Ecosystem-based Disaster Risk Reduction in Japan

A handbook for practitioners

Ecosystem-based Disaster Risk Reduction in Japan

Japan is an archipelago of several thousand islands stretching some 3,000 kilometers from north to south, sitting on the boundaries of multiple tectonic plates. Large differences in elevation between the coastal and mountainous areas create steep terrain and many rapid rivers. Japan is located in one of the world's most seismically active areas and accounts for about 20 percent of the world's large earthquakes as well as about 10 percent of all active volcanoes in the world. Japan has four distinct seasons influenced by monsoon and heavy precipitation especially during the rainy and typhoon seasons.

Because of these geographic and climatic features, Japan is prone to frequent typhoons, volcanic eruptions, earthquakes and tsunamis, river flooding, and landslides, which have been causing great damage to society, affecting people's lives and properties since ancient times.

At the same time, the high rates of tectonic activity created complex geography and a variety of habitats, which make Japan one of the rare countries in the world rich in scenic beauties and biodiversity.

Japanese people have long been cultivating a sense of reverence for nature, which can be both nurturing and destructive, and fostering wisdom and philosophy for adapting to and living in harmony with nature instead of conquering it. Sacred groves with shrines, as well as folklores and place names associated with disaster and

preparedness, are found everywhere in the country. The Japanese also have a tradition of utilizing ecosystems for mitigating disaster, such as by maintaining forests to prevent soil erosion, planting pine trees along the coast to mitigate winds and blown sand, planting bamboo trees along river banks to reduce flooding, and using rice paddies as temporary water reservoirs.

However, as nationwide development and social transformation progressed along with the rapid population and economic growth during the postwar and subsequent years, Japan began to lose its biodiversity, as well as reverence for nature and traditional wisdom. In addition, as a result of expanding residential development into disaster-prone areas, substantial additional costs are being incurred for constructing, operating, and maintaining social infrastructure to protect these areas.

The Great East Japan Earthquake and Tsunami of March 2011, as well as the major radioactive release caused by the Fukushima Daiichi Nuclear Power Plant severe accident, led to tremendous damage to people's livelihood and the surrounding natural environment. This experience reminded us once again that we are not separate from nature, which provides us sustenance but also major perils. We were also made aware of the need for more comprehensive disaster risk reduction strategies in preparation for disasters that surpass our worst-case scenarios, including the review of national land use and management in addition to approaches focusing on artificial structures.

In order for us to enjoy safe and affluent living, we must find new ways to live with nature. To this effect, a new concept called "ecosystem-based disaster risk reduction (Eco-DRR)" is emerging that seeks to reduce disaster risks by harnessing the disaster preventing/mitigating functions of healthy ecosystems. Ecosystem-based regional development programs are spreading worldwide, including Green Infrastructure, an EU strategy aiming to create a network of healthy ecosystems as part of social infrastructure to support people's lives.

This handbook introduces some approaches to disaster risk management based on a symbiotic relationship between nature and humanity, and compiles basic information on practical matters for reference.


Reforestation for preventing sediment discharge and floods (Source: Kobe City)

Tree-planting by citizens

Coastal forest for preventing high tides and blown sand

Cutting overgrown bamboo trees

Rice terraces for mitigating floods

Rice paddies for retarding floods
(Source: Hyogo Pref.)

Urban greenery for mitigating inundation
(Source: Sapporo City)

Retarding reservoir for mitigating floods
(Source: Aso GIAHS)

Restored wetland for mitigating floods

Coral reef for damping high-wave energy

Mangrove forest for mitigating damage from high tide

Homestead woodland for windbreak

Why Is Eco-DRR Nece

As population grew in Japan, with its limited flat areas, after the World War II, residential development has expanded even to areas that are susceptible to natural disaster. To protect such areas, social infrastructure projects have been implemented primarily by means of constructing artificial structures.

However, the Great East Japan Earthquake generated tsunami waves that far exceeded the design limits of such structures, causing massive damage. This experience compelled us to adopt a new approach to building disaster-resilient communities through "multiple protection" by combining physical and institutional measures that are aimed to "reduce disaster risks" and "ensure safe evacuation" in times of mega-tsunamis and other calamities based on the principles of "human safety first" and "disasters have no predictable limits."

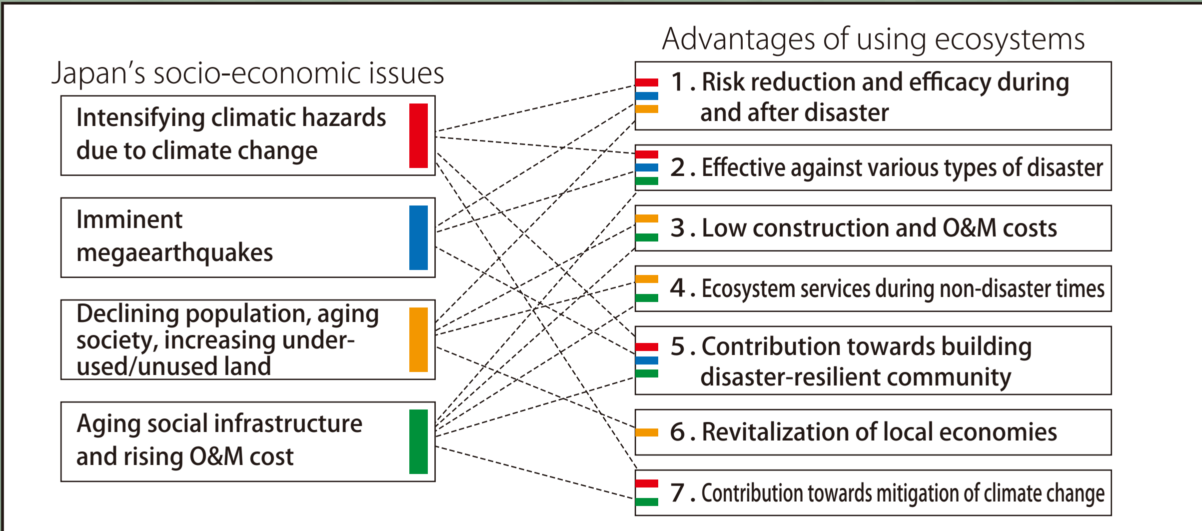
As mega-earthquakes and extreme weather patterns associated with climate change are predicted to occur in the future, we need to plan and prepare for catastrophic natural disasters that exceed our assumptions to prevent and reduce disaster risks. In addition, there are issues of declining population and aging society along with the rising operation and maintenance (O&M) cost of the existing and aging social infrastructure facilities. We need to find a new approach to managing disaster risks by incorporating more comprehensive spatial planning and land use strategies.

Ecosystem-based disaster risk reduction (Eco-DRR) is a concept to reduce the risk of being exposed to natural hazards by avoiding development of disaster-prone areas, as well as by using healthy ecosystems as buffers, to protect people's lives and properties. It also aims to reduce the vulnerability of society and build disaster-resilient communities by harnessing the multiple functions of ecosystems, such as provisioning of food and materials. This concept is referred to as "Green Infrastructure" and is increasingly drawing attention globally in recent years.

Advantages and benefits of Eco-DRR include: (i) various effects becoming evident both at the time of disaster and during post-disaster rehabilitation period, (ii) effectiveness against various types of hazards, (iii) possible cost savings in initial investment and O&M using existing local natural resources, and (iv) provide ecosystem services during non-disaster times. Conservation of biodiversity and ecosystem services also leads to the preservation of local industries and landscapes, thereby supporting the community and the livelihood of residents.

On the other hand, the buffering effect of ecosystems is hard to measure quantitatively. Thus, it is important to combine ecosystems with artificial structures in an optimal balance according to the conditions of each locality.

Declining population means more land becoming available, which can be looked at as an unprecedented opportunity for comprehensive regional and community development, during the process of which Eco-DRR should preferably be introduced systematically and step by step under long-term.



Solutions to topical issues promised by Eco-DRR

ssary for Our Future?

