

## KNOWLEDGE NOTE 6-1

**CLUSTER 6: The economics of disaster risk,  
risk management, and risk financing**

# Measuring the Cost-effectiveness of Various DRM Measures





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**The Japanese experience shows that—if done right—preventive investments pay. The Japanese government invested about 7 to 8 percent of the total budget for disaster risk management (DRM) in the 1960s, a move that most probably decreased disaster deaths. Cost-effectiveness analysis (CEA) and cost-benefit analysis (CBA) of DRM projects have been widely implemented both at national and local levels in Japan. Different procedures for such analysis have been followed according to the type of project, the funds, and the governing entity responsible. The Japanese experience shows that CBA is applicable to DRM-related projects and is a useful tool in choosing among different options and understanding the effectiveness of a project.**

## INTRODUCTION

The Great East Japan Earthquake (GEJE) and other recent disasters remind us of the importance of early actions to implement adequate prevention measures, mitigate risks, and establish sound postdisaster financing mechanisms to reduce human, economic, and financial impacts. Even if documented evidence is still lacking, there is a growing consensus that investing in disaster risk management (DRM) is cost-effective, though measuring cost savings is difficult. Several lessons can be derived from the CBA and CEA conducted in Japan.

## FINDINGS

### NATIONAL BUDGET FOR DRM

Every year many people lose their lives and property in Japan due to natural disasters. Up until the 1950s, numerous large-scale typhoons and earthquakes caused extensive damage and thousands of casualties (figure 1). In the 1960s DRM spending represented 7 to 8 percent of the national budget (figure 2). As mechanisms to cope with disasters and mitigate vulnerability to them have progressed (by developing DRM systems, promoting national land conservation, improving weather forecasting technologies, and

FIGURE 1: Disaster deaths in Japan, 1945–2011

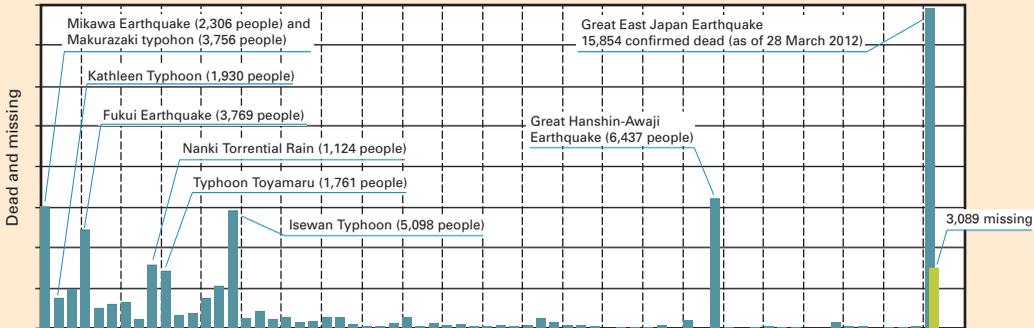
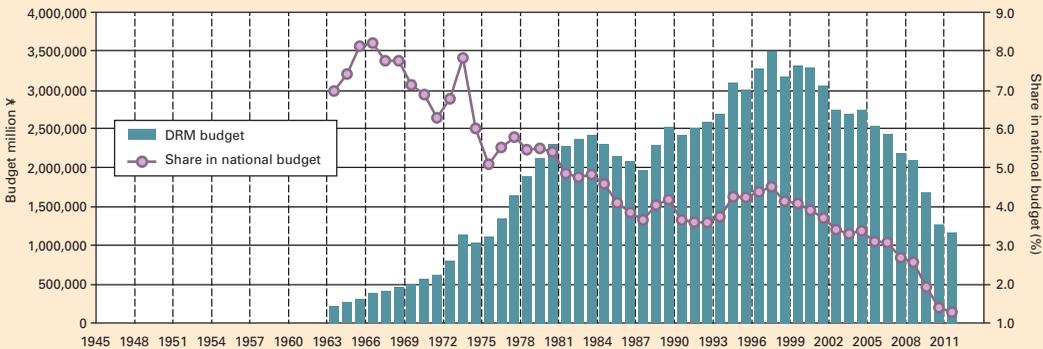


