BENEFIT-COST ANALYSIS FOR REDUCING THE VULNERABILITY OF THE HOUSING SERVICE SECTOR ASSOCIATED WITH NATURAL HAZARDS

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Houses or living in buildings near the coastline are more likely to experience damage from natural disasters such as flooding, tsunamis. The damages to the housing service sector near the coastline due to natural hazards can cause billions of dollars annually. Most tsunami waves from natural disasters are less than 10 feet. It has been known that elevating your house will help reduce damage to our property from most natural disasters near the coastline. To improve the resiliency of the housing sector, reconstructing houses by the method of elevating coastal houses will be useful to minimize the associated risks and property damage. The major objectives of this research are to conduct a benefit-cost analysis in terms of private, financial, economic, efficiency using nominal and real terms for minimizing the vulnerability of houses near the coastline associated with natural hazards. To measure the benefit and cost of a strategy of elevating coastal houses, this research will conduct a benefit-cost analysis due to the investment costs for reconstructing houses by the method of elevating coastal houses using historical economic and financial data. Reducing risks of property damages and economic perturbations in the housing service sector through reconstructing houses by the method of elevating coastal houses will lead to improving the resiliency of interrelated infrastructures and sectors. Moreover, the resiliency of the houses near the coastline will help in speeding the recovery from or resistance to natural hazards in the long run.

Keywords: Property damage, Disasters, Resiliency, Reconstructing houses, flooding, coastal houses.

1 INTRODUCTION

The current trend of economic loss from natural disasters has continually been on rise, and the cumulative economic loss from flooding reaches out 2,227 billion U.S. dollars in 2020. Moreover, it points out that disasters have been exacerbated by accelerated unplanned and ineffective construction in floodplains in many areas (Adam et al. 2020). According to the Disaster Housing Recovery Coalition, they insist that the disaster housing recovery framework is broken and in need of significant reform (Mickelson et al. 2020). It said that current building design standards and U.S. Infrastructures do not take into account current and future climate trends (Mickelson et al. 2020). We find that the trend of the economic loss from natural disasters has continually been on the rise since 1950, and especially, has noticed an upward trend that has reached 400 ~ 500 billion-dollar in recent years since 2010. Moreover, it shows that the loss of weather-related disasters has substantially increased over time and indicates that weather-related events account for the massive loss among natural disasters (Adam et al. 2020). In more detail, we can look at the details of the various natural disasters related to weather, and how each
disaster and economic loss have changed over time (Weyant 2014, Jung and Wallace 2014). Recent massive disasters such as flooding, tsunami, and hurricane provide significant lessons regarding economic losses they have on infrastructures and economic systems (Jonkeren and Giannopoulos 2014). Therefore, to minimize the vulnerability of houses in areas where there is a risk associated with natural hazards such as flooding, tsunami, and hurricane, this research conducts a benefit-cost analysis related to the investment costs for reconstructing houses by the method of elevating houses using economic and financial data.

2 BACKGROUND RESEARCH

2.1 Problem Statement and Needs

Reconstructing a building and a town after a catastrophic disaster such as flooding, tsunami, and hurricanes is a significant and immense undertaking. As mentioned previously, the Disaster Housing Recovery Coalition pointed out that the existing disaster housing recovery framework lacks efficient mechanisms and methods and needs significant reform (Mickelson et al. 2020). We need to take into consideration the fact that a new disaster housing recovery framework should reflect current and future climate trends and how each disaster and economic loss have changed over time. There were the estimated various sea-level rise scenarios affected by hurricane storm surge in Sarasota County. These estimated various sea-level rise scenarios suggest that reconstructing houses by the method of elevating houses will be appropriate and reasonable for designing a national disaster housing recovery framework in preparation for similar types of natural disasters in the future. There are houses in Santa Rosa County that were elevated as part of a Hazard Mitigation Grant Program grant-funded project to mitigate the repetitive loss of properties due to natural disasters. Funds were for projects to perform long-term hazard reduction after a major disaster and to reduce the loss of life and property due to natural disasters. Table 1 shows statistical data of damages of structures, deaths, and economic loss that is caused by flooding, tropical storms, and hurricanes in recent years. As can be seen from the scale of recent damages caused by flooding, tropical storms, and hurricanes, it can be seen that single flooding alone can result in over 10 billion-dollar economic losses.

