Bay, a large breakwater registered as the deepest in the world, with a maximum depth of 63 m below water and a height of 8 m above sea level (Figure 7 b,c), played an important role in protecting the port and city of Kamaishi up until 3/11. Similarly, 10 m high coastal dikes, known as "Great Walls," in the Taro district of Miyako City served as

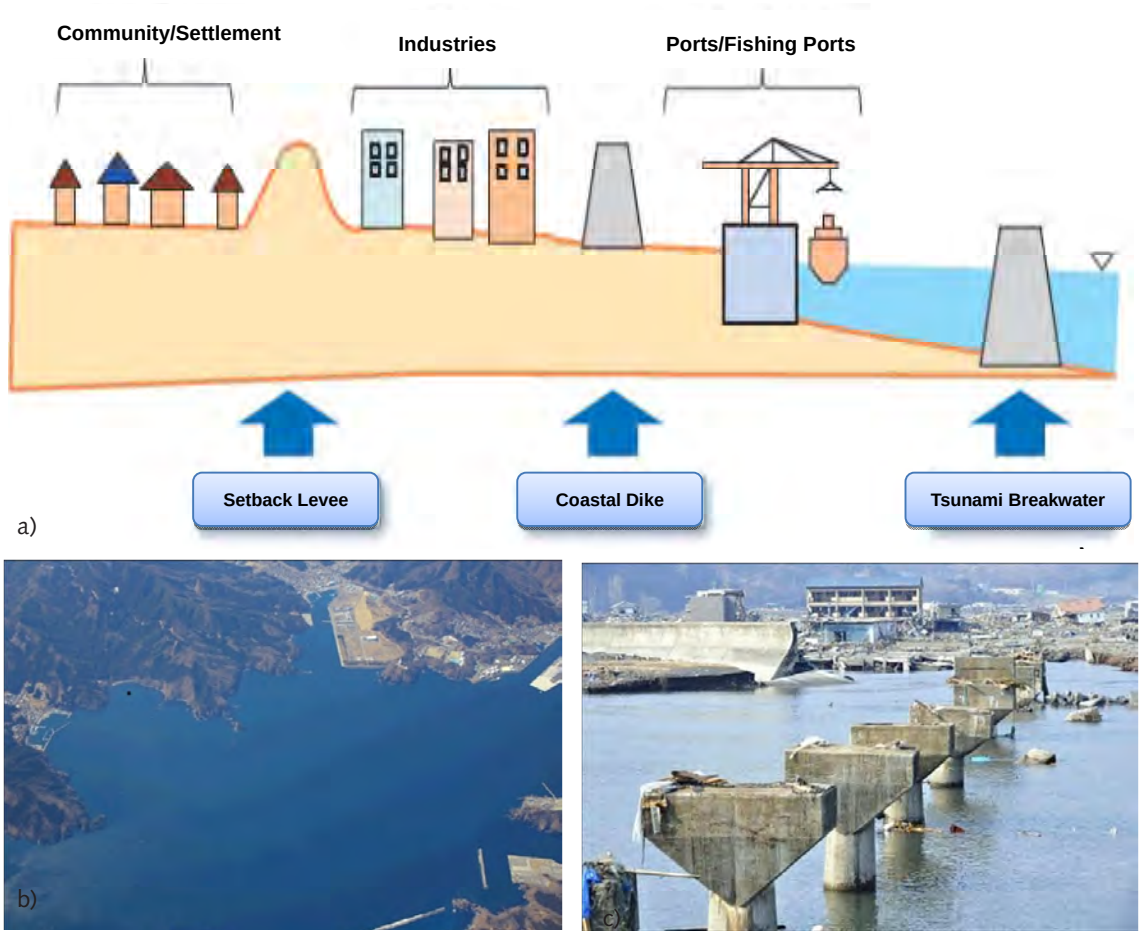


Figure 7: a) Images of Tsunami breakwater, coastal dike, and setback levee (Towards Reconstruction 2011), b) world's deepest breakwater (63-meters deep) in Kamaishi, Iwate Prefecture (Japan Probe 2011a), c) failed breakwater in Otsuchi, Iwate Prefecture (Japan Probe, 2011b)

important and effective countermeasures before the 3/11 Tsunami. However they could not prevent overflows and were destroyed after 3/11 (Mimura et al., 2011).
The 3/11 tsunami caused 190 of the 300 kilometers of coastal defense structures to collapse (Ishiwatari and Sagara, 2012; Mimura et al., 2011). In some cases the structures delayed the arrival and reduced the force of the tsunami, but the majority of structural measures failed, depending to some degree on their type (Tanaka et al., 2012b). The coastal structures could not prevent the disaster or adequately mitigate damages as the tsunami exceeded the level they were designed to withstand. Where the seawalls collapsed, some parts of the coastal areas were inundated by spring tides (Mimura et al., 2011).

3.4 Tsunami countermeasures after March 11, 2011

In December 2011, the parliament passed a law requiring the construction of "tsunami-safe cities". Local government authorities will use zoning restrictions to prevent people from living in low-lying areas and will improve evacuation protocols to augment the protection provided by sea walls (Cyranoski, 2012). Authorities are also planning to restore DRM coastal forests as part of the structural countermeasures, along with dikes and earth mounds.

The tsunami triggered by the Great Eastern Japan Earthquake damaged about 3,660 hectares of forest. In accordance, the Japanese Government has decided to invest ¥59 billion in replanting trees in Tohoku (Cyranoski, 2012). There has been some debate over the effectiveness of forests in mitigating the impacts of the 3/11

tsunami, with arguments that forest debris increased damage to built structures in some areas. There were, however, various reports of how areas behind some coastal forests were less damaged than others and how vegetation was able to block debris such as concrete blocks, cars and even ships, from being carried further inland by the storm surge. In Hachinohe, the forest stood firm while being hit by 6 m waves, preventing more than 20 boats from being swept inland which would have caused additional damage (Koshimizu, 2012; Nandasena et al., 2012).

Protection forests provide many ecosystem services which include mitigation of impacts of coastal hazards such as tsunamis, salty winds, and airborne sand that can damage agricultural fields, sources of income from tourist attraction, and provision of scenic landscapes (Shaw et al. 2012). Unfortunately, the power of the 3/11 tsunami rendered much of the protection forests ineffective (Koshimizu, 2012). Coastal forests fell due to liquefaction of the ground caused by the earthquake, increasing the impact of the tsunami, rather than having a mitigating effect. Koshimizu (2012) states that it was anticipated that coastal forests could be rendered useless by liquefaction, but no countermeasures were taken. According to researchers who study earth and environment interactions at Tohoku Gakuin University in Sendai, trees that caused the most damage still had their roots intact. The roots did not break, but came right out of the ground due to limited root-soil structure (Cyranoski, 2012; Nandasena et al., 2012). Trees with roots reaching deeper than 3 meters were generally able to withstand the force of the tsunami. To help allow roots to extend deeper, the Forestry Agency plans to raise the ground along the coast by three to five meters before planting the trees (see Chapter 4). Debris from the disaster will be used to help raise the ground level. The agency also intends to follow recommendations to increase the width of disaster reduction forests from the standard 50 – 100 meters to 200 meters (Yomiuri Shimbun, 2011).

The Miyagi prefectural government recommends aiding the recovery of DRM forests by coordinating it with other rehabilitation works, selecting indigenous tree species for restoration of coastal forests that also support biodiversity, and through collaboration with non-profit organizations, volunteers and the private sector. For instance, a committee made up of residents, local business people, and university students from Watari, Miyagi Prefecture, is working on the "Watari Green Belt Project." The project focuses on the reconstruction of the pine groves that were destroyed by the tsunami and aims to rejuvenate them by planting about 40,000 pots of seedlings currently being prepared in 2014. The committee is also involved in workshops concerned with the design of the groves and surrounding coastal region, and is part of the town reconstruction plan (Watari, 2011).

Natural protections such as coastal vegetation, forests, and topographical elevations such as coastal headlands, dunes and cliffs play an important role in absorbing and deflecting wave energy and consequently reducing tsunami impacts (Nandasena et al., 2012). The town of Misawa is an example of where coastal vegetation and dunes mitigated tsunami impacts during the Great Eastern Japan Earthquake. According to witnesses the tsunami did not reach the top of the dune in Misawa, leaving the vegetation belt and the village behind the dune undamaged (Nandasena et al., 2012). The vegetation on the dune in Misawa supplemented the dune's ability to mitigate the impact of the tsunami. The vegetation on the dune helped to increase its stability, but even without vegetation the dune would still have had the ability to mitigate a tsunami of a similar scale (Nandasena et al., 2012).

The mitigating effects of protection forests and green belts in relation to the type and magnitude of specific hazards will need to be clarified (Koshimizu, 2012). This will require collaboration amongst key actors such as foresters, engineers and urban planners. Further clarification and understanding will also assist in the development of effective multilayered tsunami and earthquake defenses. The reconstruction plan for Sendai city provides an example of such urban planning and multilayered defenses (Figure 8). During the reconstruction of the eastern part of Sendai, several measures will be introduced to reduce the potential impact of future

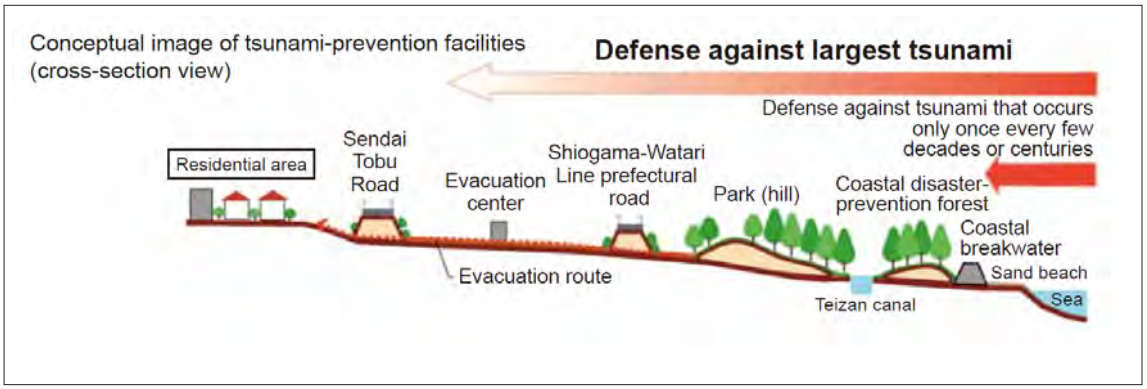


Figure 8: Conceptual view of tsunami-prevention facilities (City of Sendai, 2012)

tsunamis. The measures include raising the height of roads to act as breakwater and utilizing coastal disaster-prevention forests (City of Sendai, 2012).