FIGURE 2: Change in DRM spending in Japan



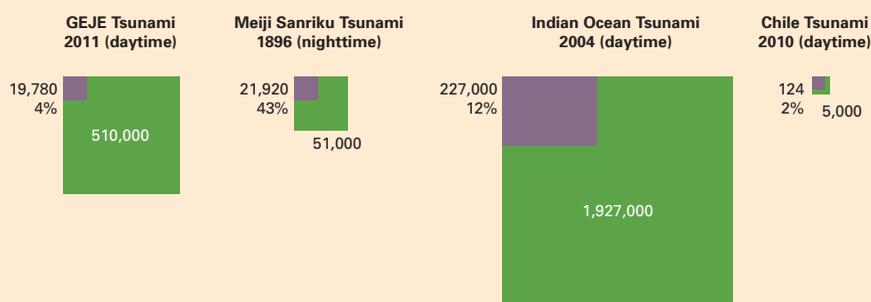
upgrading disaster information communications systems), the number of disaster-related casualties, especially from floods, has been decreasing over the years with the exception of a few outliers.

### COMPARISON OF DAMAGE WITH OTHER TSUNAMI DISASTERS

The GEJE is the strongest earthquake to ever hit Japan; the destruction it caused is staggering. But it is clear that if Japan were not so well prepared, things could have been much worse.

A longstanding tradition of effective disaster prevention paid off. While almost 20,000 people lost their lives on March 11, the mortality ratio of the GEJE—which hit during the

FIGURE 3: Comparison of tsunami damage by tsunami disasters



Tsunami (year)	Dead and missing <sup>a</sup>	Damaged houses	Population in affected areas <sup>b</sup>	a/b (%)
GEJE (2011)	19,780	259,415	510,000	4
Meiji Sanriku (1896)	21,920	7,957	51,000 <sup>2</sup>	43
Indian Ocean (2004)	227,000	1,700,000 <sup>1</sup>	1,927,000 <sup>3</sup>	12
Chile (2010)	124	1,500	5,000 <sup>4</sup>	2

Notes: 1) In population; 2) Number of damaged houses x average number of household members in Iwate (6.38); 3) Dead + population lost houses; 4) Number of damaged houses x average number of household members (3.5).

daytime—was considerably lower compared to the Meiji tsunami of 1896 (nighttime) or the Indian Ocean tsunami of 2004 (which also hit during the day) (figure 3).

Over the years, the Japanese government has invested in structural and nonstructural measures to prevent disasters and reduce their impacts. Around ¥1 trillion was invested in coastal dikes and breakwaters just in the areas affected by the GEJE, and yearly investments in earthquake monitoring and warning systems amounted to about ¥2 billion. Furthermore, a number of nonstructural measures—including community-based disaster risk management (KN 2-1), DRM education (KN 2-3), and business continuity plan (KN 2-4)—have been further developed over the years.

## MEASURING COST-EFFECTIVENESS

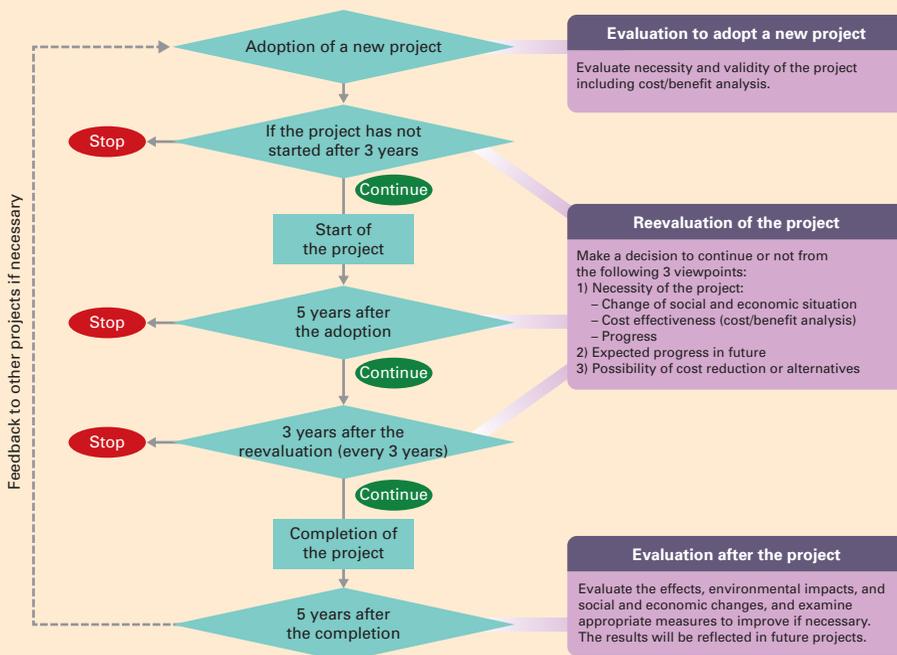
It is essential to make sure that limited financial resources are used in a cost-effective way. Effective spending has high rates of return but is difficult in practice. There are varieties of criteria being used for evaluating the cost-effectiveness of projects, such as CBA, CEA, multicriteria analysis (MCA), and so on. CBA is a well-known tool, particularly useful for governments seeking to compare alternatives. CBA is used to organize and present costs and benefits of measures and projects and to evaluate cost efficiency. CBA was originally developed as a rate-of-return assessment and financial appraisal method to assess business investments. The main purpose was to compare all the costs and benefits of an