Table 1. The scale of recent damages caused by flooding, tropical storms, and hurricanes.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Location</th>
<th>Deaths</th>
<th>Structures/Claims</th>
<th>Economic Loss(USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>07/12/05</td>
<td>Flooding</td>
<td>South Dakota</td>
<td>0</td>
<td>2,700+</td>
<td>50+ million</td>
</tr>
<tr>
<td>09/26/10</td>
<td>Tropical Storm Eliza</td>
<td>Midwest, Northeast</td>
<td>0</td>
<td>50,000+</td>
<td>400+ million</td>
</tr>
<tr>
<td>10/24/12</td>
<td>Flooding</td>
<td>Midwest, Northeast</td>
<td>0</td>
<td>36,000+</td>
<td>500+ million</td>
</tr>
<tr>
<td>02/26/12</td>
<td>Tropical Storm Sandy</td>
<td>Southeast</td>
<td>0</td>
<td>75,000+</td>
<td>500+ million</td>
</tr>
</tbody>
</table>

An effective disaster housing recovery framework is required to reduce the vulnerability of the housing service sector associated with natural disasters as well as to assess the benefit and cost of strategic investments in the housing service sector to mitigate the disaster impact. This research attempts to suggest mechanisms and an effective disaster housing recovery framework for assessing the impact of reconstructing houses by the method of elevating houses.
2.2 Scope of Research

This research focuses on evaluating a proposed project for reducing the vulnerability of houses near the coastline about reconstructing houses by the method of elevating coastal houses. Figure 1 shows the estimated area affected by 1-meter sea-level rise due to natural disasters such as flooding, tsunami, and hurricanes. The estimated area affected by 1-meter sea-level rise due to natural disasters can be the project area for reconstructing houses by this method. Hence, this project has more to do with hazardous areas where the houses need to be elevated rather than how many buildings require to be elevated. Therefore, the simulation of the estimated area affected by one-meter sea-level rise near the coastline or the shore of a lake, as shown above, is a great help in planning a useful disaster housing recovery framework after natural disasters. It evaluates a proposed project with a development period of five years and a benefit period of fifteen years. The proposed project could be relative to the reconstructing houses in the estimated area affected by one-meter sea-level rise near the coastline or the shore of a lake, regardless of the specific number of buildings.

Figure 1. Estimated area affected by 1-meter sea-level rise (Florida division of emergency management).

3 METHODS USED

Cost-benefit assessment, in general, is a process of measuring and comparing the benefits and costs of an investment project (Forester et al. 1984, Boardman and Forbes 2011). Hence, cost-benefit assessment in this research can be defined as the process of evaluating the costs and benefits of a construction project that is the weighting-scale approach to decision-making (Loose 1977, Raucher 1986). In simple terms, all the cash-flows and other intangible benefits are located on one side of the balance, and all the costs and disadvantages are located on the other (Schwing et al. 1980). Whichever weighs, the heavier will be selected. Investment projects identify a difference from not investing in the projects, and the role of benefit-cost assessment is to measure the difference (Whittington and MacRae 1986). Two as yet hypothetical states of the circumstance that the circumstance undertaking the project and the circumstance not undertaking the project can be compared (McKean 1968). There are two alternatives: the circumstance that undertakes the project that reduces the vulnerability of the housing service sector or the circumstance that does not undertake the project that reduces the vulnerability of the housing service sector. The circumstance without the project will not be the same as the circumstance before the project (Jonkeren and Giannopoulos 2014, Harberger 2015).