▶ Intensifying Climatic Hazards due to Climate Change

- Climate change is also affecting the weather patterns in Japan, where the numbers of extremely hot days (maximum temperature of 35˚C or above) and sultry nights (minimum temperature of 25˚C or above) are increasing.
- The frequency of hourly rainfall of over 50mm has increased about 1.4 times compared to some 30 years ago, and the number of days with precipitation of over 100mm is also on the rise.
- Flood frequency is predicted to increase 1.8 to 4.4 times in the future. With the rising sea levels due to climate change, coastal areas will be increasingly exposed to the risks of high tides and waves and resulting submersion and inundation. In addition, seawater (saltwater) flowing upstream from the estuaries may affect the river-water intake system and intrude groundwater.

▶ Imminent Mega-Earthquakes

- With large earthquakes predicted to occur in the near future, the risks of tsunami and other disasters remain high.
- For instance, scientists predict a 70% chance of a major earthquake for both the Tokyo Metropolitan Area and the area along the Nankai Trough in the next 30 years.

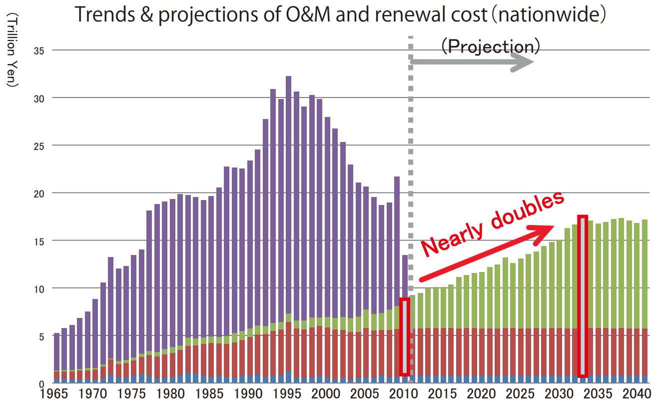
▶ Declining Population, Aging Society, Increasing Under-Used/Unused Land

- As population decreases and society ages at a rapid pace in Japan, the area of land that is not properly managed is expected to increase and expand due to lack of manpower and other resources.
- Population is predicted to decrease to less than half by 2050 in over 60% of existing residential communities.

▶ Aging Social Infrastructure and Rising O&M Cost

- Most of the existing social infrastructure facilities were constructed during or shortly after the high economic growth period (1955 - 1973), which means the ratio of social infrastructure 50 years or older will increase at an accelerating pace in the next 20 years.
- New construction cost reached its peak in 1995 and has since been falling, whereas O&M cost is projected to nearly double in 2030.
- To reduce disaster risk with limited funds, comprehensive land use planning, prolongation of service lives of facilities, and other strategic measures are needed.

Trends & projections of O&M and renewal cost (nationwide)



Legend: New construction /Improvement; O&M; Renewal; Post-disaster rehabilitation

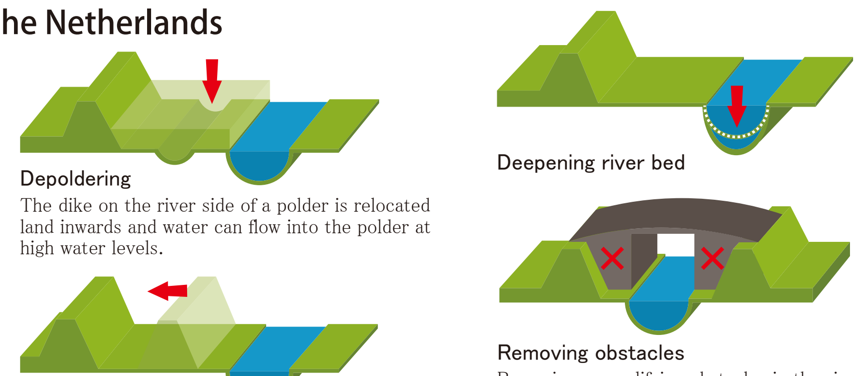
Note1: As no published data are available for new construction/improvement costs between 2008 and 2010, the figures are estimated based on the budgetary growth rate and actual amount invested in each segment of public works projects during the 3 years.

(Source: MLIT)

Column

"Room for the River" Program in the Netherlands

In response to the floods that caused massive damage in 1993 and 1995, the Dutch Government revised its water resource management policies and has been implementing a program called "Room for the River" in over 30 locations. It aims to control floods and enhance the safety of river areas across the country by creating more room for the rivers and restoring the ecosystems through the restoration of polders, recreation of floodplains, relocation of dikes, and other measures.



Depoldering
The dike on the river side of a polder is relocated land inwards and water can flow into the polder at high water levels.

Deepening river bed

Dike relocation
Relocating a dike land inwards increases the width of the floodplains and provides more room for the river.

Removing obstacles
Removing or modifying obstacles in the river bed where possible, or modifying them, increases the flow rate of the water in the river.

(Source: Modified from Department of Communication, Rijkswaterstaat Room for the River, 2015)

Benefits and Advantages

1 Risk Reduction and Efficacy during and after Disaster

When designing measures against natural disaster, it is important to consider how to reduce risks before disaster and support recovery afterwards. Assessing the vulnerability of the area and maintaining healthy ecosystems before disaster strikes contribute to risk reduction.

Ecosystems can mitigate the impact of disaster at the time of its occurrence and provide water, fuel, and other survival essentials until lifelines are restored, thus lowering the vulnerability of the area. During the post-disaster phase, ecosystems, with their ability to restore themselves, support the recovery of local industries such as fisheries and communities by providing various services.

2 Effective Against Various Types of Disaster

Properly managed ecosystems have physical abilities to protect people from a variety of hazards, such as storms, heavy rains, slope failures, debris flows, floods, high tides, and tsunamis. For instance, coastal forests, which shield houses and crop fields from ocean winds and sand, may also mitigate tsunami damage by dissipating tsunami energy, capturing drifting objects, and delaying the arrival time of tsunami.

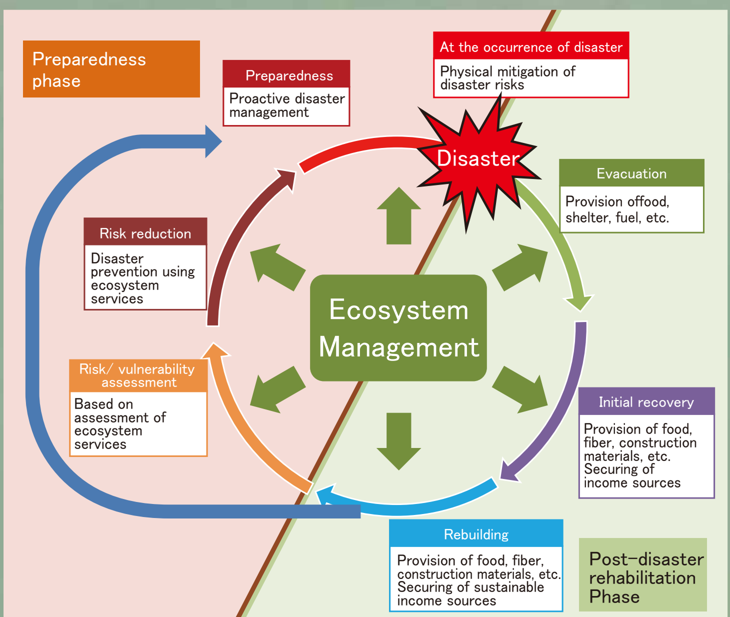
3 Low Construction and O&M Costs

With the rising O&M cost of social infrastructure, reduction of construction cost and prolongation of service lives are increasingly required of future social infrastructure projects. Adopting an Eco-DRR approach may reduce the initial and O&M costs compared to merely building artificial structures. If the existing ecosystems are used as a buffer zone instead of land development, for instance, the cost will be minimal.

4 Ecosystem Services during Non-Disaster Times

In addition to reducing disaster risks, ecosystems provide water, food, fuel, scenic beauty, and a variety of other services, thereby supporting tourism and the primary industries in the region.

For example, coastal forests mitigate tsunami damage by reducing its energy intensity at the time of disaster, while bringing multiple social/economic/environmental benefits during non-disaster times, such as protection against winds and blown sand, formation of coastal landscape, provision of habitats for wild species, and enhanced recreational attractions.