investment (even if accruing across different sectors, in different locations, and in different time periods) from the perspective of society. But for most DRM projects there is a lack of information, especially regarding benefits and profits, making it difficult to accurately estimate the cost-effectiveness of measures (Mechler 2005).

### CBA IN JAPAN

In Japan project appraisals, including CBA, are conducted for public works projects before they are adopted, and every three to five years after adoption to evaluate project efficiency (figure 4). Committees for project appraisal (consisting of academic, business, or legal experts) are established for national and local entities responsible for project implementation, who evaluate the project efficiency of adopted projects. The committees assess the need, cost benefits, progress, possibilities for cost reduction, and the continuity of projects. The appraisal results and associated documents are made open to the public to ensure the transparency of decision making.

FIGURE 4: MLIT public works project evaluation process, based on Government Policy Evaluation Act (2002)



Source: MLIT.

A system for evaluating government policies was first introduced in Japan at the prefectural government level to reassess or conduct interim evaluations of ongoing projects. The first attempt at such evaluation was done by the Hokkaido prefectural government in 1997.

The central government, recognizing the importance of such a system, established the Government Policy Evaluations Act (GPEA) in 2001, to provide a legal framework for evaluating government policies. The GPEA aims to promote accountability; provide efficient, high-quality government services and projects; and ensure that the outcomes of these services and projects meet the needs of the nation.

The GPEA calls for all government policies, programs, and projects to be assessed before their inception, to be evaluated after their completion, and to be reassessed or subjected to interim evaluation when necessary.