3.5 Policies

A key aim of recovery management is to use the opportunity to build or strengthen the resilience of a society, its citizens, government, infrastructure, livelihoods, and natural environment. The Great Eastern Japan Tsunami exposed the shortcomings of Japan's disaster risk management strategies, which placed emphasis on structural measures. Structural countermeasures were constructed for protection against smaller and more frequent tsunamis, but offered little protection against the powerful tsunami that struck the coast of Tohoku on March 11 (World Bank, 2012). Building structural defenses against the largest possible event is financially, socially and environmentally impractical. The Great East Japan Tsunami (GEJT) demonstrates the need for flexible and multilayered approaches to DRM, combining structural and non-structural measures.

In June 2011 the Reconstruction Design Council, in response to the GEJT, released a report titled "Towards Reconstruction – Hope Beyond the Disaster," presenting their recommendations for the reconstruction process. The report emphasizes the need for reconstruction efforts that strengthen disaster risk reduction and importantly, identifies the reconstruction effort as an opportunity to address environmental issues. Reconstruction efforts should also facilitate the recovery of nature's disaster prevention functions (Forestry Agency, 2012). For example, restoring coastal forests and green belts can delay and mitigate the energy of tsunami waves and block debris from moving inland and destroying homes and farms. Risk reduction should focus on people-oriented measures that move away from exclusive reliance on waterside defensive structures. In addition to breakwaters, the functions of inland setback levees must be enhanced and land must be raised on man-made

Box 1: Coastal forests are now listed as one of the multiple protections against tsunamis by the Reconstruction Design Council (Ohta, 2012). The Forestry Agency has put forth a new policy to promote the conservation of the natural environment in Japan. Coastal forests with highly developed disaster prevention functions are designated as "Conservation Forests." National Forests with diverse forest ecosystems have been designated as "Protected Forests" or "Green Corridors" which connect several "Protected Forests".

(Forestry Agency, 2011)

earthworks, where areas, routes, and buildings for evacuation can be developed (Towards Reconstruction, 2011).
In July 2011 the National Government released the "Basic Guidelines for the Reconstruction in Response to the Great East Japan Earthquake." Four of the disaster affected prefectures- Aomori, Iwate, Miyagi, and Fukushima - have also developed their own reconstruction policies following this, which include the restoration of coastal forests (Forestry Agency, 2012; see also Chapter 4).

The Committee to Review Park and Green Belt Maintenance Methods for Tsunami Prevention under the Ministry of Land, Infrastructure, Transport and Tourism (MLIT), believes in the concept of multilayered defenses, effectively combining concrete levees and coastal forests. It states that evacuation green belts should be established on higher ground and that it is important to secure evacuation routes that lead to them. The Committee believes that other varieties of trees under the black and red pines should be planted to achieve a multilayered forest that would have higher chances of survival in various types and scales of disasters (Koshimizu, 2012).

3.6 Strategies

The reconstruction projects for the Great East Japan Earthquake are to be consensus-based processes and agreed upon by the multiple stakeholders that include the municipality and local residents as well as governmental human resources assistance to support reconstruction. The reconstruction officials would like to establish a standard system that can be used nation-wide to contribute not only to the current efforts for reconstruction but also to future responses to disasters events. The strategy involves conceiving "Tsunami Resilient Town-Building Systems" with "multiple defenses," combining hard and soft response measures (Towards Reconstruction 2011). New laws now mandate tsunami safe cities and require local governments in coastal areas to simulate a massive tsunami's impact on the region and develop zoning policies accordingly (Cyranoski, 2012).

Experts concur that building towering seawalls to resist a once-in-a-millennium tsunami is not pragmatic (Cyranoski, 2012; Mimura et al., 2011). Japan's Ministry for Reconstruction, said that rearranging cities to make them safer - by moving houses to higher ground, for example – runs into logistical and political problems. Over the next 10 years, the government expects to spend ¥23 trillion ($285 billion) on reconstruction. The starting point is coastal defenses. Of the region's 300 km of seawalls, 180 km were washed away.

A national committee on tsunami countermeasures has recommended rebuilding coastal walls or levees up to 12 meters tall – several meters taller than the old barriers. Their height would be designed to withstand the second or third biggest tsunamis to have hit a particular location, based on simulations and analyses of historical records. The committee also recommends erosion-resistant foundations and sloping embankments on the landward side to avoid water pouring over the walls from scouring the soil and toppling the structures. Experts also agree that residential areas and critical facilities such as schools and hospitals should be moved inland and uphill wherever possible. Where this is impractical, a sufficient number of new buildings should be tall and sturdy enough to serve as tsunami shelters. Low-lying land near the shore should be reserved for parks, forests, and fields. Ideally, a second ring of embankments supporting roads and railways would protect business districts from waves that top shoreline barriers (Normile, 2012).

Following the GEJT there were around 40,000 reports of forest related damages in the 15 prefectures affected by the disaster. An estimated 250 forest areas were destroyed or heavily damaged by the tsunami that followed the earthquake (Forestry Agency, 2012). The Miyagi prefectural government recommends the following actions to help the recovery of DRM forests (Shaw et al., 2012):

- Coordinating with other rehabilitation works, such as coastal dikes and debris management
- Selecting tree species that conform to local conditions and support biodiversity
- Collaborating with nonprofit organizations, volunteers, and the private sector

The Forestry Agency implemented projects to restore conservation forests and set up the Ad-hoc Committee on the Restoration of Damaged Coastal Forests. The committee was tasked with reviewing the resiliency of coastal forests against tsunamis and with studying potential strategies for restoring forests. The committee concluded that even though coastal forests do not necessarily provide complete protection against the largest possible tsunamis, they should nevertheless form part of multi-layered countermeasures against tsunamis (Forestry Agency, 2012). The recommendations for the restoration of coastal forests put forth by the "The Ad-hoc committee on the Restoration of Damaged Coastal Forests" include four strategies (Figure 9) (Forestry Agency, 2012):

1) restoration as before
2) reinforcement of protective facilities
3) expansion of forest width
4) improvement of overall functions of coastal forests

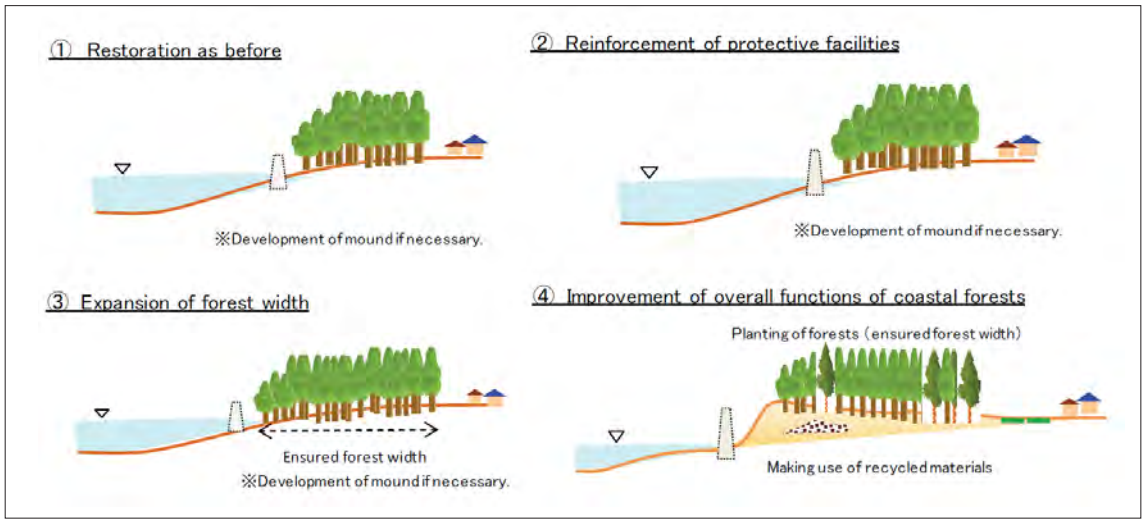


Figure 9: Four Strategies for the Restoration of Coastal Forests (Forestry Agency, 2012)

In March 2012, the Ministry of the Environment released a report entitled "Basic Concept for Reconstruction using Natural Parks in Sanriku". The report promotes a basic principle - Green Reconstruction: creating a new national park - walking together with the natural environment fostered by the Forests Rivers Sea and Satoyama, towards reconstruction (MoE, 2012a). Under this basic principle, the Ministry of the Environment proposed 7 projects as follows (Figure 10):

- Establishment of the new Sanriku Fukko (reconstruction) National Park
- (Restructuring of Natural Parks)
- Long distance nature trail: Tohoku Coast Trail
- Fukko (reconstruction) Ecotourism
- Reconnecting the Forests, Rivers, Sea and Satoyama
- Promoting development of human resources who play a major role in sustainable society
- Monitoring the Natural Environment
- Satoyama Satoumi Field Museum

With these projects, the Ministry of Environment is trying to revitalize local society, economy and nature and enhance resilience of the areas affected by the Great East Japan Tsunami by promoting eco-tourism and natural disaster education.