Roles of ecosystems at each phase of disaster management
(Source: Modified from Sudmeier-Rieux, 2003 and Lloye-Jones, 2009)

Coastal pine forest capturing drifting objects (Source: Miyagi Pref.)

# of Eco-DRR

5 Contribution towards Building Disaster-Resilient Community

In implementing an Eco-DRR project, it is important to involve diverse local stakeholders from the planning stage and create opportunities for them to learn about the local ecosystems along with the history and traditional wisdom associated with disaster, identify and share vulnerable spots and the current status of preparedness. This process enables them to think independently how to protect themselves from disaster.

The joint planning and maintenance of ecosystems by stakeholders will create opportunities for local residents and organizations to interact and foster relationships with each other. This can promote cooperation among community members and facilitate quick response in times of disaster and during recovery, as well as early detection of any change in ecosystems that may undermine their risk-reducing effects.

6 Revitalization of Local Economies

Eco-DRR can minimize environmental impact and preserve local sceneries and land areas producing local specialties, thereby supporting the tourism and primary industries, contributing to regional revitalization.

In addition, maintenance and enhancement of ecosystems' functions require proper management, which may facilitate the use of local resources and create new jobs that are unique to each locality.

Kirihama Beach, Hyogo Pref.

7 Contribution towards Mitigation of Climate Change

Disaster risks associated with climate change are becoming a reality. To reduce such risks, the need for "adaptation" of nature and human society is increasing, for which Eco-DRR can be very effective. In addition, ecosystems such as forest and wetland serve as carbon storage, meaning that their conservation, restoration, and proper management will contribute to "mitigation" of climate change.

In other words, Eco-DRR has synergistic effects as measures against climate change.

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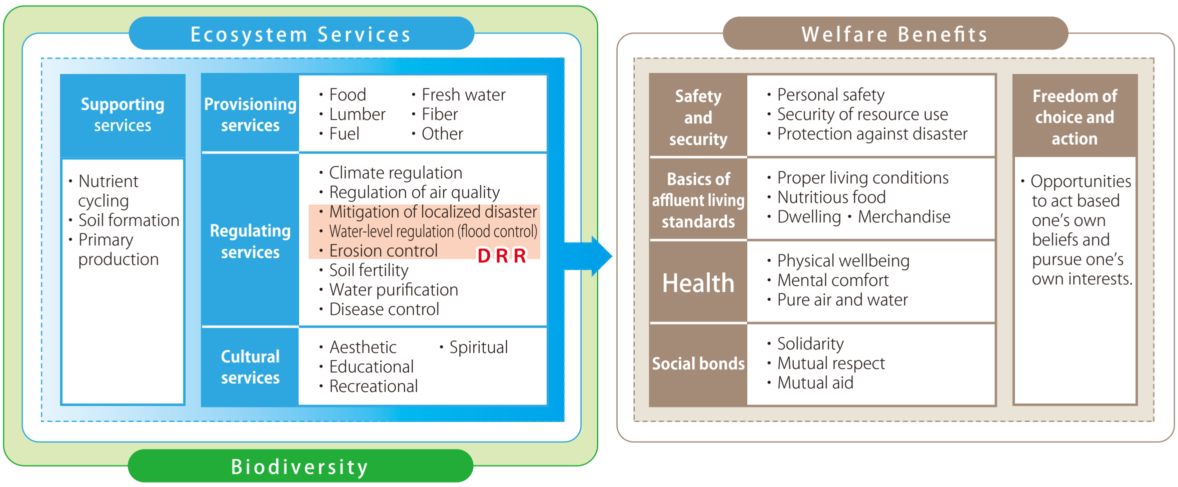
Ecosystem Services Support Our Livelihood

Our daily lives are supported by "ecosystem services", multiple benefits derived from ecosystems and biodiversity. To ensure safe and affluent living, it is important to maintain healthy ecosystems so that the full spectrum of diverse services can be utilized.



▲ Ecosystem services and benefits (Source: Modified from Millennium Ecosystem Assessment, 2005)

Traditional Eco-DRR

Ecosystem-based disaster risk reduction is not a new concept.
Japanese people have a long tradition of conserving/utilizing local ecosystems to prevent disaster, adjusting land-use and other living patterns to mitigate damage, and adopting various other creative approaches based on lessons learned from past disaster events.
It is important to find a good balance between safety and affluent life in each region by learning from and drawing on the traditional wisdom for managing disaster risks and enhancing the quality of living.

Institutionalization of Protection Forests

The idea and institutional system of conversing forests to prevent sediment disaster began appearing during the Asuka Era (538 – 710). The Edo Shogunate (1603-1867) issued the Regulations on Mountains and Rivers to impose restrictions on the development of upstream forests for controlling floods in downstream. *Kimbatsurin*, or modern-day equivalent of protection forests, in which logging was prohibited for the purposes of conserving headwater and protecting scenic beauty, already existed in the medieval ages. During the Edo era, *Kimbatsurin* were designated throughout the country under such names as *Tomebayashi*, *Otomeyama*, and *Mizudomeyama* to restrict the cutting of standing trees. Subsequently, the Meiji government (1868-1912) established the protection forest system to manage and protect forests that were important for disaster risk reduction according to the natural and social environment of each area.

Homestead Woodland to Protect Homes from Winds

Homestead woodland ("*Yashikirin*"), or windbreak trees surrounding houses, are seen in many parts of Japan. *Yashikirin* are called by different names in different regions, such as "*Igune*" in the Sendai Plain, "*Kainyo*" in the Tonami Plain, and "*Tsuiji-matsu*" in the Izumo Plain, indicating that they are deeply rooted in their respective local communities.

Protection Forests for Water Damage Prevention

Riverside protection forests protect riverbanks from erosion and mitigate flood hazards.

Shingen Takeda, a noted warlord of Kai Domain (now Yamanashi Prefecture) of the sixteenth century, constructed "*Shingen Zutsumi*" (Shingen Levees) over a period of 20 years following a major flood in 1542. Floodplains were constructed behind *Shingen Zutsumi*, to mitigate flooding, and zelcova, bamboo, and other trees planted to reinforce the embankments. In 1610, Shigeyasu Narutomi launched an integrated irrigation and flood-control project along the Chikugo River of Bizen Domain (now Saga Prefecture) by taking advantage of the unique characteristics of the river area to develop various irrigation/flood-control facilities, such as flood protection forests combined with discontinuous levees ("*Kasumi-tei*") and a water channel called "*Hamaguri Suido*" that used irrigation ponds to regulate water flow.

Tsuiji-matsu in Izumo Plain, Shimane Pref. (Source: Shimane Pref.)

Protection Forests for water damage prevention
(Kyushu Regional Forest Office, Forestry Agency)

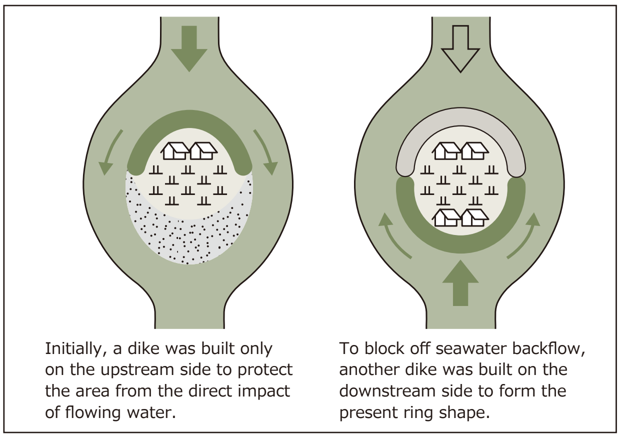
Approaches

Waju zone where Kiso, Nagara, Ibi Rivers merge
(Source: Agricultural and Rural Development Information Center)

▶ Protection against High Water by Waju (ring dikes)

Waju refers to a community surrounded by a ring dike (*Waju zutsumi*). Waju is a traditional wisdom to create marshy lowlands suitable for farming to both benefit and protect the inside area from floods. Many *Waju* were constructed during the Edo Era, the most famous of which are found in the Nobi Plain in the lower reaches of the three major rivers of Kiso, Nagara, and Ibi.