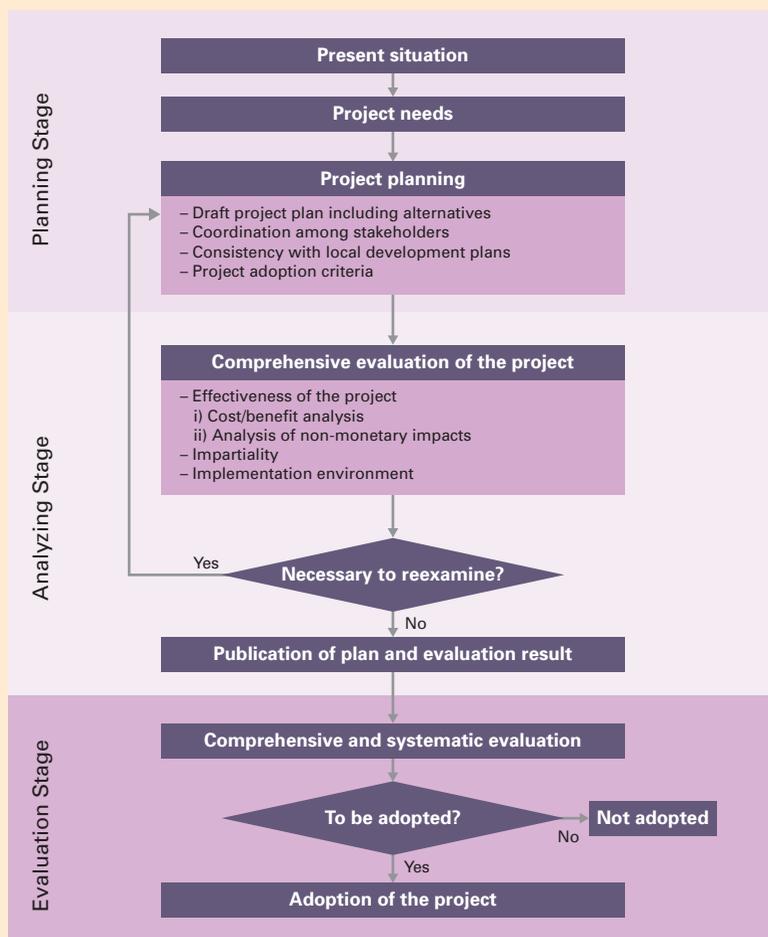
## **CBA FOR COASTAL PROJECTS**

Under the GPEA (2001), the Ministry of Land Infrastructure Transport and Tourism (MLIT) conducts CBA on every project based on the Technical Guidelines of Cost-Benefit Analysis for Public Works Projects (2004). These guidelines set out the overarching principles to be followed by each individual department (such as river, road, or urban development) of the MLIT. Maintenance and management of existing infrastructure and disaster-rehabilitation works are excluded. The Reconstruction Authority has confirmed that post-GEJE rehabilitation efforts will not be subject to CBA evaluation.

In 1987 the MLIT and Ministry of Agriculture, Forestry and Fisheries published the “Guidelines for Cost Benefit Analysis for Coastal Works.” The guidelines were revised in 2004 following the inclusion of disaster prevention, environmental conservation, and sea-coast utilization considerations into the objectives of the Seacoast Act (figure 5). The guidelines recommend that benefits from sea-coast works projects should be quantified into monetary values as much as possible based on probabilities and risks relevant to the following issues:

- Protection of inland properties from flooding by tsunamis and storm surge (expected losses are estimated by multiplying the damage ratio to the value of properties such as buildings, crops, public infrastructure, and so on).
- Prevention or mitigation of damage to land and properties from erosion (the same methodology of protection of properties from flooding).
- Prevention or mitigation of damage by blown sands and sea spray on inland properties and crops, and negative effects on daily life such as through additional labor (expected losses are estimated by evaluating the depreciated value of buildings, damaged crops, and labor loads for cleaning).
- Protection of natural environments such as ecosystems and water quality, and the development of better landscape planning (the values of natural landscapes and ecosystems along the sea line are estimated, as are the benefits of implementing projects; the seawater purification function of the beach is also valued).

FIGURE 5: **Process of seacoast project from planning to adoption**

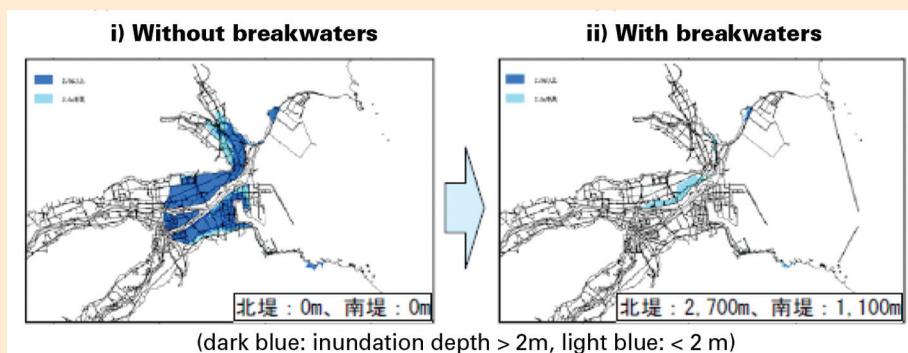


Source: MLIT.

- Utilization of seacoast for activities such as recreation and sea bathing (the values of the expansion of recreation activities, fatigue recovery effects, land development, and so on are estimated)

Specific costs to implement a project—including major initial outlays for the investment effort and maintenance expenses—are estimated. The costs and benefits identified have to be discounted to ensure that current and future effects are comparable. Finally, costs and benefits are compared under the economic efficiency decision criteria, such as net present value (NPV), B/C, or the economic internal rate of return (EIRR).