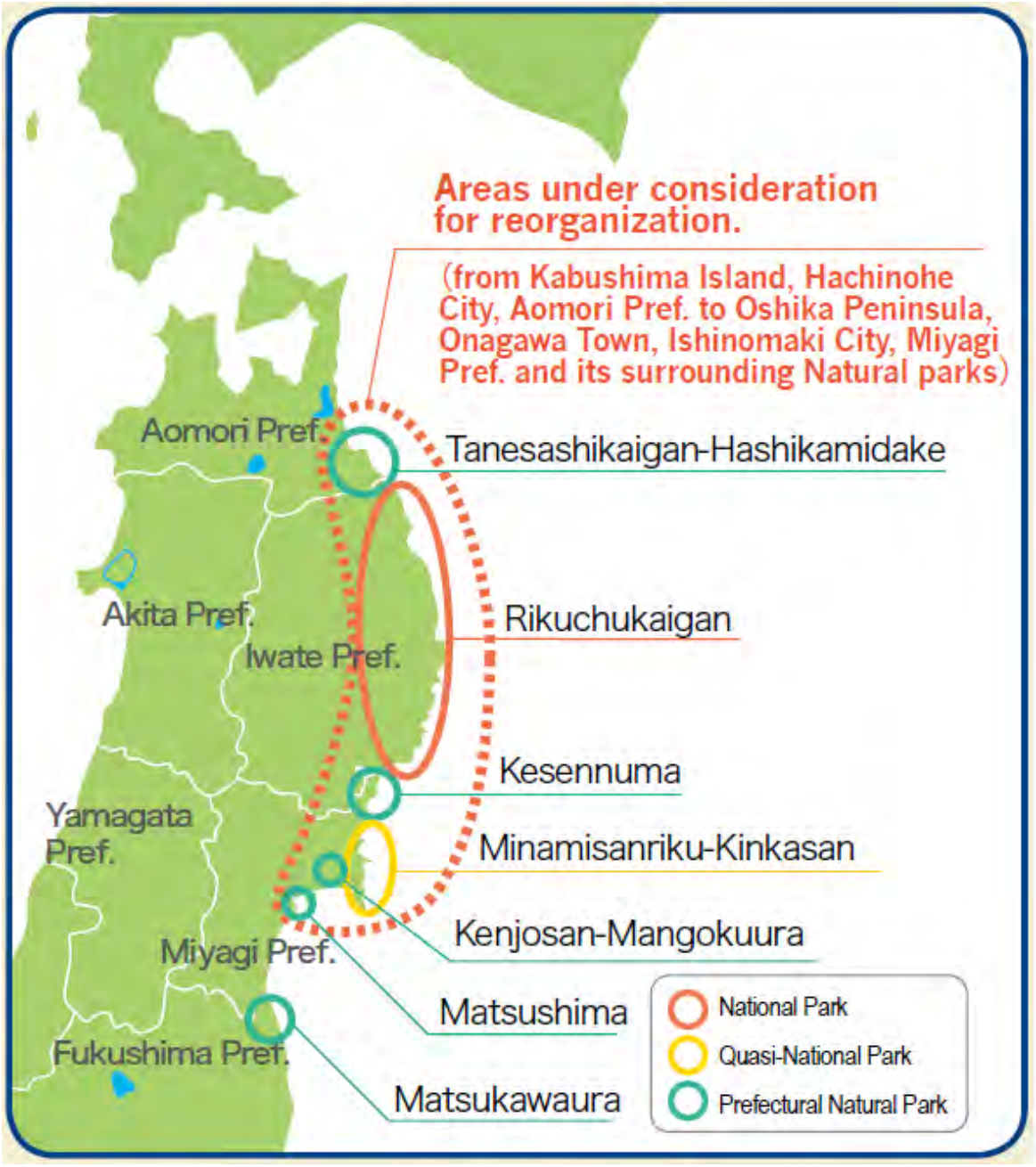


Figure 10: Concept Map of Reorganization of Natural Parks (MoE, 2012a)

One of the examples that MoE is planning on disaster education is to preserve remnant debris of Nakano-hama camping site at Miyako city, Iwate prefecture and develop a park around the area to demonstrate the magnitude of GEJT tsunami disaster. It also plans to develop a disaster education programme for visitors (MoE, 2012b).
Another project to guide reconstruction, the "10 Year Restoration Project for Coastal Forests in the Tohoku Region" was initiated by the Organization for Industrial, Spiritual and Cultural Advancement (OISCA). The decade long project aims to increase seedling production and planting to support coastal forest restoration. The project also aims to prioritize the restoration of farmland and creating employment opportunities.

In Miyagi Prefecture, the "Green Renaissance" restoration project takes a "hands-on" approach to the clearing of debris. Clearing the land with mechanical means may destroy the structure of the soil and consequently, it may take a long time for the soil to be productive again. The project encourages the clearing of debris by hand. The project also uses fresh water to flood and desalinate rice paddies. Thus, any chemicals that may harm the surrounding ecosystems are avoided. Similar projects are under way across Tohoku, including parts of the Urato Islands, Kesennuma, Ishinomaki, and Sendai City (CNN, 2012). The majority of debris clearance and reconstruction efforts have been focused on expedience rather than environmental concerns. For this reason, corporate funding of smaller scale projects such as the "Green Renaissance" is of great importance.

4. Documenting Perceptions of Impacted Communities on the role of Ecosystem Services for DRR

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4.1 Introduction

As reconstruction efforts following the 3/11 events are implemented in the affected areas of Sendai, it is critical to document the perceptions of local communities on the role of ecosystem services for disaster risk reduction. These communities can provide valuable observations and lessons from their experiential learning on impacts from loss of ecosystem services. They can also contribute to the understanding of the role of such ecosystem services during and after a disaster.

Such information is critical in planning for and allocating resources to the restoration of these services (see Chapter 3). It can also play an essential role in ensuring that the ecosystem services are not further damaged due to reconstruction efforts. Reconstruction operations on this scale can have a significant environmental footprint, particularly if environmental considerations are not taken into account in planning and managing operations such as clean-up and waste disposal. This exacerbates the vulnerability of communities to future disasters and impacts upon the timeframe for their livelihood recovery. This Chapter describes the hypothesis and objectives as well as presents the research methods used in documenting the perceptions of communities on the role of ecosystem services in disaster risk reduction. It documents reflections on how the loss of such services may have exacerbated the effects of the 3/11 events and how they have impacted upon the recovery of livelihoods. The data collated through this research is also presented, together with its analyses as discussion and some key conclusions.

4.2 Working Hypothesis

The research was based on the working hypothesis presented below. The hypothesis was intentionally formulated positively to highlight an optimistic perspective on the recovery process:

The role of ecosystems and ecosystem services was taken into account during the reconstruction effort following the 3/11 Tohoku chain of disasters.

4.3 Approach and Methods

Focus group discussions and interviews

In order to test the above hypothesis several interviews were conducted. The interviews were also complemented with Focus Group Discussions (FGD) an approach used so that group dynamics could enhance the interview flow without interference by the researchers. Individual reactions and perspectives could also be observed, however as post disaster interviews are always a sensitive approach, particularly in terms of willingness to participate and other psychological and cultural restraints, FGD provided a collective space for people to participate together. An open questionnaire consisting of six to eight open questions was developed. The difference in the number of questions asked depended on the interview environment. More questions were utilised where "warm-up" questions for setting the context were needed but not all questions were necessary for the evaluation of the research hypothesis. After the initial "warm-up" questions the questionnaire was structured as follows.

In part one, questions about landscape changes in the last decades, the local ecosystems and the services they provide were raised to document the basic perception on the situation before the 3/11 event. The second part consisted of questions about the 3/11 event, and more specifically on the tsunami, including perception on if and how ecosystems were able to reduce the impact of the 3/11 tsunami. The third and final part focused on

the recovery and future development plans, especially issues such as the possibility of participation/involvement in the planning process and their own willingness to relocate.

Depending on the answers of the interviewees, the order and formulation of questions were flexible. The interviews were mostly conducted in Japanese with translation of key answers into English. In addition to the basic questionnaire, side questions and explanations were given as required. Although ecosystems and ecosystem services are well known and well defined concepts in the scientific community, the terms are not commonly used in daily life in Japan. The term Ecosystem is the same in English as in Japanese (生態系), but for the non-scientist it was sometimes necessary to "translate" it into more common words, e.g. types of nature. In order to avoid imposing the authors' perception on the focus groups and other interview partners, other relevant examples were used to explain the terms.

Together with the FGDs, a small number of household interviews and stakeholder interviews were conducted which did not follow the structure of the questionnaire but were merely guided by it.

Interview locations
Considering the emotional sensitivities from the effects of the tsunami, a precautionary approach was taken to identify the interviewees and structure the discussions. The initial interviews were arranged through networks of staff of Tohoku University. Following these initial interviews, personal recommendations, as well as opportunistic connections in the field led to other interviews. Questionnaire based interviews were also facilitated through the networks of interviewees such as some former Tohoku University staff. These questionnaires have been transcribed. Table 2 shows the conducted interviews as well as the type of interview. The focus regions for the interviews (see Table 1) were Yuriage, a part of Natori city, and Tamaura in Iwanuma city.