The *Waju* dikes in the Nobi Plain were initially not closed circles, but had a horseshoe shape with the opening facing the downstream direction. The residents used the opening to drain water during floods and grew crops during non-flood seasons for a living. Over time, as the riverbed grew shallower by settled sediment, *Waju* became increasingly susceptible to swamping. To counter this, dikes were extended to take the present ring form. They also built retarding water reservoirs in the southern lower part of Waju to prevent inundation, and utilized sediment and driftwoods brought by floods for farming and daily use.



Formation of Waju
(Source: Agricultural and Rural Development Information Center)

▶ Names of Localities Speaking of Past Disasters

Places, which have experienced destructive floods or sediment disasters in the past, may have names that are indicative of such events. Certain *kanji* characters used in place names also indicate highlands, lowlands, reclaimed coastal areas, ponds and rivers.

water:

川・池・浜・津・洲・沢・湧

coastal/riverside area, lowland, wetland, etc.:

浅・深・崎・戸・門・田・谷

areas that have experienced major sediment disaster:

蛇・竜・龍

Column

International Trends

The United Nations launched the “International Decade for Natural Disaster Reduction” in 1990 with an objective to decrease the loss of life, property destruction, and social and economic disruption caused by natural disasters, and established an inter-agency secretariat for disaster risk reduction under the International Strategy for Disaster Reduction in 2000. In 2015, the Sendai Framework for Disaster Risk Reduction 2015-2030 was adopted to establish action guidelines for preparedness, which emphasizes the sustainable use and enhanced management of ecosystems for reducing disaster risks.

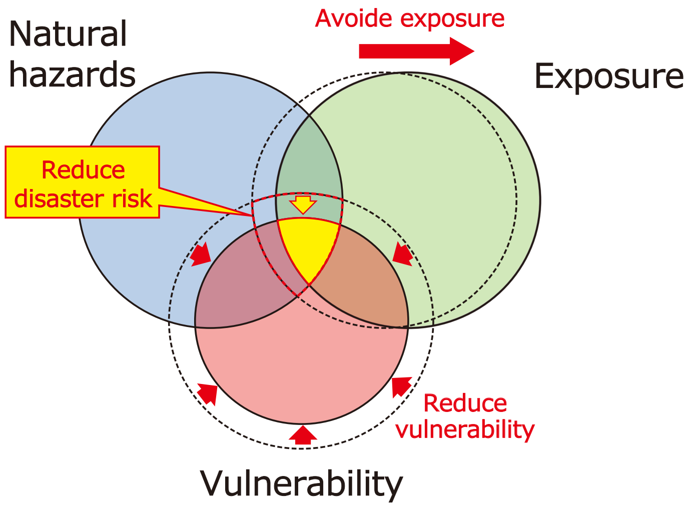
3rd UN World Conference on Disaster Risk Reduction at Sendai
(Source: Prime Minister of Japan and His Cabinet)

To promote and scale-up implementation of Eco-DRR in line with these international movements, the Partnership for Environment and Disaster Risk Reduction (PEDRR) was established in 2008 as a global alliance of the United Nations Environmental Programme (UNEP), the International Union for Conservation of Nature (IUCN), international NGOs, and research institutes.

Ecosystem-based Approaches

Natural Hazards and Disaster Risks

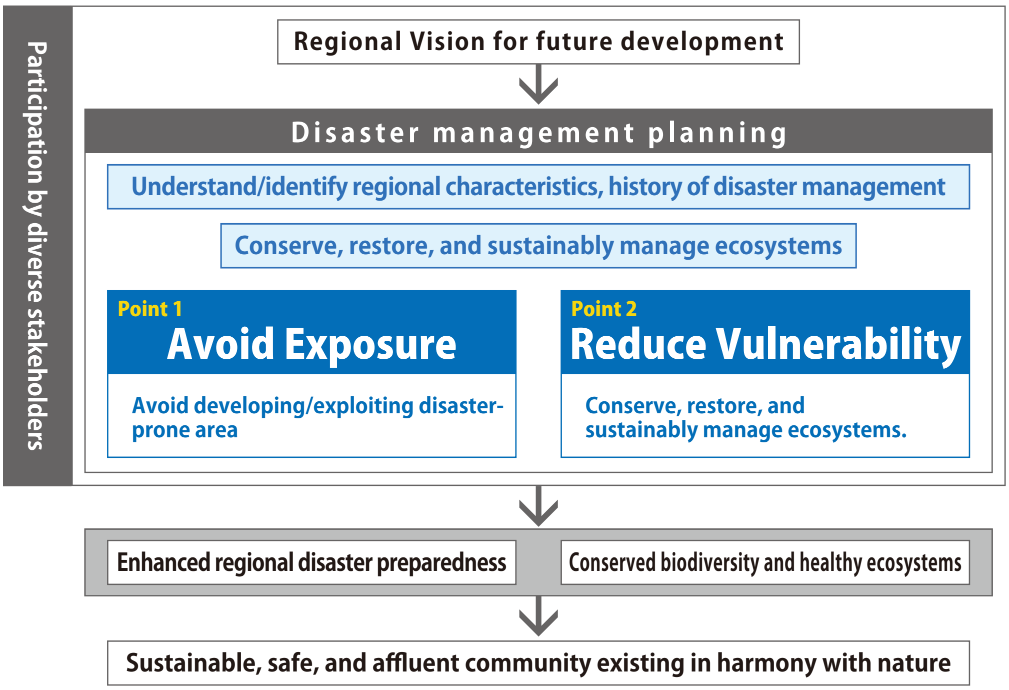
The term “natural disaster” refers to a calamitous event, such as a volcanic eruption, earthquake, tsunami, river flooding, typhoon, or landslide, that causes loss or damage to human lives, houses, other properties, and social infrastructure because its intensity or magnitude exceeds the coping ability of human society.
Natural hazards that cause no damage to human society do not constitute disasters.
Disaster risks can be understood in terms of “exposure of human lives and properties to natural hazards” and “vulnerability to natural hazards.”
To reduce disaster risks, it is important to avoid “exposure” and decrease “vulnerability,” both of which can be effectively reduced by properly utilizing ecosystems.



Concept of disaster risk reduction
(Source: Modified from ADRC, 2005)

Concept of Ecosystem-based Disaster Risk Reduction

The concept of Eco-DRR can be summarized as follows:
An approach to reducing disaster risks that takes into account (i) regional characteristics, (ii) joint participation of local residents and diverse other stakeholders to conserve, restore and sustainably manage the local ecosystem, (iii) avoiding exposure to disaster by avoiding utilization and development of areas prone to natural hazards, and (iv) reducing social vulnerability through diverse other functions of ecosystems.
This approach reinforces local communities’ preparedness for disaster while conserving biodiversity and ecosystem services, thereby contributing to the development of sustainable, safe, and affluent society living in harmony with nature.”



Concept of Eco-DRR

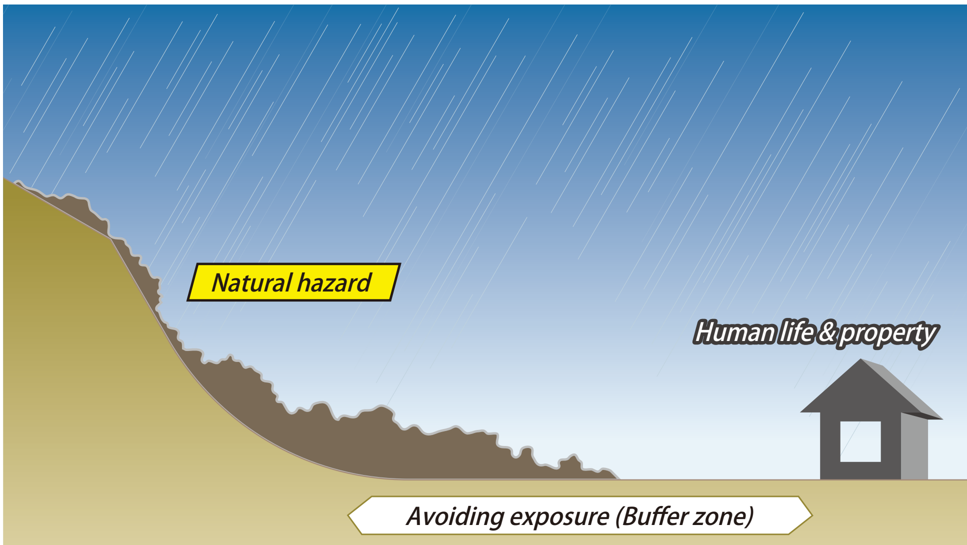
for Disaster Risk Reduction

▶ Reducing Disaster Risks based on Ecosystems

Avoiding Exposure

Exposure of human lives and properties to natural hazards can be avoided by not developing disaster-prone land areas and by conserving/restoring ecosystems.