FIGURE 6: **Simulated inundation areas**



Source: MLIT.

The breakwater construction project in Kuji Port, Iwate Prefecture—started in 1990 and to be completed in 2028—is a good example of the CBA application to a DRM project. The efficiency of the project was last reevaluated in 2010, when the costs were estimated at ¥108.5 billion and the benefits at ¥136.5 billion. The EIRR was calculated at 4.8 percent, and B/C at 1.3. In this evaluation, prevention of inland flooding and sea disasters were considered as monetized benefits, while a decrease in the affected population, improvement of moored vessels security, and stability and development of local industry were considered as qualitative benefits. The project is estimated to reduce the potentially inundated area from 377 to 50 hectares, and reduce the damage to housing from 2,618 to 330 houses (figure 6). Annual estimated benefits are:

- Protection from inundation: ¥4.2 billion
- Protection from marine accident by storm: ¥5.6 billion
- Residual value: ¥11.4 billion

## REGULATORY IMPACT ANALYSIS ASSESSING NONSTRUCTURAL MEASURES IN JAPAN

Assessing the cost-effectiveness of nonstructural measures presents specific challenges. In Japan, a regulatory impact analysis (RIA) is legally mandatory since 2007 to improve objectiveness and transparency in the process of regulatory establishment. RIAs are applied to nonstructural countermeasures such as changes in land-use regulations. They are designed to objectively assess the potential impacts arising from the introduction of a new regulation or the amendment or abolishment of an existing regulation. Each ministry publishes guidelines to conduct RIAs, which include CBA requirements.

For example, an RIA was undertaken before the adoption of the Act on Building Communities Resilient to Tsunami in December 2011. The changes in regulations outlined in the act—including new land-use regulations and changes of floor-area-ratios for tsunami-evacuation buildings in the designated zone—were assessed through the RIA. It was estimated that the benefits from these changes could outweigh the costs of implementation, as they develop more resilient urban areas through increased safety of housing and public facilities in tsunami-exposed areas and construction restrictions for potentially dangerous buildings. For more information on the act, please consult KN 2-7.

The costs considered in the RIA include the costs associated with the approval processes for structures that contribute to tsunami evacuation; the costs of preparing evacuation plans or evacuation drills; and various administrative costs for approval, inspection, or monitoring of buildings or land use. The benefits, on the other hand, include prevention of inappropriate development, facilitation of prompt evacuation in case of tsunami disasters, and promotion of adequate maintenance of tsunami-disaster-mitigation facilities—all of which contribute to the protection of lives and the mitigation of damage in tsunami-risk areas. These costs and benefits were considered qualitatively in the RIA.

The MLIT has conducted approximately 50 RIAs since 2007. One was conducted, for example, when the Act on Promotion of Seismic Retrofitting of Buildings was revised in 2005 to add schools, welfare facilities, and buildings for storage or treatment of hazardous objects to those facilities under the guidance of administrative offices, and to establish “retrofitting support centers” nominated by the government.

## NEW APPROACH TO EVALUATING THE EFFECTIVENESS OF DUAL-PURPOSE INFRASTRUCTURE

The Sanriku Expressway being constructed along the sea shore in the tsunami-affected Iwate and Miyagi prefectures contributed to the recovery of this area (KN 1-2-1). But the evaluation of the cost-effectiveness of such redundant infrastructure (that is, a road used as part of a DRM facility) has never been taken into account before in Japan. The Japanese government is now trying to modify its evaluation methodology to include the potential benefits of road projects from the perspective of disaster management and DRM.

Evaluation methodology is used when the MLIT adopts a new road construction project that is expected to be a key route for rescue and relief supplies, materials, and resources for emergency response, and to form a wide range of road networks for DRM. The evaluation of the disaster mitigation function involves:

- **Necessity evaluation.** Clarify why the project is needed based on DRM considerations (for example, for transportation of rescue and relief supplies, transportation to emergency medical facilities, and reaching core cities in and around the stricken area).
- **Efficiency evaluation.** Numerically estimate the level of improvement and evaluate its priority (for example, improvement of the disaster management function by securing transportation between core cities or within the regional network, like shortening of travel time, dissolution of isolated areas, and so on).