Date	Location	Interviewee	Type
18 July	Tohoku University	Government official of Sendai City Hall	Open
20 July	Sendai Tech. College	Group of Students	Questionnaire test
03 August	Natori city Restaurant	Group of Students	Questionnaire: IG 1:
12 August	Yuriage JHS Container	Group of Persons active at the Yuriage	Questionnaire: IG 2:
12 August	Tamaura (Iwanuma)	Housewife	Questionnaire: IG 3:
12 August	Iwanuma Temp. Housing	Elderly Women & Middle aged Man	Open/ Narrative
17 August	Minamisanriku	Mayor of Minamisanriku	Open/ Narrative
17 August	Minamisanriku	Tourist house owner & Restaurant owner	Open/ Narrative
18 August	Minamisanriku	Married couple	Open/ Narrative
19 August	Iwanuma Temp. Housing	Group Interview	Questionnaire: IG 4:
20 August	Yuriage Garage	Married couple	Questionnaire: IG 5:
20 August	Yuriage Machi Cafe	Voluntary group active in reconstruction of Yuriage	Questionnaire: IG 6:
27 August	Tohoku University	Government official of Sendai City Hall	Open

Table 2: Conducted interviews

Yuriage (Figure 11) and Tamaura (Figure 12) are only ten kilometers from each other and while the physical-geographic background is similar, the social and settlement structures are different (see Chapter 2). Yuriage, as part of Natori city, is a coastal village with a fishing port as a major source of employment, while Tamaura, a part of Iwanuma city, is situated further inland with only smaller hamlets and industrial areas located near the coast.

Interview Groups (IG)
As shown in Table 2 several interviews were held in Iwanuma and Yuriage. Six of these interviews followed the questionnaire and the responses are summarized in section 4.4. The interviewed groups varied in size, age and social background (no personal data was collected and therefore some information below represent general impressions of the group):

IG 1: The first group interviewed consisted of ten students, all of whom have studied at the Sendai National College of Technology (KOSEN). The interview was conducted according to the questionnaire. Except for one, all students were indirectly affected by the tsunami.

IG 2: A group of four people gathered for the interview at Yuriage Junior High school information centre. They were around the age of 45–50 and had been directly affected by the Tsunami.

IG 3: This single person interview was conducted in Tamaura (Iwanuma city). The woman interviewed was around 35 years old, married and had a son who was seven years old at the time and who was also present during the interview. When the tsunami hit Iwanuma the woman was able to evacuate to the high roof of a factory. Her house was inundated up to 50 cm (inside the first floor).

IG 4: The second questionnaire based interview in Iwanuma city took place at one of the temporary housing areas (see Figure 12). The contact was established one week prior to visiting the site and a spontaneous open/narrative interview was conducted during an evening. As a follow up, the local people offered the opportunity for a group interview for August 19th. A tradition involving eating somen noodles flowing along a bamboo pipe (Nagashi somen) was planned for August 19th and therefore it was ideal for conducting the interview amongst the already gathered community. On the 19th a group of three women (aged between 30 and 60) and three men gathered for the questionnaire based interview.

IG 5: The interview took place at a car garage in the center of Yuriage. The shop owner and his wife (both around the age of 60) were interviewed. They were born in Yuriage and expressed the wish to continue living there. The man mentioned that the Tsunami lasted for around 9 hours in their area and his wife mentioned that her mother was hit by the tsunami while sitting in a car. Her mother survived, even if the car was washed along the road because it did not roll over.

IG 6: The last interview took place at the Machi Café in Yuriage. Interviewees were the café owner, as well as two women who gathered for a computer training course. The participants were willing to participate immediately. The Machi Café was set up to support and encourage tsunami victims through the difficult times. It has since become a gathering and information point in Yuriage, with locals frequently getting together to exchange views and ideas.

Figure 11: Interview locations in Yuriage (IG 2: JHS Container; IG5: Garage; IG6 Machi Café) (Source: by authors).

Figure 12: Interview locations in Iwanuma (IG:3 Household Interview; IG:4 Temporary Housing Area) (Source: by authors).

4.4 Interview Summaries

This section provides a summary of the discussions for each question in the questionnaire as well as for each group of interviewees. All key points are noted below even though sometimes the answers were not directly linked to the question, in order to reflect as closely as possible the thought processes of the respondents. The results of the interviews are discussed in section 4.5.

1.A: What are the changes in the landscape, especially with regard to ecosystems like rice paddies and forests? (IG: 1)

- Sendai Airport rail link
- New streets near the link, built in 2007
- Houses and shops constructed along the new streets
- Most students perceived no other changes in the area
- The students claimed that the landscape of Yuriage is almost the same as in the past.
- The students also perceive Yuriage as a village with many old people and rice paddies
- Shinkashi-gawa in Shiogama city (north of Sendai port) changed as underground pipes were constructed to carry the river water

1.B: How did the landscape change in the last decades? (IG: 2-6)

IG: 2

- Number and quality of roads increased in the last decade
- Number of rice paddies and other agricultural areas reduced in size
- Marina for a National Athletic Meeting was built by the sea

IG: 3

- Number of houses increased (e.g. Megumino)
- One interviewee's own house was built on a former rice paddy.
- Two new seaside parks with forest

IG: 4

- First reaction: expression of fear to go to the sea again
- Length of the beach was found to be shorter than in the past
- Road in front of the Junior High school was widened.
- Fireflies used to be in Iwanuma in the past (not related to the tsunami)
- New harbor

IG: 5

- There were ferries to cross the Natori-gawa until bridges were built
- The Junior High school was moved to a new location
- Many rice paddies were transformed into settlement areas
- The women mentioned that Yuriage was always a port town

IG: 6

- Increased amount of settled area (houses)
- Construction of the seawall and dykes
- Possibility to catch fish before seawall construction, not longer possible for them now

2. What kind of ecosystems do you find in the research area?

IG 1: (No response)

IG 2:

- Rice paddies
- Pine trees (coastal protection forest)
- The sea
- The Teizan channel
- A farm for carnation
- Mountain

IG 3:

- The Igune (Sendai dialect for an isolated group of houses surrounded by a small forest within an area of rice paddies, similar to homestead woodland).
- Many trees in the small forest died (salinization) after the tsunami and were consequently cut down
- Rice paddies (inhabited by a large number of frogs before 3/11 but now only a few are found)
- Currently, rice paddies are of little use (intensive rehabilitation and desalinization needed)
- In areas with good drainage, desalinization already started
- Irrigation canals (unfortunate role as the tsunami waves rushed easily through them into the city)
- Western side of the Teizan was believed to be tsunami safe before 3/11

IG 4:

- Pine trees (coastal protection forest)
- The Teizan Channel (believed to have protected people from the tsunami)
- Rice paddies mugwort (an edible plant).

IG 5:

- Pine trees (coastal protection forest)
- Rice paddies
- The river (Natori-gawa)
- The sea

IG 6:

- The Natori-gawa, consisting of sweet and salt water
- Possibility to catch fish in the river (especially enjoyed by children)
- Teizan channel eastern side: poor drainage caused rainwater to flood the area due to slow run off
- Ark shell clams (specialty of Yuriage)
- Certain understanding that a tsunami would not come to Yuriage
- Luck decided who survived

3. What kind of ecosystem services do you receive from the ecosystems mentioned above?

IG 1:

- Coastal Forest service: protection of houses as they serve as windbreaks (the coastal protection forests consist of pine trees), recreation (visiting the "trees at the beach"), and prevention of landslides
- Rice paddies: produce rice and an area to catch Japanese Killifish (Fundulus) and crayfish
- Sea provides food and is a medium to cool the coastal nuclear power plants
- Rivers: drainage systems
- Dams (along rivers) produce electricity (water power) Islands are perceived to reduce the impacts of tsunamis (how they do so was elaborated on, in the next question)

IIG 2:

- Fresh food, that could either be sold or used for oneself
- Ecosystem has influence on the climate: Yuriage is generally warmer than Sendai

IG 3:

- Igune: protection from high wind speeds
- Rice paddies: access to nature such as providing habitats for frogs (playground for children)

IG 4:

- Mushrooms could be collected from the pine trees
- Rice paddies: food
- The Teizan channel and the sea: source for fish
- Pine trees protect sandy beaches from erosion
- Teizan channel used to wash off the salt water after swimming in the sea, also as a source of bait (for fishing), shells serve as toys

IG 5:

- Food (fish) from the sea
- Rice from the paddies

IG 6:

- Teizan channel used by students for rowing boats
- There are places along the coast where the pine trees were not uprooted and washed away: may have been planted differently; able to protect houses
- The people living near the sea saw abnormal conditions of the sea: evacuated at once (people living inland did not have this impression and stayed, and most of them died)
- Natori city office did not have any measures in place against the tsunami
- It was reported that the tsunami would not come to Yuriage

4. A: For the tsunami case: did ecosystems help to reduce the impact or what helped? (IG: 1)

- The coastal protection forest and islands (especially those in Matsushima bay): were helpful in the case of the tsunami (not generally but specific to location)
- Islands, the protection forest, hills and rocks: changed the tsunami path (redirecting and reducing the energy)
- Seawall reduced the tsunami impact (not an ecosystem)
- Rice paddies near the coastline: no direct influence but an indirect one: as people did not settle as near to the coast and were therefore less impacted
- Seabed: if steep close to the coast the tsunami was higher (Figure 13 below)

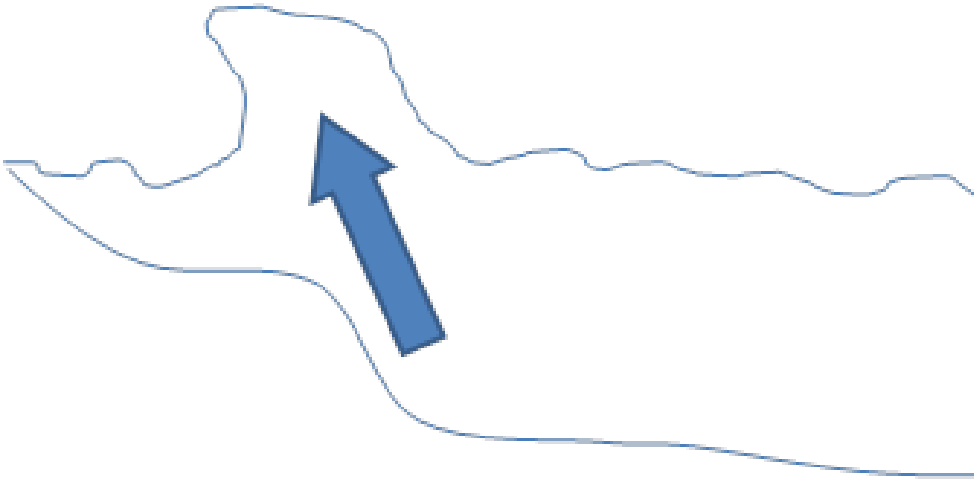

Figure 13 Figure drawn by interviewees in IG 1.