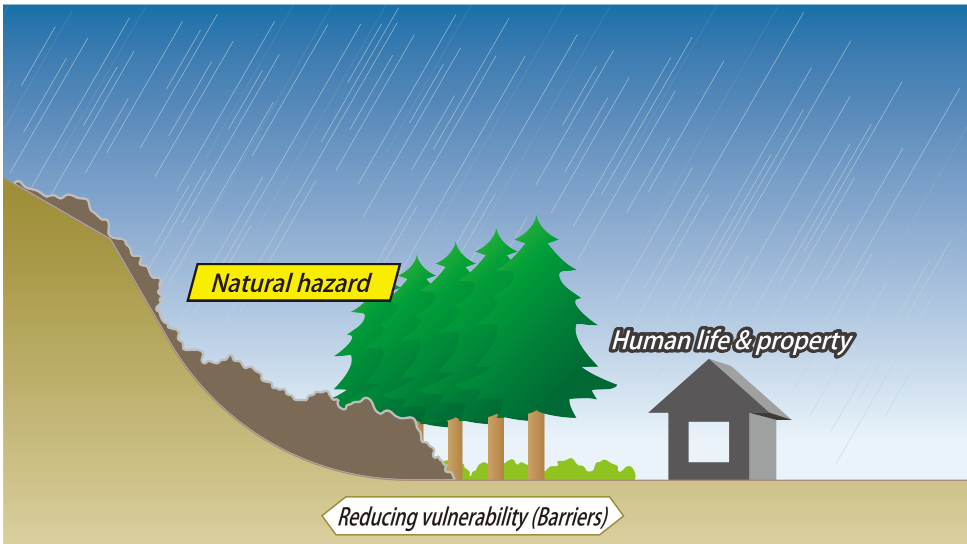
Identify areas that are susceptible to natural calamities (such as wetland, coastal ecosystems, forests on steep hills) based on the geography, local ecosystems, and historical records; then avoid developing such areas so as not to expose human lives and properties to natural hazards. Properly maintained or restored ecosystems serve as buffer "zones" in times of disaster and bring various other services and benefits to human society on a daily basis, such as healthy aquatic environment, bio-resources, and recreational space.



Reducing Vulnerability

Healthy ecosystems can act as physical "barriers" against natural hazards to reduce their impact, and provide food and other resources to support livelihoods of people, thereby reducing the vulnerability of society.

Examples of healthy ecosystems that are serving as "barriers" against disasters such as forests preventing soil erosion, windbreak and sand break forests mitigating tsunami, coral reefs mitigating high tide damages, salt marshes mitigating surge wave damages, and wetlands working as temporary flood reservoir. Ecosystems also purify water and perform multitude of other functions in addition to providing food, fuel, construction materials, and other resources. These functions are expected to support human lives and reduce socio-economic vulnerability.



Key Points in Adopting Eco-

Point 1 Examine Options from a Comprehensive Perspective

When implementing disaster management measures, it is important to make decisions from the perspective of how to build disaster-resilience of the whole region rather than addressing the risks of individual sites, while endeavoring to contribute to the enhancement of socio-economic resilience of society at large. Accordingly, disaster management strategies should preferably be devised as part of comprehensive regional development planning from multiple standpoints and based on visions as to how the region's environment, landscape, industries, and communities should look like in the future.

In doing so, it is important to use a spatial-planning approach integrated with a temporal perspective as to how the land has been used in the past and should be used in the future.

Point 2 Develop a Regional Consensus

Eco-DRR is often accompanied by a need to alter existing land-use patterns. As the risk level varies for different people depending on the type of land and the method used, it is important to have sufficient risk communication towards making regional decisions and reaching a regional consensus. Involvement and consensus among diverse stakeholders will be especially crucial when an Eco-DRR project requires continuous maintenance of ecosystem by local residents in order to sustain its disaster-reducing effects after the completion of the construction work.

During the consensus-building process, public meetings, open discussions, and disclosure of information validated by science will play a vital role. To obtain the understanding of stakeholders, we also need to employ other creative approaches, such as presenting a quantitative analysis of disaster-reducing effects of the project along with the potential risk of disaster damage that may occur if the ecosystems are not conserved, assessing (quantitatively if possible) the ecosystem services that can be enjoyed during non-disaster times, showing mock-up models and drawings, and using easy-to-understand language. Conducting an anonymous questionnaire survey will also be effective in encouraging people to express their honest opinions.

Point 3 Utilize Local Ecosystems, Disaster-related History and Traditional Wisdom

Having a full grasp of the regional characteristics of disasters and ecosystems, which differ vastly from region to region, is essential for effectively utilizing ecosystems to reduce disaster risks. Records of the indigenous ecosystems and past land-use patterns of the region provide important information in assessing disaster risks. Each region maintains disaster records, describing the type, place, timing, scale, and conditions of each occurrence. Folklores and place names may also indicate past disaster events. Many communities have developed their own disaster management techniques and traditions suited to the characteristics of local ecosystems based on the lessons learned from past disaster events over a long history.

Tsunami Stone Monument (Source: Iwate Pref.)

Marks the highest level of the tsunamis in the past, warning residents not to build houses below this level.

Point 4 Establish a Mechanism for Conservation and Maintenance

Continuous maintenance or upgrading in some cases for better performance, of healthy ecosystems is important in order to benefit from their disaster-reducing effects on a sustainable basis. This requires the establishment of a mechanism for continuous management by local residents, which includes the restructuring of the existing land use and management patterns while respecting traditional practices in relationship with nature.

The primary providers of disaster-mitigation and other ecosystem services are rural regions that are rich in nature, whereas the recipients of their benefits reside in larger regions, including urban districts. In order to ensure a safe and affluent living environment, where people can continue to benefit from the bounty of nature well into the future, we need to institutionalize a maintenance system, which is willingly supported by the whole citizens who are aware of the gifts of nature.

On-site Discussions (Source: Aarakawa Joryu River Office, MLIT)

DRR Approaches

Point 5 Consider Eco-DRR as a part of Spatial Planning

When considering an Eco-DRR approach from a spatial planning perspective, we need to survey the geography and assess the disaster-mitigation and other services provided by local ecosystems to create maps and identify disaster-prone areas, as well as existing and potential ecosystems that may be utilized as buffer zones or natural barriers.

In disaster-prone areas, it is desirable to restore the original ecosystems that have been lost so that they can be utilized for multiple purposes. In doing so, the ideal approach would be to ensure organic continuity from land to sea centered on areas that have excellent natural environment and resources utilized through proper conservation.

When designing regional biodiversity strategies, it is important to establish a policy based on the aforementioned planning and assessments, which should also be incorporated in land-use planning and Fundamental Plan for Regional Resilience.

Point 6 Properly Utilize Ecosystems According to the Conditions of Each Locality

When adopting an Eco-DRR approach in accordance with a spatial plan, it is important to identify the types, scales, locations, and other attributes and unique characteristics of local ecosystems that may be utilized for reducing disaster risks, as well as the types and scales of potential disasters to be managed. Ecosystem-based approaches can be divided into the following four types.

Ecosystem-based Approaches

Type	Description
Conservation/management of existing ecosystems	Conservation/management of healthy ecosystems through designation and maintenance of protected areas and other measures.
Restoration of degraded ecosystems	Restoration of degraded natural environment through regeneration of healthy ecosystems.
Creation of new ecosystems	Creation of ecosystems such as coastal protection forest for disaster risk mitigation and other purposes.
Integration of artificial structures and ecosystems	Combined use of artificial structures with the above three types of ecosystem-based approaches for reinforcing disaster-management function, conservation/restoration of ecosystems, and making use of other functions to meet the needs of the region.

