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ScienceDirect

Procedia Economics and Finance 18 (2014) 361 – 368

Procedia Economics and Finance

www.elsevier.com/locate/procedia

4th International Conference on Building Resilience, Building Resilience 2014, 8-10 September 2014, Salford Quays, United kingdom

# The cost benefit analysis of providing resilience

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**Abstract**

The vulnerability of a system is best addressed by introducing some form of resilience, hard or soft, to the risks associated with the physical, social and economic aspects of the system's ability to cope with disturbing events. Once the resilience options have been identified to meet the vulnerability of a system, it is necessary to compare the degree of resilience that the different alternatives may offer. The different concepts are examined to propose both a qualitative and a possible quantification of the degree of resilience that may be achieved by the different measures proposed for implementation. Cost Benefit Analysis is one technique used by governments and public authorities for appraising the societal benefits of public investment projects and policies. Generally, it is used to organize and present the costs and benefits, and inherent trade-offs, and to ultimately estimate the economic efficiency of projects. Is it better to be content with protection against 20-year floods or should an extra cost be considered to provide safety against centennial floods? Thus, after showing that the benefits outweigh the costs of the project and adding value to society, Cost Benefit Analysis can be used to single out the best option. As benefits and costs are difficult to estimate with certainty, some measure of uncertainty or sensitivity has to be discussed when comparing the resilience project options.


Selection and/or peer-reviewed under responsibility of the Centre for Disaster Resilience, School of the Built Environment, University of Salford.

*Keywords:* Cost benefit analysis; resilience; disaster; risk reduction

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Selection and/or peer-reviewed under responsibility of the Centre for Disaster Resilience, School of the Built Environment, University of Salford.
doi:10.1016/S2212-5671(14)00951-4

## 1. Introduction

A naturally occurring or human-induced process or event with the potential to create loss is a *hazard*, i.e. a general source of danger. The actual exposure of something of human value to a hazard is a *risk* and it is often considered as the combination of probability and loss. Thus, a hazard is a potential threat to humans and their welfare, and risk (or consequence) is the probability of occurrence of a specific hazard.

For many sectors (Abbey 1999), a 50 year return period (i.e. probability of 0.02) for a hazard is a good guideline, but sometimes the designer might feel that a 100 year return period might be better. For example, a bridge (Bindra, 1975) is a structure that is expected to be in operation during a very long period. In this context, it is natural to consider events with a return period of 50 years or even more. There are so many bridges in the world which have been standing for more than 50 years. Every structure is designed for a certain design life and it must be ensured that this structure serves for its purpose without endangering any life and property.

## 2. Is a Return Period of 50 years Acceptable?

The risk that failure of such a structure occurring during its design life has been explained by Mays (2004) as follows:

Let P be the probability of the occurrence of an event,

$1 - P$ = probability that the event will not occur

$(1 - P)(1 - P)$ = probability that the event will not occur in two successive years.

$(1 - P)(1 - P)(1 - P)$ = probability that the event will not occur in three successive years.

$(1 - P)^N$ = probability that the event will not occur during a span of N successive years.

Hence, the risk, R or the probability that the event will occur during a span of N years is given by,

$$R = 1 - (1 - P)^N$$

The probability P is given by $P = 1/T_r$. Table 1 shows, for return periods $\mathbf{T_r}$ and various spans of years **N,** the risk **R** that a flood with certain return period will be equalled or exceeded during periods of span N years.

Table 1: Risk R, that a flood of a given return period will be equalled or exceeded during periods of various lengths.

| Return Period Tr (years) | Risk R for various spans of N years | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 5 | 10 | 30 | 50 | 75 | 100 | 200 | 500 |
| 1 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 5 | 0.67 | 0.89 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 | 1.0 |
| 10 | 0.41 | 0.65 | 0.96 | 0.995 | 1.0 | 1.0 | 1.0 | 1.0 |
| 50 | **0.10** | 0.18 | 0.45 | 0.64 | **0.78** | 0.87 | 0.98 | 1.0 |
| 100 | 0.05 | 0.10 | **0.26** | 0.40 | **0.53** | 0.63 | 0.87 | 0.99 |
| 500 | 0.01 | 0.020 | 0.058 | 0.095 | 0.14 | 0.18 | 0.33 | **0.63** |
| 1,000 | 0.005 | 0.010 | 0.03 | 0.049 | **0.072** | 0.095 | 0.18 | 0.39 |
| 5,000 | 0.001 | 0.002 | 0.006 | 0.010 | 0.015 | 0.020 | 0.039 | 0.095 |
| 10,000 | 0.0005 | 0.001 | 0.003 | 0.005 | 0.0075 | 0.0099 | 0.020 | 0.049 |

Rainfall frequency and intensity records can be used to estimate the magnitude of rains and the ensuing flood flows. In this respect, it is important to note that there is a 26 % probability that a 100 year rain will occur during the next 30 years (a generation).

In practical terms, this means that *each generation has a 1 in 4 chance of experiencing flooding*, even if an exceptional rainfall intensity of 100 year has been considered. Over a 75 year lifetime, the likelihood rises to 0.53, i.e., the *average person has a 1 in 2 chance of experiencing flooding during his lifetime*.