4.B: What kind of ecosystems played a role in reducing the impact? (IG: 2-6)

IG 2:

- Pine trees did not reduce the tsunami impact, but increased impact: pine trees were the first debris to hit the houses

IIG 3:

- No ecosystem helped to reduce the impact
- uprooted pine and floating pine trees increased the impact by smashing into the house

IG 4:

- Pine trees: uprooted, rotated even vertically and added up to the destructive potential of the tsunami
- The hills/mounds: provided evacuation ground, less damage on the backside Lessons learned: find a high spot like hills or high building in the closer surrounding

IG 5:

No ecosystem played a role in that case

IG 6:

- The Teizan channel could not reduce the impact.

5.A: What do you know about the plans for the reconstruction along coastline, what would you like to see? (IG: 1)

- General knowledge about the reconstruction plan for Natori
- Elevation of the urban area by using debris and other materials
- New schools instead of repairing the damaged ones
- Ideas: higher buildings (strong enough to withstand the tsunami), evacuation platforms and buildings on pillars (to give way to the water)
- Riverbed should be deepened to carry a larger amount of "tsunami water"

5.B: What do you know about the plans for the reconstruction along coastline? (IG: 2-6)

IG 2:

- Seawall will be raised (as "first protection" measure)
- Coastal area to be elevated by 3.9 m to 4.9 m , depending on the function as a "second protection" zone or as residential area
- Many elderly people want to move back into the area where they lived before
- Question remains: where to get the soil required for elevating the whole area
- People may address Natori city office to state their opinion about the reconstruction
- Aside from the knowledge about the Yuriage plans the group knew about the resettlement in Iwanuma city

IG 3:

- Iwanuma is known to be the city responding the fastest to the 3/11 disaster in terms of reconstruction
- Experiment by city officers to plant trees on artificial hills, called "Hills of Thousand-year Hope" (made of debris and other materials) to see if the plants can root on them
- New roads are elevated above the normal level (near the coast)
- Roads in Iwanuma city to be widened: easier for construction vehicles to pass through and easier evacuations
- Group relocation has been decided. People following this plan will get support by the city
- Iwanuma City Office listens to the opinions inhabitants. But opinion of older people is taken as more important than those of other groups. Wish that the opinions are weighted equally

Refer to figures 14 and 15

IG 4:

- Iwanuma: decisive reconstruction plans were mentioned and explained in detail
- Citizens opinions were taken into account during the planning process: several meetings, joint discussion (citizens and city officials) on how the resettlement should take place
- Decision on group relocation to a new area in Tamaura (part of Iwanuma) further inland from their original homes (see Figure 14 & 20)
- The site (20 ha) will be the relocation place for six hamlets that were near the coast (see Figure 14)
- Coastal area will be transformed into an industrial zone and a National Park including artificial hills (Hills of Thousand-year Hope) to reduce the impact of potential future tsunamis
- Ground level of the new settlement site will be elevated by 60 cm in general and especially where buildings are going to be erected
- Poles for telecommunication wires, etc. not to be used (underground cables)
- Wish for vegetable gardens: community vegetable gardens will be arranged at the site

- Three elements added to the plan: a small river (water), sites for bonfires (fire) and trees (nature) for enjoyment and relaxation
- "River" to end in a pond (connected with the surrounding rice paddies by pipes) (see Figure 15)

Figure 14: Number of Persons to be relocated and original place of residence.
(Source: Adapted from Iwanuma City, 2012a)

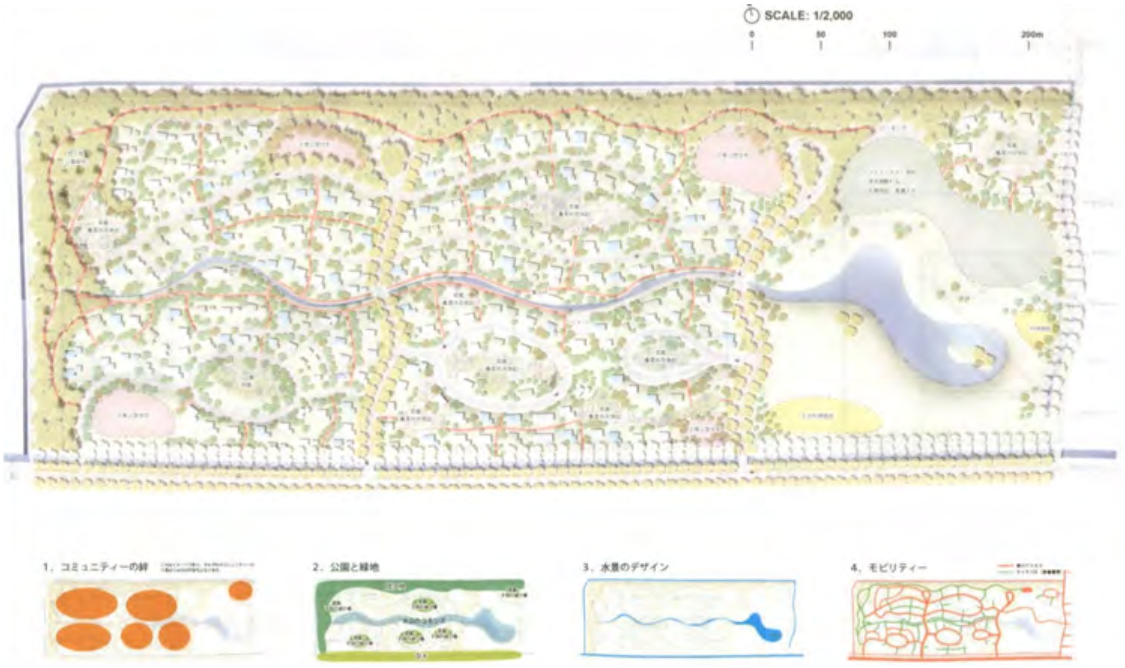

Figure 15: Draft plan for the resettlement area as reported during the interview (19th August 2012). The bottom left figure shows the new arrangement of the six old hamlets (Source: unnamed document, presented during the interview).

6. What would you like to see and is participation possible?

IG1: no response

IG 2:

- Evacuation places and high building provided by Natori city office
- It would still be possible to live close to the sea

IG 3:

- People who cannot go back to work due to e.g. sickness or disability (including old people): support from the city
- For people who are able to live on their own, they should move on with their lives as soon as possible
- Support for single people with mental care, by Iwanuma city

IG 4:

- The question was not raised as the group is already participating and expressed their wishes during the reconstruction/ resettlement planning

IG 5:

- Wish to plant grass and other plants on the dykes
- High seawalls block view on the sea, but better than not being able to live in here (many relatives in Yuriage)
- Teizan channel: it is no longer possible to live on its eastern side, people want to see new plans on how to use the channel
- Structures and buildings like e.g. cycling roads
- Lido that used to be in Yuriage to be rebuilt
- Participation: possible by attending meetings for the reconstruction plan of Yuriage

- Machi Café staff holds meetings called "Kodomo-Kaigi" (Child-meetings) according to the Reconstruction Agency's request. In these meetings children of Yuriage actively participate in reconstruction activities

7. Are you willing to be relocated if necessary, for a safer and sustainable development of the coastal area?

IG 1:

- Interviewees only indirectly affected: not necessary to be relocated
- Not willing to live near the coastline
- If they would live near the coast many people would not be willing to come there (visiting)
- Knowledge to live in an area where many people died would make them remember the tragedy too often
- Story about fear to go back: "When an evacuation order was lifted in Souma city in Fukushima Prefecture, a sushi shop came back there. But as most people did not come back there, the owner of the shop could not run the shop."