Point 7 Utilize Quantitative/Economic Assessment Results

Quantitative and economic assessments of ecosystems will provide rational criteria for making decisions to build a consensus. Results of such assessments, which show not only the disaster-reducing effects of ecosystems but also the cost performance and economic values of ecosystem services during non-disaster times, will help prioritize the needs of each locality according to its conditions and characteristics. However, the accuracy of quantitative assessment of disaster-reducing and other effects has not reached a satisfactory level, therefore further study and research are required.

Ecosystems can be assessed from the following four standpoints.

Perspectives of Quantitative/Economic Assessment

Type of benefits	Type of assessment	Example
Disaster risk reduction	Quantitative assessment	Volume of soil that can be retained by forest to show its effect in preventing slope failure, etc.
	Cost-benefit analysis	Estimated cost of damage when the disaster-mitigation effects manifested in comparison to the estimated cost when they didn't.
Ecosystem services during non-disaster times	Market goods*1	Values of tourism resources, revenues generated through the sales of local specialty goods, etc.
	Non-market goods*2	Carbon-storage, air-purification, and other functions of ecosystems.

Note 1: "Market goods" refer to goods and services that are traded in general markets.
Note 2: "Non-market goods" refer to values that are not traded in markets, such as functions make the natural environment and livelihood better.

CASE 1

Regional Planning with Comprehensive View

The Ohashi River Area Development Master Plan

The Ohashi River flows through the central district of Matsue city, Shimane Prefecture. "The Regional Development Master Plan for the Ohashi River Area," which aims to redevelop the area by controlling river flooding while conserving the environment and landscape, was formulated in response to the voices of the residents desiring to protect the city's abundant natural beauties and historical landscape prior to designing the individual components of the improvement project.
The Master Plan was established by the Investigative Commission for the Development of the Ohashi River Area in collaboration with its subordinate organ the Landscape Advisory Committee based on the needs and opinions of the residents expressed at the briefing sessions and forums.

▶ Project Operator

Ministry of Land, Infrastructure, Transport and Tourism (Izumo River Office), Matsue City, Shimane Prefecture

▶ Outline

- The Regional Development Master Plan for the Ohashi River Area provides a set of guidelines for meeting the needs for flood control, environmental conservation, landscape conservation and community vitalization in the tributaries of the Hii River basin; Ohashi River, Tenjin River, and Asakumi River.
- The Master Plan sets a specific development policy for each zone of the area. The upstream zone aims to build a community with more water amenity spaces. The middle zone seeks coexistence of humans and other species by conserving environment and water resources as part of the sceneries of rivers, canals, crop fields and wetland. The downstream zone emphasizes appreciation of the historical, cultural, and environmental values associated with water and preserves them for the future generations.
- The content of the Master Plan is reflected in various projects and programs related to the comprehensive development of the entire Ohasi River area, including the Ohashi River Improvement Project, which integrates river improvement and hinterland development.
- The Master Plan was finalized through 11 Investigative Commission meetings, 10 Landscape Advisory Committee meetings, and a total of 70 briefing sessions (1,576 participants in cumulative total) in 8 districts, where each item on the list of opinions from the residents and experts were discussed based on the responses from relevant administrative agencies until consensus was reached.

▶ Disaster prevention/mitigation

- Mitigation of flood damage (river widening/deepening, embankment)

▶ Ecosystem Services during Non-Disaster Time

- Provision of educational opportunities (environmental education)
- Enhancement of aesthetic values (landscape)
- Provision of recreational opportunities (aquatic space, river bank trails, fishing)

Citizens' Forum poster

Matsue residents invited to observe a full-scale mock-up

(Source: MLIT)

CASE 2

Regional Consensus Building

The Uda River Flood Control Planning Council

Prior to formulating an improvement plan of the Uda River flowing through Yonago City, Tottori Prefecture, a council comprised of experts and local residents was established to discuss and compile a "Proposal for the Uda River Area Flood Control Plan."
The council proposed to utilize the existing crop fields as temporary water storage sites in times of flood, instead of significantly altering the present land use patterns, which was accepted by the stakeholders.

Field trip

Project Operator

Tottori Prefecture

Outline

- Prior to designing the Uda River Improvement Project for mitigating frequent inundation of houses and crop fields, the Tottori Prefecture established the Uda River Flood Control Planning Council comprised of local residents (community association members), related organizations (NPOs, chamber of commerce, land improvement districts, fisheries cooperative association, etc.), academics and empirical experts to build the Uda River Area Flood Control Plan based on consensus among stakeholders.
- The Council discussed flood control measures such as improving local sections of waterway, constructing embankments in residential districts, utilizing the existing crop fields as temporary water storage sites while maintaining their soil fertility, and conserving forests to increase their water retention capacity.
- While discussing options for making a practical, feasible proposal for flood control, the Council held public meetings to listen to the opinions of a wide range of residents before finalizing the proposal for the Uda River Area Flood Control Plan.
- The Tottori Prefecture disclosed the process and content of discussions held by the Council to the residents of the Uda River area via newsletters and other media, and held briefing sessions and conducted questionnaire surveys to encourage participation of the residents in the decision making process.

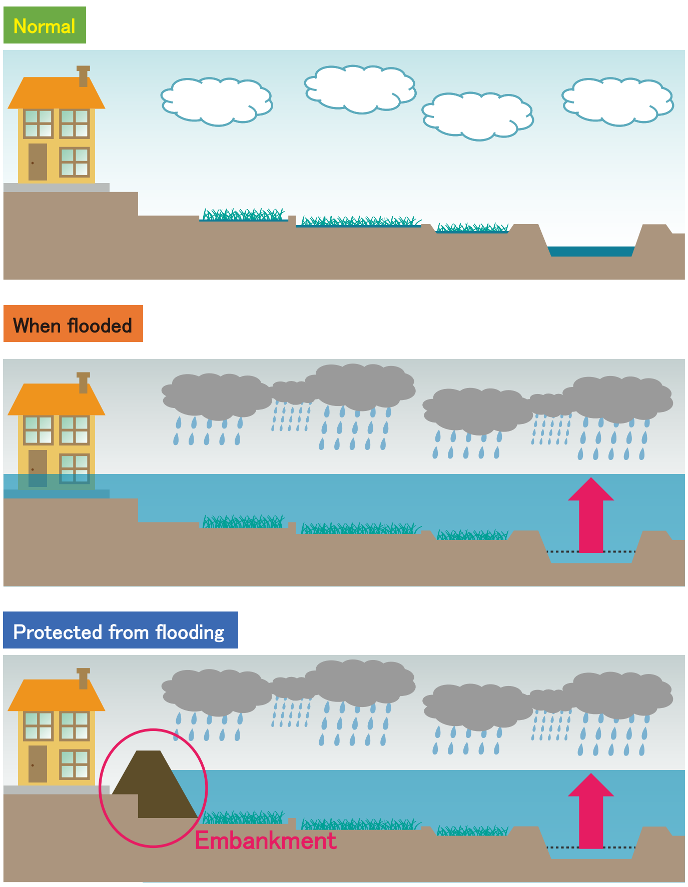
Public meeting

Disaster prevention/mitigation

- Temporal storage of flood water in crop fields, flood control function by forests

Ecosystem Services during Non-Disaster Time

- Provisioning service (water for irrigation)
- Conservation of biodiversity and habitat (86 insect species, 36 bird species, 15 fish species, 4 mammalian species, 3 amphibian species, 2 reptilian species, 2 plant species, plus some crustacean and shellfish species)
- Enhancement of aesthetic values (natural environment, countryside scenery)
- Provision of recreational opportunities (places for relaxation and refreshment)



Use of crop fields as temporary water storage sites to protect houses from flooding without altering their land use for agricultural production.

(Source: Tottori Pref.)

CASE 3

Disaster Prevention and Mitigation through Conservation and Revitalization of Ecosystem

Protection Forests

The Forestry Agency designates forests that are important for disaster prevention purposes as the Protection Forests, where cutting down trees, alteration of land shapes, and other activities are restricted, in order to enhance their various functions, including headwaters conservation and prevention of sediment collapse and other disasters.