- **Effectiveness evaluation.** Compare effectiveness among several alternative plans and similar projects.

## LESSONS

CEA and, more in particular, CBA, has several limitations, including the difficulty of accounting for nonmarket values, the lack of accounting for the distribution of benefits and costs, and the issue of choosing the correct discount rate. In addition, CBA of DRM presents additional challenges related to the fact that the planning horizon of DRM measures is typically longer than that of policy makers, and that the occurrence of natural hazards needs to be captured with stochastic methods (Mechler 2005). Conducting probabilistic CBA often proves difficult because of the absence of reliable hazard and vulnerability data. This is perhaps the greatest challenge faced by the DRM community in conducting comprehensive economic studies of proposed DRM measures in developing countries. Despite limitations, CBA remains the most commonly used tool to analyze the benefits and costs of DRM measures. In a review of the existing literature on CBA of DRM measures in developing countries, a Global Facility for Disaster Reduction and Recovery (GFDRR) study finds a wide variation in methodologies, assumptions, discount rates, and sensitivity analyses, suggesting that DRM analyses are highly context sensitive (GFDRR 2007).

CBA on infrastructure projects has been widely implemented both at national and local levels in Japan. Different procedures have been identified according to the type of project, the funds, and the governing entity responsible. Different type of costs are included in the analysis, such as operational, maintenance, and fiscal costs; also, different types of benefits are accounted for, such as the protection of inland properties and the natural environment or recreational utilization. The Japanese experience shows that CBA is applicable to DRM structural projects and is a useful tool to help choose among different options (higher B/C is one of the variables to be taken into account when making decisions) and to understand the effectiveness of a project/measure. Nonstructural measures, such as land-use regulations and building codes, can be evaluated as well. For example, administration costs and other necessary costs can be compared when deciding among alternative measures.

The use of CBA must be adapted to the type of measure that is being evaluated. Infrastructure and soft measures require different approaches—not only different procedures and calculations, but also different objectives and bottom-line evaluations. It is also important to introduce clear guidelines about how, when, and where to implement CBA. The Japanese experience also proves that sectoral guidelines released by specific ministries are very helpful, as they describe in practical terms each step to be taken when implementing CBA.

While saving lives is the top priority, valuing such lives when assessing the potential benefits of different measures is extremely challenging and poses complex ethical and political questions. But ignoring the value of life implicitly considers people “useless”—and it would be unethical if property is protected but lives are not. For example, background work done for the joint United Nations–World Bank (UN-WB) report *Natural Hazards, UnNatural Disasters* shows how, if the value of lives saved were ignored, retrofitting buildings in the Turkish district of Atakoy would not be cost-effective, with a B/C lower than 1. Background work done for the report finds that including a value of life of \$750,000 in the benefits, however, tips the scale toward retrofitting. And only by including the value of lives saved

(at \$400,000 each) did earthquake-strengthening measures for apartment buildings and schools in Turkey pass the cost-benefit test (UN-WB 2010). This example shows the limitations of CBA. Other techniques such as MCA have been explored and could be more acceptable from an ethical perspective. MCAs do not at present offer much help for practical decision making in Japan.

## RECOMMENDATIONS FOR DEVELOPING COUNTRIES

Despite its limitations the CBA can be a powerful tool when deciding on and prioritizing DRM measures. It is useful when the issues are complex and there are several competing proposals, and particularly so when comparing alternatives. Nevertheless, considering multiple variables and different objectives at the same time, its use has declined over the years (even at the World Bank).

It is important to set clear rules about when, how, and on what CBA should be performed. Regulatory frameworks, policy procedures, and specific guidelines (possibly at sectoral levels), overseen by specific ministries, can certainly improve the implementation of CBA for DRM.

Connections between decision making and CBA must be clear. CBA can be one informative input, or one of the main variables in decision making. Any decisions should be transparent and reviewed regularly. In the Japanese context, project appraisal committees consisting of external experts and academics evaluate the projects before their adoption, and then reassess their effectiveness to secure transparency and accountability in decision making.

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