IG 2:

- The question was left out as the group already indicated that they want to stay in Yuriage

IG 3:

- Wish to move away from the coast and willing to be relocated, but no financial means to do so
- If a City Office decides to choose local reconstruction, people who choose the local reconstruction can get support from the Office
- Other people e.g. who do not choose group relocation cannot get any supports from the Office
- Natori city officers might tend to give older people´s opinions a greater weight than other people's opinions

IG 4:

- The question was not raised during this interview as the resettlement has already been decided and it was stated that it was "everyone's" wish to group relocate

IG 5:

- Wish to stay in Yuriage: born and raised there. Despite what happened, they want to stay near the sea

Refer to Figure 16

IG 6:

- Living on the eastern bank of the Teizan channel was prohibited after 3/11. The houses must be "moved" inland to the western side (Figure 16 from red to green house)
- If someone wants to move further inland (Figure 16, red arrow and yellow house), this is not possible due to the Natori city reconstruction plan

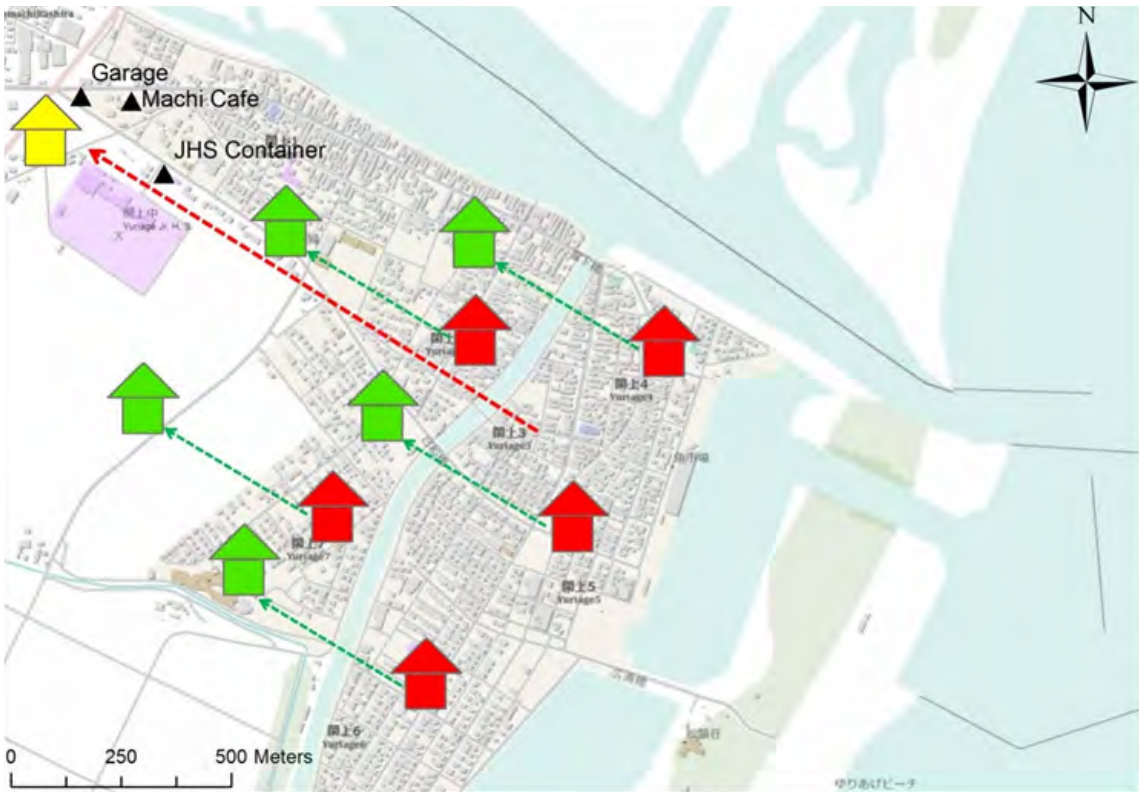

Figure 16: Relocation in Yuriage according to IG 6. Red houses indicate the former residences, green houses the new ones. Moving (red arrow) from the Teizan channel's east bank to the northwest is not possible according to the reconstruction plan (IG 6) (Source: by authors).

8. In your opinion, what kind of ecosystem could help against a tsunami or other natural hazards? (The question was only raised in the first interview – IG1).

Refer to Figure 17 and Photos 1 and 2

- Coastal protection forest: ecosystem that should be enhanced. Whole coastal area should be converted into forest. (Cherry trees in Ishinomaki reduced the impact of the tsunami)
- Construction of hills
- Technological suggestions: new places need to be built, away from the coastline. As the Tobu road (the local expressway - see Figure 2 major road from north to south) helped to evacuate the area, the access to it should be enhanced
- New, higher seawall (official plan): the students preferred better escape routes and elevating the area
- Buildings should be built on pillars and the second floor should be for parking. On Higher Floors the people should be allowed to work and live (Fig. 17b.)
- Other ideas: ditches built to work as catchment for tsunami water (Figure 17c), triangle shaped constructions on the side of buildings to strengthen the whole construction against a tsunami and the floating debris, "tsunami wave returner" (Figure 17a)
- Idea of Coastline (Fig. 17d) that includes a coastal forest, rice paddies, pasture, the "catchment ditch" and buildings that use renewable energy
- When asking about more "nature specific solutions" it was mentioned that they better have had Igune planted

Picture 1: View from Yuriage JHS towards the east, showing the Buddhist temple surrounded by the foundations of destroyed buildings (Photo by authors).

Picture 2: View of the Teizan channel (north of Yuriage). The forest was destroyed by the tsunami and is now removed. On the left (west) a waste treatment facility (build after 3/11) can be seen (Photo by authors).

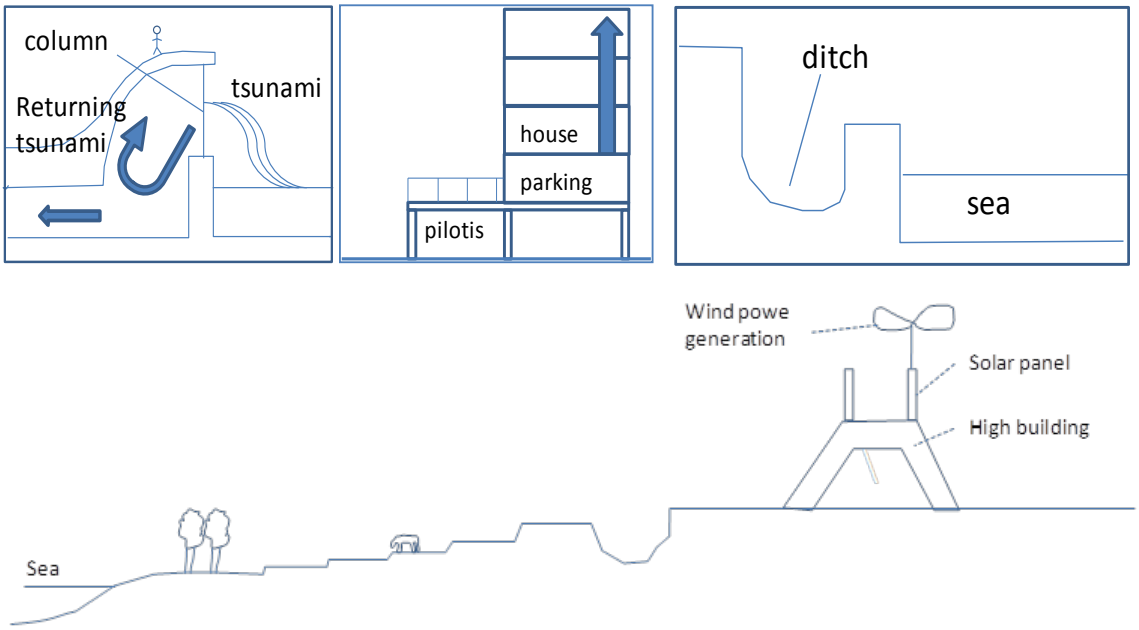

Figure 17: Sketch by an interviewee (IG 1) (From top left clockwise a,b,c,d).

4.4 Discussion

The perception of ecosystems and their services, especially in the context of disaster risk reduction, varies amongst the groups that were interviewed. Questions were open ended and therefore, in some instances, were not answered exactly according to the order in the questionnaire.

The first question aimed at understanding the general perception of landscape changes during the last decades. Younger people provided more detailed answers about recent changes like the Sendai Airport rail link or the diversion of a smaller river underground. Older interviewees provided more general information such as a decreased number of rice paddies and the increased number of settled areas. All interviewees recognized changes in infrastructure and daily life aspect, but elderly people realized the transition from agricultural land to settled area (especially in Iwanuma) to a greater extent.

Similar responses were provided by all groups for Question 2, on ecosystems. The rice paddies were consistently recognized as a specific ecosystem because rice paddies are still a major part in the landscape and are part of daily life. Another well recognized ecosystem was the coastal protection forest, or "pine trees" that formed a green belt from north to south along Sendai Bay´s coastline before the 3/11 Tsunami. The sea and the river (Natori-gawa) were mentioned by a few people only. The term ecosystem caused some challenges as most interviewees did not understand it. Therefore terms like "elements of nature" or similar had to be used to explain the word. With regard to this issue a precautionary approach was taken in order to avoid prompting answers (e.g. rice paddies). Other perceived ecosystems were the Teizan channel and last but not least the Igune (an isolated group of houses surrounded by a small forest within an area of rice paddies).

As a follow up to what ecosystems can be found in the surroundings of the interview sites, interviewees were asked to name the services these ecosystems provided. The most common service described was the provision of food. Rice paddies offer rice and even fish, the sea provides fish and the forest can be used to find mushrooms. The rice paddies also serve as playgrounds for children. Recreational aspects were also related to the forest, the beach and the Teizan channel. Interestingly younger people and those actively involved in the recovery process reported disaster risk reduction as a service. The coastal protection forest serves as a windbreak and reduces the amount of sand blown into the settlements from the beach (erosion). The forest on the

mountainside is also known to prevent landslides. Energy, generated through dams along the rivers, and cooling water for nuclear power plants from the sea were also perceived as ecosystem services. One interviewee mentioned that ecosystems (no specific system mentioned) provide climate regulation. Islands were reported to prevent, or at least reduce, the impact of tsunamis (Islands were seen as a barrier or wave breaker and not as an ecosystem). This perception is related to Matsushima Bay, an area northwest to Sendai, where several small islands served as wave breaks before the tsunami reached the mainland.