At the time of the Great East Japan Earthquake, coastal protection forests and sand hills functioned as dampers and catch fences against tsunami and beached boats thereby alleviating direct impact and damage to the houses in the hinterland, and demonstrated disaster mitigation effects. Consequently, coastal protection forests are now being restored or maintained to enhance their disaster prevention/mitigation functions against tsunami and high tides.

Project Operator

Forestry Agency

Outline

- Protection Forests are classified into 17 groups according to their purposes (headwaters conservation; prevention of sediment discharge, sediment collapse, blown sand, windbreak, flood damage, tide damage, drought damage, snow damage, fog damage, avalanches, falling rocks, and fire; fish protection; navigation target; public health; and scenic beauty) and being managed and conserved in ways that are appropriate for their respective designated purposes.
- For examples, the Forest Agency systematically designated Protection Forests and restricted logging and land-use conversion, as well as implemented erosion control projects in degraded Protection Forests to prevent sediment erosion and collapse.
- The total area of Protection Forests in Japan is 12,143ha (as of March 31, 2015), of which headwaters conservation forests account for about 70%, and sediment protection forests to prevent sediment discharge caused by erosion and collapse account for about 20%.
- Coastal protection forests, such as the protection forest for blown sand, windbreak, tide damage, and fog damage, serve the functions of mitigating these damages.
- In the wake of the Great East Japan Earthquake, certain effects of coastal protection forests, such as reduction of tsunami energy and capturing of drifting objects, were confirmed in six prefectures: Aomori, Iwate, Miyagi, Fukushima, Ibaragi, and Chiba. For this reason, coastal protection forests are now being restored to enhance their mitigating effect of tsunami impact while giving due consideration to the local ecosystem.

Disaster prevention/mitigation effects

- Landslide prevention and soil protection (prevention of sheet erosion/shallow landslide), headwaters conservation (flood mitigation), and prevention of other disasters (wind and snow damage)

Protection Forest for sediment collapse prevention (Mashike Town, Hokkaido)

Ecosystem Services during Non-Disaster Time

- Conservation of biodiversity (conservation of ecosystem)
- Conservation of global environment (mitigation of global warming)
- Creation of comfortable environment (climate change mitigation, air purification)
- Improvement of health and recreational services (recuperation, relaxation)
- Enhancement of cultureal services (landscape, scenic beauty, learning, education)
- Production of materials production (timber, food)

Protection Forest for tide damage prevention (Ishigakijima City, Okinawa Pref.) ▶

(Source: Forestry Agency)

CASE 4

Hybrid of Ecosystem and Artificial Structure

High-tide Protection by Combination of Seawall and Nakatsu Tidal Flat

Prior to conducting the planned sand-covering work at the Nakatsu Tidal Flat in Nakatsu City, Oita Prefecture as part of a port expansion project, a public-private joint team conducted a biological survey to evaluate the values of the tidal wetland and consider alternative options based on the findings of the survey. As a result, values of the tidal wetland's natural geography and ecosystem were recognized, and an alternative construction method, which could harness the disaster-preventing effect of the tidal wetland while conserving the environment, was selected from multiple options and implemented.

Project Operator

Oita Prefecture

Outline

- In 1996, a project titled "Eco Port" was formulated to carry out sand covering in the Nakatsu tidal flat using excavated mud and sand as part of expansion work of the Nakatsu Port. However, in response to the requests of local communities and based on feedback from environmental-assessment experts of the Investigative Commission, it was decided to consider construction of seawalls incorporating both high-tide protection and environmental conservation of the tidal flat.
- Consequently, the Oita Prefecture established the "Advisory Board for the Environmental Improvement of Nakatsu-Port Oshinden-District" comprised of experts, local residents, environmental groups, and administrative agencies to conduct public-private joint surveys to investigate the geography of the shore area, as well as the current conditions of the ecosystems. As a result, data showing geographic changes along the shore and around the estuary were obtained, and 170 species, including rare species, were identified in the Nakatsu Tidal Flat.
- As the survey results clearly indicated irreplaceable values of the tidal flat, several alternative options were compared and examined. As a result, greater emphasis and value were placed on the protective function of the natural geography of the foreland, and the idea to set back the seawall line further landward than the original plan to preserve a natural sandy beach and wetland in front of the seawall was adopted.

Nakatsu Tidal Flat (Source: MLIT)

Disaster prevention/mitigation effects

- Protection against high tides and waves

Ecosystem Services during Non-Disaster Time

- Provision of food (shellfish fishery, *nori* (seaweed culture)
- Conservation of biodiversity and habitat (horseshoe crab, blue whiting, amphioxus, black finless porpoise)
- Provision of educational opportunities (utilizing the results of studies on local history associated with oceans and shores in the environmental study classes in elementary, junior-high, and senior-high schools.)

Setback dike

CASE 5

Vitalization of Local Economy

Restoration of Wetland in Kabukuri-numa

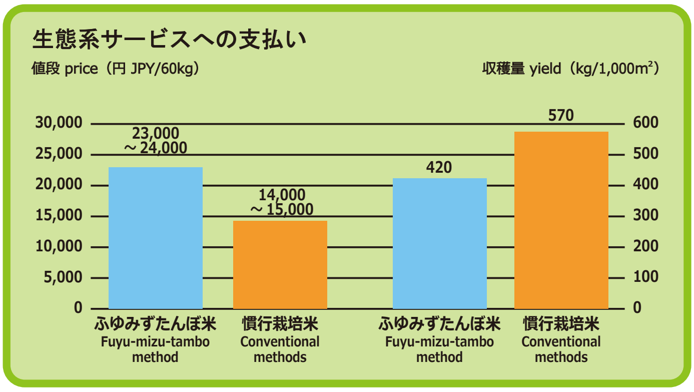
The Kabukuri-numa (a freshwater marsh) in Osaki City, Miyagi Prefecture, which was originally to be fully dredged to fortify its flood-retarding function, succeeded in conserving the natural landscape and ecosystem while still functioning as a flood-control basin by converting adjacent fallow fields into wetland. Kabukuri-numa is one of the largest wintering sites for migratory birds in Japan. Since over-population could lead to spread of infectious diseases, an operation called "Fuyu-mizu-tambo (flooding rice paddies in winter)" is carried out to break up their populated roosting sites into dispersed locations while providing them places to rest. "Kabukuri-numa and the surrounding rice paddies" was registered as a wetland under the Ramsar Convention. Rice produced in the surrounding fields is sold as premium rice under the brand name "Fuyu-mizu-tambo rice," bringing stable income for the local farmers.

▶ Project Operators

Ministry of the Environment; Ministry of Land, Infrastructure, Transport and Tourism; Miyagi Prefecture, Osaki City, Former Tajiri Town, Japanese Association for Wild Geese Protection; Kabukuri Numakko Club

▶ Outline

- In 1954, a plan was finalized to manage Kabukuri-numa and the surrounding rice paddies as a flood-retarding basin. The implementation of this plan began in 1970 with the construction of overflow banks and compensation for resettlement of residents. Full-scale dredging of the marsh was initially scheduled for 1996 because its flood-retarding functions were declining due to mud and sand inflow. However, in response to concerns expressed by people about the possibility of losing the precious scenic beauty and biodiversity in Kabukuri-numa, it was decided to reconsider the plan and explore alternative ideas that could ensure the flood-retarding function without undermining the natural environment, and possibly bring other benefits to local farmers, by allowing partial dredging of the marsh.
- As a result of expanding Kabukuri-numa by turning the surrounding fallow land to wetland, as well as owing to various conservation measures and the water-level management system established by the residents, a vast wintering site was created for various goose species. The Ministry of the Environment designated Kabukuri-numa as a national wildlife sanctuary to protect migratory birds.
- Over 90% of white-fronted geese wintering in Japan are said to flock in the northern part of Miyagi Prefecture, with most of them tending to concentrate in Kabukuri-numa and a few other sites. As it was feared that overconcentration of migratory birds could cause spread of infectious diseases and water pollution, an operation called "Fuyu-mizu-tambo (flooding rice fields in winter)" was launched in an attempt to break up the concentrated roosting sites of white-fronted geese into dispersed locations.
- Here are the findings so far: (1) birds flocking in Fuyu-mizu-tambo (flooded rice fields) eat not only fallen grain but also weeds, the growth of which is also prevented by flooding the fields, (2) bird droppings rich in phosphate act as high-quality natural fertilizers, (3) soil is further enriched by the symbiosis of earth worms (*Tubificina*), loaches, frogs, and diverse other species. These are pleasant by products of the project, which also include the production of high-value-added rice sold under the brand name "Fuyu-mizu-tambo rice."