3.1 Assumptions of Cost-Benefit Analysis

The assumptions used in this research have several main points as follows: (1) The analysis evaluates a proposed project with a benefit period of fifteen years and a development period of
five years. It is assumed to estimate 10 billion dollars on property damages. The required total investments at the end of year 1, 2, 3, 4, and 5 are 100 million, 150 million, 250 million, 300 million, and 200 million, respectively. (2) The income tax rate is 22%, and the discount rate for the SPC is 11%. The inflation rate is 2%. (3) The interest charge is added each year to the capital outlay for that year to get the total outlay using the loan interest rate. Interest during the development period is capitalized. (4) Initial maintenance cost in year 6 is 5.5 million, and it remains constant in real terms over the remaining life of the project. (5) The initial benefit is 170 million/year beginning at the end of year 6. This benefit is expected to grow at an annual rate of 3%, beginning in year 7. (6) The initial annual benefit level is normally distributed with a mean $170,000,000 and a standard deviation of $25,000,000. (7) The benefits increase each year has an unknown distribution and hence is assumed triangular with a minimum of -2%, a most likely value of 3%, and a maximum of 6%. (8) The initial year’s maintenance cost has a Pert distribution with a minimum of $3,500,000, a mode of $5,500,000, and a maximum of $8,500,000. (9) In subsequent years (from Y7 to Y20), the maintenance cost is equal to the previous year’s cost plus a normally-distributed random component with a mean $0 and a standard deviation of $450,000. (10) The nominal loan interest rate is known with certainty, but one it has identified at the beginning of the project, it is fixed for the life of the project. It is assumed a Pert distribution with a minimum of 4%, a mode of 9%, and a maximum of 15%. (11) Under the U.S. tax law, depreciation and loan interest, but not loan principal payment, are tax-deductible, and the interest during the development period is capitalized.

3.2 Results of Cost-Benefit Analysis

The analysis consists of two scenarios, as follows: (i) Economic/market analysis - assessing the benefits and costs of the project at market prices without any consideration of financing or taxes except that interest during construction will be included in capital charge to be applied in year 5.

<table>
<thead>
<tr>
<th>Year</th>
<th>Benefits</th>
<th>Costs</th>
<th>Net Benefit</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1,000,000</td>
<td>500,000</td>
<td>500,000</td>
</tr>
<tr>
<td>2</td>
<td>1,000,000</td>
<td>500,000</td>
<td>500,000</td>
</tr>
<tr>
<td>3</td>
<td>1,000,000</td>
<td>500,000</td>
<td>500,000</td>
</tr>
<tr>
<td>4</td>
<td>1,000,000</td>
<td>500,000</td>
<td>500,000</td>
</tr>
<tr>
<td>5</td>
<td>1,000,000</td>
<td>500,000</td>
<td>500,000</td>
</tr>
</tbody>
</table>

Figure 2. Results of cost-benefit analysis.
(ii) Financial/private analysis - assessing the benefits and costs to the Special Purpose Corporation. It is assumed the SPC makes a loan for 85% of the total investment with the 15% equity paid at the end of year 5, repayable at an 8% interest rate.

4 STOCHASTIC SIMULATION RESULTS

It is simulated with the iterations that are set to 5000. It represents that it will take 5000 random draws for each of its random parameters and calculate NPV for each one. Simulation settings represent a bunch of different settings that could be used to alter these simulations. The key ones to note are the iterations that are already set to 5000 and the initial seed option under the sampling option. This option sets the initial starting point for its random number generator and allows it to replicate these results. It should be ensured that its simulation starts at the same point on this list every time for replicating exactly these results from a Monte Carlo analysis. It can be simulated through the different outputs like the NPVs and see how these different assumptions about project financing or cash flows after finance and taxes affect the distribution of project performance.
5 CONCLUSION

Even though the sea-level rise from natural disasters such as flooding, tsunami, and hurricanes is not considered a disaster in the typical sense of four phases of disaster management, the immense damages from the impact of sea-level rise are predicted to be disastrous results to the communities. The vulnerability and increased damages of the housing service sector from natural disaster events ultimately lead to diminish the community's resilience and to increase the damages and risks of societal and economic loss. In fact, the annual economic loss from flooding, tsunami, and hurricanes result in devastating consequences for billions of dollars in property damages of people in the communities. Therefore, reconstructing houses by the method of elevating houses after a more typical disaster, such as hurricanes, flooding, and tsunami, could consider preparedness and mitigation opportunities to decrease the vulnerability and housing service infrastructures. Accordingly, this research analyzed some methodologies according to several scenarios and conducted the benefit-cost analysis in terms of private, financial, economic, efficiency using nominal and real terms. The benefit-cost analysis of several scenarios for reconstructing houses by the method of elevating houses would improve disaster housing recovery frameworks and redevelopment decisions of the shore of a lake and the coastline where the risks from future inundation, tsunami, and storm surges could be an issue. The ultimate outcome of this research is that it can lead to reasonable redevelopment decisions for minimizing the associated risks and property damages, improving the resiliency of the housing sector infrastructures near the coastline or the shore of a lake, and decreasing the vulnerability of the housing service sector related to natural hazards.

References