In case of the Igune, several services were mentioned. The forest provides protection from strong winds and snow. It can also provide food and building materials. The concept of Igune represents traditional knowledge about disaster risk reduction using ecosystem services.

Based on the working hypothesis, the fourth question aimed at obtaining knowledge about ecosystem based disaster risk reduction in the case of the 3/11 tsunami. Most interviewees had a very clear perception about the role of ecosystems in the 3/11 tsunami, and especially about the coastal protection forest. Several interviewees described the negative effects of the uprooted pine trees, which led to a more severe destruction than in cases where no trees were involved. This perception is highly subjective as the case of Yuriage shows the devastating impact of the tsunami to houses without a protective forest along the sea. Nevertheless, in some places along the coast houses right behind the forest suffered less than others. The perception of the "destructive" pine trees led to the wish for bamboo forests along the coast (despite knowing that it is not possible due to the sandy soil). The often mentioned Teizan channel did not have any influence on reducing the tsunami impact according to several interviewees, similar to the rice paddies. The latter at least was perceived as a passive element of protection. In cases where settlements did not replace the rice paddies near the coast, they served as "open space" to maintain some distance with the coast, giving additional time to evacuate and reduce the tsunami strength. Islands and hills were the only "ecosystems" that had a clear positive connotation, as the case of Matsushima bay where several islands had shown to be useful.

In the first interview (IG 1) the question about the interviewees perception of ecosystem based disaster risk reduction was raised as a separate question (here number eight) but yielded similar responses as discussed above for the other interview groups (IG 2-6). However a major difference can be observed: there is still a strong positive perception about the coastal protection forest (IG 1). Interviewees even described the case of Ishinomaki (a city northeast of Sendai that was severely impacted and where trees reduced the impact in a specific area) as a clear role of forests in reducing the risks. The student group concluded that the whole coastal area should be converted into a forest, and that settlements and infrastructure should be moved further inland.

The final set of questions (five to seven) shifted the topic from the past and recent events towards the future development of the area of Yuriage and Iwanuma. Although not explicitly mentioned during the interviews, several interviewees knew about the government's plan to build a 7.2 m high seawall from Fukushima prefecture up to the northern area of Miyagi Prefecture. While it is challenging for the people of Natori (Yuriage) and Iwanuma to cope with the destruction and make important decisions for the future, in most cases the interviewees had basic knowledge about the official recovery plans.

Yuriage, which is a densely populated coastal village and is part of Natori city has to overcome different challenges compared to Iwanuma city, where the destruction was less due to fewer settlements. While the local government has decided to move people away from the coast in both, Natori city (Yuriage) and Iwanuma, the approaches to do so differ.

Reconstruction in Yuriage:
The current plan for Yuriage is based on a top down decision-making process by the mayor to rebuild Yuriage by moving the settlement from the Teizan channels east bank to the west. This "parallel" shift includes houses and buildings that were located further inland. According to official maps shown in Yuriage (Figure 18 and 19) the first protection line will be a seawall, 6.1 to 7.2 m high (depending on the sources, see Figure 18 blue line) and the seawall will replace the current lower seawall. The second line of protection (Figure 18 yellow line)

will be a raised mound along the Teizan channel's west side, with a height of 4.9 m. It will be lower than the seawall but higher than the settlement area and it will be planted with trees. As Figure 18 shows this plan aims to redirect the tsunami onto the coastal rice paddies rather than into the settlement area. Other plans show the area on the eastern side of the Teizan channel as potential industrial area (Natori City, 2012).

Figure 18: Official Yuriage reconstruction plan
(Photo by authors taken at Yuriage reconstruction information site).

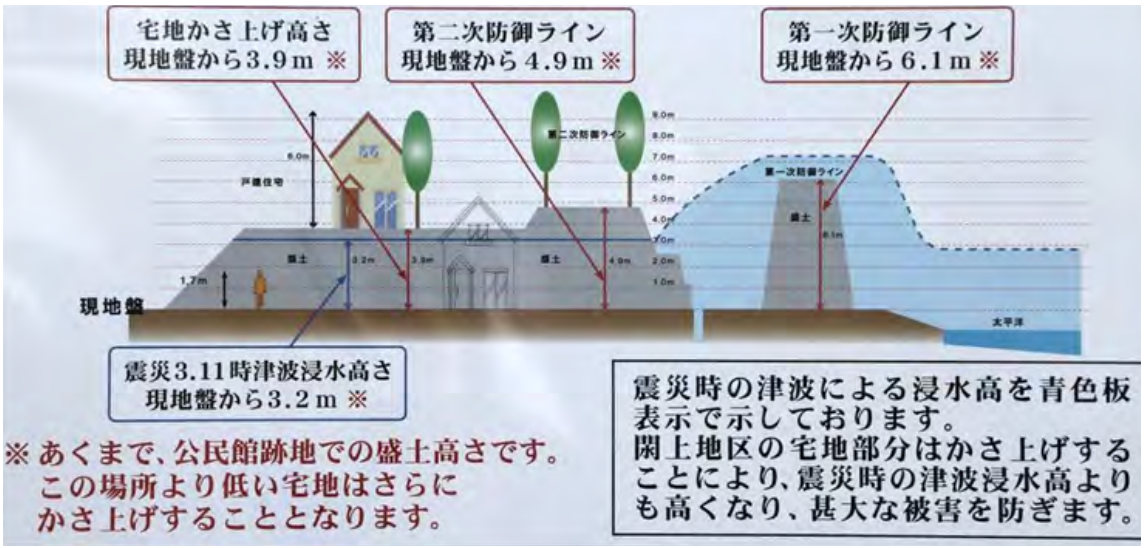

Figure 19: Official Yuriage reconstruction plan
(Photo by authors taken at Yuriage reconstruction information site).

Picture 3: Example for areal elevation according to the reconstruction plan in Yuriage (Photo by authors).

Picture 4: Reconstruction plan model in the community room at the temporary housing area in Iwanuma (Photo by authors).

Question six showed that this plan is questioned by several of the interviewees; especially those with children prefer group relocation (as it takes place in Iwanuma which is further inland and therefore a safer location). According to the interviewees, the official meetings about the reconstruction plan gave the impression of possible participation in the process (e.g. "Kodomo-Kaigi"), but the interviewees pointed out that most of the discussions outcomes were not taken into account and top down decisions by the local government were being pushed forward. Older people tended to stay in Yuriage and according to one interviewee a reason for this could be that they are not expecting to experience another tsunami in their lives for that area.

Resettlement in Iwanuma:

Figure 20: Draft reconstruction plan for Iwanuma: Resettlement (Source: Iwanuma City, 2012b).

Similar to Yuriage, an official decision was taken to move away from the coast in Iwanuma. However, unlike the perceived case of local government decision-making in Yuriage, an Urban Planning Professor from Tokyo University, born in Iwanuma, actively engaged in this process (as shown in Question 6). Figure 20 shows that six coastal hamlets (dotted blue lines) will be relocated to one more inland area in Tamaura (central red dotted area). The decision to relocate six hamlets to one place was based on the evaluation of several potential relocation sites and the consensus amongst the majority of displacees to relocate together. The protection forest is planned to be replanted along the coast, forming a park. Additionally, artificial hills behind the government's seawall will be constructed. These hills are the mentioned "Hills of Thousand-Year Hope" (see Figures 21 & 23).

During the evacuation on 3/11 the small roads lead to traffic jams and people died in their cars as they could not escape with their vehicles. Therefore, widening the roads and elevating them to a certain degree, is also a priority. One interviewee mentioned that the well elaborated group resettlement and reconstruction of coastal Iwanuma had the downside of being an all or nothing decision. People who do not follow the plan will get little support from the governmental side for recovery efforts.

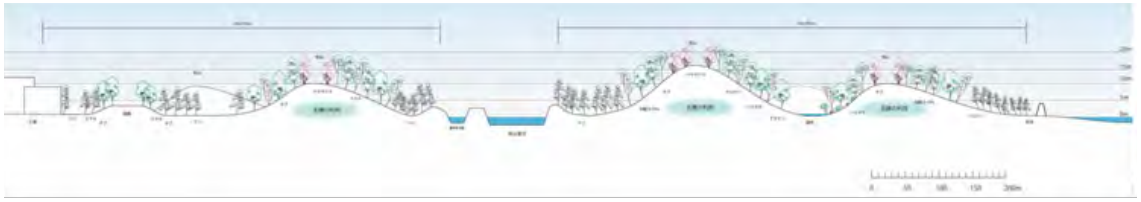

Figure 21: Draft reconstruction plan for Iwanuma: coastal forest and "Hillss of Thousand-year Hope" (Source: Iwanuma City, 2012b).

Although the pine trees along the coast were perceived as harmful in the 3/11 event, they appeared in the early plan for the new relocation area. This shows that a clear differentiation between the general overall positive effects of these trees and the 3/11 negative impacts are understood by the population. The new area was planned to be surrounded by a small forest not only for aesthetic but also for recreational and disaster risk reduction purposes. Igunes are also to be reintroduced in locations in the form of smaller settlements around Tamaura, which are surrounded by rice paddies. As the area for relocation was being prepared for settlements the plans changed (Nov. 2nd 2012). The new plan shows a very different picture than the plans presented by the interviewees. The surrounding forest was removed; the settlement is now denser and streets are rectangular (still wider than similar ranked streets). One central park (Figure 22: light-green striped area) with a lake and two smaller parks (Figure 22: light-green) areas are what is left of the original ideas. Also, the plans moved away from single houses to a mixture of Apartments (Figure 22: central green area) and houses. The old hamlet structure is also not as clear as before (Figure 22). The reported ecosystem based disaster risk reduction idea (although not called like this by the interviewees) seems to have disappeared from these new plans (Figure 22).