Added value of "Fuyu-mizu-tambo rice"

▶ Disaster prevention/mitigation

- Prevention of flood (rice paddies function as a flood-retarding basin)

▶ Ecosystem Services during Non-Disaster Time

- Provision of food (production of high-priced rice)
- Photosynthesis, net primary production (by vegetation in rice paddies and ridges)
- Conservation of biodiversity and habitat (rice paddies provide habitat for diverse species)
- Provision of recreational opportunities (eco-tourism)

Fuyu-mizu-tambo (Osaki City)

Eco-DRR as Part of Administrative Policy in Japan

Ecosystem-based disaster risk reduction has been increasingly incorporated into the policies and planning of the Japanese Government.

▶ National Biodiversity Strategy of Japan 2012-2020

The National Biodiversity Strategy of Japan 2012-2020 (2012 Cabinet decision), which was established based on the lessons learnt from the Great East Japan Earthquake, stresses the importance of conserving and restoring ecosystems for reducing disaster risks.

National Biodiversity Strategy of Japan 2012-2020

▶ Basic Act for National Resilience / Fundamental Plan for National Resilience

The Basic Act for National Resilience Contributing to Preventing and Mitigating Disasters for Developing Resilience in the Lives of the Citizenry (enacted in 2013) lists policies for establishing and implementing measures, one of which is to "give due consideration to symbiosis with nature and harmony with the environment." Its Supplementary Resolution also aims to "promote land use taking advantage of regional ecosystem-based functions to prevent and reduce disasters."

Fundamental Plan for National Resilience (2014 Cabinet decision), which was established based on the above Basic Act, states the government's intention to "promote ecosystem-based disaster risk reduction according to the characteristics of each region by assessing the disaster-preventing/mitigating functions of ecosystems, such as coastal forests and wetlands, during disaster events, as well as other functions that can be provided during non-disaster times."

▶ National Spatial Planning / The National Land Use Planning

The National Spatial Strategy (2015 Cabinet decision) aims to "promote Green Infrastructure that utilizes diverse functions of natural environment (habitats for plants and animals, formation of aesthetic landscape, and control of temperature rise, etc.) in social infrastructure development and land use, towards developing sustainable and attractive national land and local communities in the face of full-scale population decline."

It also states "it is important to promote disaster management that is sustainable, efficient, and effective by utilizing disaster-preventing/mitigating functions of natural ecosystems. In addition, such ecosystems as coastal forests and wetlands can be utilized not only for providing various functions including conservation of biodiversity and provision of scenic beauty and recreational space during non-disaster times, but also for adapting to environmental change due to climate change."

The National Land Use Plan (2015 Cabinet decision) also states the government's intention to "promote Green Infrastructure and similar approaches that utilize diverse functions of natural environment (habitats for plants and animals, formation of aesthetic landscape, and control of temperature rise, etc.) in social infrastructure development and land use, towards developing sustainable and attractive national land and local communities."

▶ Priority Plan for Social Infrastructure Development

The Fourth Priority Plan for Social Infrastructure Development, which was approved at an Cabinet meeting in September 2015, states that "Japan needs to keep pace with international discussions and activities in promoting Green Infrastructure, which is designed to harness diverse functions of natural environment (habitats for plants and animals, formation of aesthetic landscape, and control of temperature rise, etc.) for enhancing the attractiveness and living comfort of local communities, reducing disaster risks, and enjoying various other benefits."

Q&A

Q 1 Isn't our safety more important than environmental conservation?

Ecosystems-based disaster risk reduction is a process of reviewing the existing land use plan to prevent people and properties from occupying disaster-prone areas and finding an optimal balance between natural and artificial structures to ensure and reinforce the safety of local communities against disaster. In addition to the rising O&M cost of aging infrastructure facilities, we are now pressed to manage the risk of intensifying weather patterns associated with climate change, as well as mega-earthquakes and other calamities. Eco-DRR is expected to be one of more effective methods to counter these challenges.

Q 2 I don't believe forests can prevent flood and tsunami.

Japan has a long history of harnessing ecosystem services for reducing disaster risks, including conserving forests to prevent sediment collapse, planting pine trees along the coast to control wind and blown sand, planting bamboo trees along river banks to mitigate flood. It is indeed difficult for forests alone to completely halt flooding or block tsunami waves. Thus, we need to implement comprehensive plans, such as avoiding exploiting disaster-prone areas and/or combining natural environment with artificial structures.

Q 3 What are the advantages of utilizing ecosystems for disaster risk reduction?

Ecosystems have physical functions to mitigate disaster and serve as buffers and barriers to protect people from various types of hazards. Conservation of ecosystems and biodiversity may also lead to the vitalization of local economies, especially the tourism and the primary industries, as it will preserve scenic beauty and production of unique local goods.
On the other hand, if Eco-DRR involves any change in the existing land-use patterns, it needs to be carried out over a long time span to obtain the local residents' understanding and consent. Another challenge is the difficulty of quantitatively assessing the buffering function of ecosystems. Accordingly, it is important for each regional community to introduce and implement appropriate Eco-DRR approaches by envisioning what it should look like in the future from a long-term perspective.

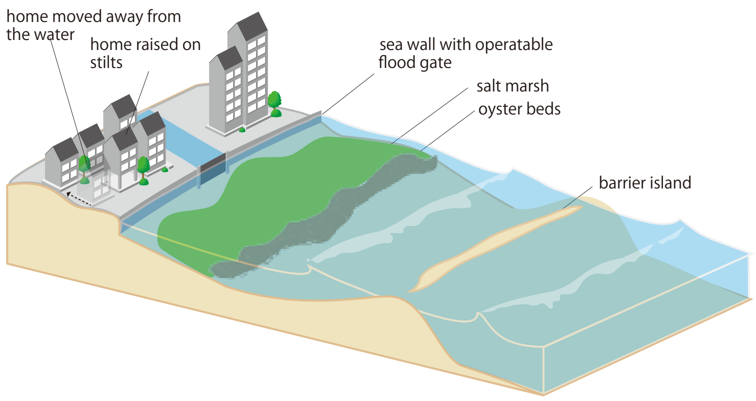
Q 4 How do Eco-DRR approaches differ from environmental considerations in social infrastructure projects?

Environmental considerations in social infrastructure projects are mostly implemented with the main focus placed on minimizing the negative impact on the environment (such as use of alternative construction methods, changing of routes, creating new habitat for substitution).

Eco-DRR or Green Infrastructure lets us harness multiple functions of ecosystem services to develop sustainable and attractive national land and local communities.

Q 5 What does it mean to combine ecosystems and artificial structures?

By combining artificial structures and multiple functions of ecosystems to complement each other, more resilient and economical social infrastructure can be developed. Ecosystems may reduce damage to artificial structures thereby retarding deterioration. It is important to select the optimal combination according to the conditions of each locality.



Hybrid: combination of artificial structure and ecosystems
(Source: Modified from Wowk, 2015)

Q 6 Are the benefits of Eco-DRR so called "stock effects"?

Social infrastructure projects are said to bring "flow effects" and "stock effects. "
(i) Flow effects: short-term economic effects on the construction and other production industries.
(ii) Stock effects: long-term effects of social infrastructure in increasing the area's productivity and safety, and enhancing the environment.
Ecosystem-based social infrastructure is expected to deliver a variety of long-term benefits of stock effects, including "multiple ecosystem services that can also be provided during non-disaster times," "restoration and resilience-enhancement of ecosystems," "excellent economic performance," and "vitalization of local economies," in addition to the direct benefits of the infrastructure.

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