Figure 21: Draft reconstruction plan for Iwanuma: coastal forest and "Hillss of Thousand-year Hope" (Source: Iwanuma City, 2012b).

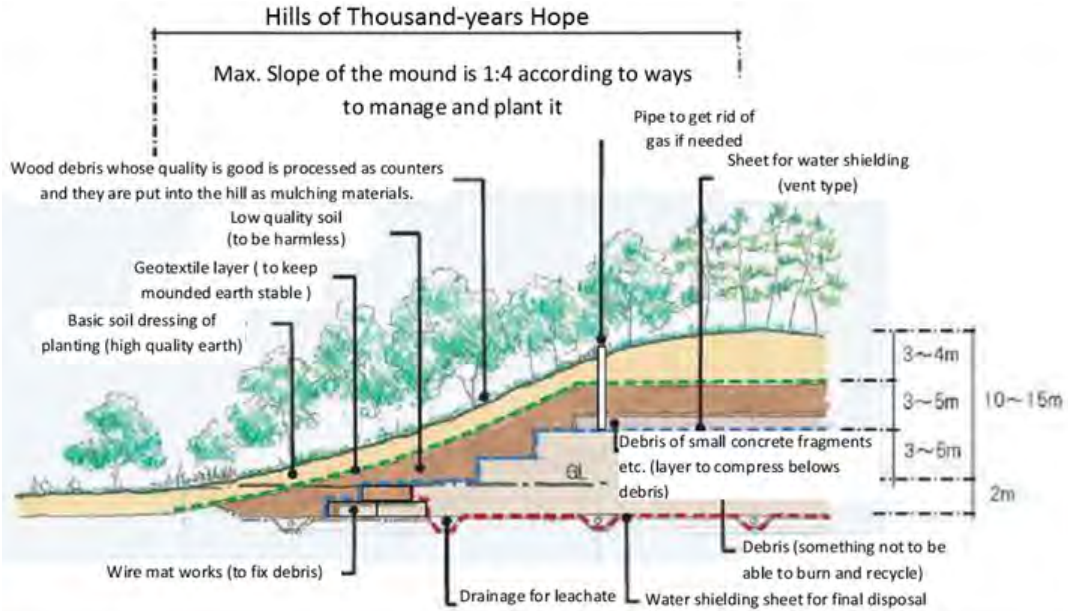

Figure 23: Detailed structure of a "Hills of Thousand-year Hope" (Source: Iwanuma City 2012a).

Picture 5: Example of a "Hill of Thousand-year Hope" (Photo by authors).

Picture 6: Igune near the Sendai coast (Source: F.G. Renaud 2012).

4.5 Concluding remarks on the field work

The reconstruction and resettlement taking place in Iwanuma and Yuriage are only but two examples along the northern Japanese Pacific coast. Both communities suffered from many casualties and significant destruction of infrastructure. Yuriage has chosen an engineering approach for disaster risk reduction while Iwanuma decided on an integrated approach (engineering and ecosystem based) by replanting the coastal forest, building the Hills of Thousand Year Hope and resettling further inland when compared to Yuriage. Therefore we can conclude that the research hypothesis was at least partially verified. However, the recent plans for Tamaura raise questions about the participation being taken fully or if cost-benefit calculations (e.g. higher cost for reconstruction) may hinder the wish to change things towards, for example e.g., ecosystem based DRR and sustainable development. Further investigations are necessary to follow these changes and determine if lessons will be learned for the longer term. The role of ecosystems in terms of disaster risk reduction is not recognized as such, but there are clear indications that people perceive nature to have several benefits, one of which is the protection from disasters. It is also recognized that there are events that cannot be stopped by human means (engineering) due to their exceptional magnitudes such as the 3/11 tsunami, and evacuation is the only option.

5. Conclusions

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The March 2011 Great East Japan Earthquake and Tsunami (3/11 event) had dramatic impacts on the coastline of Japan, resulting in many casualties, missing people, serious environmental damage and destruction of infrastructure. The event led to a cascading chain of disasters: first an earthquake which on its own, generated little relative damage, but which triggered tsunami waves that affected the east coastline. The tsunami then triggered a nuclear disaster when the waves damaged the Fukushima Daiichi nuclear power plant. Due to its high exposure to various hazards and lessons learnt from previous disasters, Japan is one of the best prepared countries in terms of disaster prevention. Such a chain of events anywhere else in the world would have most likely resulted in an even larger scale of destruction.

Disaster risk reduction (DRR) addresses causal factors of disasters, exposure and vulnerability reduction, management of the environment and resources and improved preparedness. This small research initiative addressed only one of these dimensions, namely the role of ecosystems in DRR. The research was carried out along the coast near Sendai city, one of the area's most affected by the events of 3/11. The scientific and grey literature reviews, as well as the policy reviews conducted in this research confirm that Japan has a long tradition of protecting itself from disasters through the use and management of ecosystems. This is particularly evident in coastal regions where coastal protection forests have been planted for centuries. Moreover, the long-established settlement pattern using trees and vegetation, locally known as igune, is also a demonstrative example of how Japan uses ecosystems for protection. Coastal forests and igune provide daily protection from hazards such as wind-blown sand and sea-water, storm surges, cyclones and tsunamis (see Tanaka et al 2013). The research interviews with various social groups in the region also showed that these ecosystem services are well recognized by the population, which values these coastal protection forests greatly, not only for their buffering effects with respect to hazards but also because of the recreational services they provide.

However, the effect of these ecosystems and in particular of coastal vegetation is debated in the case of tsunamis (see Kaplan et al., 2010 and Lacambra et al., 2013 for discussions on this topic in the context of the 2004 Indian Ocean tsunami). There is anecdotal evidence that the coastal protection forest served as a buffer for people and infrastructure against the tsunami waves in Japan. Nevertheless, as is apparent from the many satellite and air photos taken after the tsunami and as noted by many of the interviewees in our research, this effect is contested. Some interviewees asserted that broken or uprooted trees aggravated damages by slamming into houses, which can be verified by the many uprooted trees found in the region after the event. A counter claim was that trees and protection forests blocked debris coming from the sea (such as fishing boats) thus protecting people, property and infrastructure.

Our research results lead to three broad conclusions. Firstly there is a need for further scientific investigation in determining the exact role played by coastal vegetation and other environmental features in protecting populations and infrastructure along the entire affected coastline. It is important to note that rarely does one factor alone explain differentials in damages and it is likely that multiple factors contributed in protecting some areas when compared to others. Further research on which tree species or vegetation combinations withstood the impact better than others is also required, complementing the work already started by some universities in Japan (e.g. Tanaka et al., 2013). These studies need to be systematized, meaning that they need to move away from detailed analysis of specific case study contexts so that broad lessons can be drawn. Another research gap is linked to the proposed reforestation programmes on mounds such as in the case of Hills of Thousand-year Hope. The question of what the mounds will be made of is still being debated and could comprise non-toxic tsunami-generated debris or topsoil. Regarding the former, it remains to be seen if the substrate can indeed support deep-rooted plants while in the case of the latter, it needs to be clarified where this topsoil could come from and if taking that topsoil from other areas does not generate other environmental problems in these areas, i.e. the tradeoffs need to be carefully considered.

Secondly, coastal protection forests should be seen as providing a whole array of services, and not only to protect people against hazards and specifically against tsunamis. It is therefore reassuring that, because of the value attached to these forests by coastal communities, some municipalities in the areas covered in this research consider the replanting of coastal forests in their reconstruction plans, often in conjunction with other, non-ecosystem based solutions. This should be encouraged further through continued capacity development and awareness-raising on the topic.

The third point is one of space. While restoring destroyed coastal vegetation may not be a challenge, increasing its extent means that something else needs to give way, such as housing areas or infrastructure. Chapter 4 presented various relocation plans. Implementing the plans will allow for some additional space for coastal forests or rice paddy fields. However, in affected regions where land scarcity is an existing issue, re-vegetating the coast may be more challenging. As discussed in Chapter 4, yet another challenge of space is linked to the desire of some populations to be resettled according to the igune concept. Authorities may not be able to accept these plans due to space limitation in relocation areas (see the example of Tamaura).

Despite the recognized role of coastal forest in protecting against various hazards, many people, particularly at decision-making level, prioritize technological measures. It is interesting to see from our interviews that the younger generation also mentioned technological measures as a principal DRR solution when their attention was drawn to the possible role of ecosystems. This may not be surprising, given the fact that Japan has already successfully implemented many technology-based solutions to the various hazards they have faced, although the 3/11 tsunami dramatically illustrated the limitations of these solutions in the context of coastal hazard protection. Such a bias for technological measures requires systematic consideration of the role of ecosystems in the rebuilding process, if ecosystems are to be an integral part of risk reduction and reconstruction in Japan. This may require some time for research to deliver information on unanswered questions, however this should not be the reason to dismiss ecosystems as an option. On the other hand ecosystem-based DRR should not be promoted as a panacea for limiting the impact of future hazards in Japan and elsewhere but their careful consideration and uptake (in isolation or in combination with technological measures) could lead to a no-regrets solution (Estrella et al., 2013) that would incorporate coastal protection, protection of people and infrastructure, boost biodiversity, add recreational value, diversify livelihoods and may provide a more cost-effective solution.

Acknowledgements:

We are grateful for the financial support from the Keidanren Nature Conservation Fund. We are indebted to all the respondents to our surveys for their time and valuable insights. We would also like to thank Dr Noralene Uy from the Graduate School of Global Environmental Studies, Kyoto University, Japan for her comments on a previous draft of this report.

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