Levee Example for EGDe$

1 Levee Case Study Overview

There is no "with Uncertainty" variant of the Levee Example. This is a highly simplified example only meant for illustrative purposes and is not a true representation of a full economic or LCC analysis. Furthermore, many of the assumptions made herein are unjustified and should not be considered as recommendations.

Narrative

After a 100-year flood hits a city, the CPT decides to adopt a flood mitigation strategy. After a study, two mutually exclusive alternatives emerge as realistic for the city to pursue: 1. buyout all properties in the 100-year floodplain and turn the area into greenspace; 2. build a 1.5-mile-long levee designed to work for a 100-year flood. To select the most economic option, an economic analysis is commissioned on each alternative. Regardless of the option, it is assumed that 25 % of the purchased homes do not return to the city's tax base.[1]

The mitigation measure would be focused in a residential area with a high-risk of flooding, and within the 100-year flood plain. The area consists of 600 homes in total (average value of $130 000 for non-waterfront properties (Realtor.Com)), with 100 being considered waterfront properties (average value $190 000 (Krause 2014))[2]. The buyout option would require all homes to be purchased, while the levee would require all 100 waterfront properties, and 100 additional properties, be purchased to make room for levee construction. Two hundred of the homes, including all homes in the levee construction area, are eligible for FEMA grants which cover 75 % of the cost (Federal Emergency Management Agency 2014). The tax rate on all properties is 1.52 % (Smith 2014, Feb 4). A planning horizon of 75 years and a 5 % discount rate are assumed. The initial step in the analysis was to determine the total losses because of the flood. Table 1 outlines these losses.

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[1] For the sake of simplicity, the analysis foregoes an examination of the large economic impact of potentially losing 175 households from the city. This is a real concern however and in a true analysis should not be ignored. For this case study, it may be assumed that, although these homes leave the tax base, they remain close enough to continue to work in, and add equivalent value to, the city.

[2] For the purposes of this example, fluctuations in home value, appreciation, and other time varying aspects of home value are omitted for simplicity.

Table 1. Losses from flood

Category	Item	Value
Direct	Structural Losses	Waterfront – 90 % of value (Hallegatte 2015) Construction area – 75 % of value (Hallegatte 2015) All other – 50 % of value (Hallegatte 2015)
Direct	Evacuation	$1 982 148 (Pfurtscheller and Schwarze 2008)
Indirect	Relief	$11 100 027 (Pfurtscheller and Schwarze 2008)
Replacement and Repair	Clean up	$2 775 007 (Pfurtscheller and Schwarze 2008)
Fatalities	Lives lost (value of statistical life)	14 (assumed) ($7.9 million)

2 Assumptions

The following values are assumed for both alternatives:

Planning horizon – 75 years
Recurrence rate of Flood Event – 100 years
Real discount rate – 5 %
Value of a statistical life - 7 900 000 USD

Other key assumptions have been made to simplify the example. These are not necessarily realistic and should not be considered prescriptive for an actual LCC analysis.

1. Both alternatives function as designed for a 100-year flood, meaning no structural damage, and the assumed floodplain and disaster magnitude are accurate
2. Evacuations would still be required in the event of a 100-year flood for precautionary purposes
3. All one-time costs occur in year zero, while OMR costs first occur in year one and repeat annually
4. The analysis compares all values relative to the implicit option of doing nothing.

Assumptions related to specific values derived for the analysis are mentioned as they arise from the narrative.

3 Data

3.1 Cost Data

The expected costs of each mitigation measure are found in Table 2.

Table 2. Costs for each mitigation measure

Category	Item	Buyout Value	Levee Value
Direct	Buyout of homes[3]	$59 897 500	$31 590 000
Direct	Structure demolition	$12 000 per home (improvenet)	$12 000 per home (improvenet)
Direct	Construction of greenspace	$200 000 (Cape Gazette 2016, Apr 27)	-
Direct	Levee design	-	15 % of construction cost (USACE 1982)
Direct	Levee construction	-	$10 million/mile (Koch 2010)
Indirect	Indirect (as percentage of pertinent direct costs)	30 %[4] (assumed)	30 %[5] (USACE 1982)
Operations, maintenance, and repair (OMR)	OMR costs on pertinent items	$15 000 per year (North Carolina State 2015, CNLM 2004)	$63 871 per year (Fairfax County, Virginia Government 2008)

3.2 Benefit Data

Event Related Benefits (*Benefits* screen in EDGe$)

In this case the community estimated all event-related benefits as the percentage reductions of the 100-year flood loss value given in Table 3. All values in Table 3 are assumed.

Table 3. Percent reduction in losses for a 100-year flood for each option

Category	Item	Buyout Value	Levee Value
Direct Loss Reduction	Structural Losses	100 %	100 %
Direct Loss Reduction	Evacuation	80 %	33 %
Indirect Loss Reduction	Relief	80 %	85 %
Replacement and Repair Loss Reduction	Clean up	35 %	75 %
Fatalities Loss Reduction	Fatalities averted	13 Statistical Lives	14 Statistical Lives

Non-Disaster Related Benefits (Resilience Dividend)

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[3] This assumes there is no pushback from the community, litigation, or other costs that commonly arise due to the acquisition of private land by a government entity. These could be included in a more realistic model. Also, this value accounts for the 75% reduction in costs from FEMA grant eligible properties.

[4] 30 % of Greenspace construction and Structure demolition only

[5] For all direct costs excluding the buyout of homes

Along with the on-flood benefits of each measure, the effects of mitigation measures on non-flood items was determined. The greenspace created by the buyout is expected to increase day visitors and overnight visitors by 22 % (48 USD per visit) and 26 % (107 USD per visit) respectively (Harnik and Welle 2009). Current estimates for the city are 10 000 overnight visitors and 15 000 day visitors per year. Table 4 summarizes these values. The greenspace, while removing the value of any waterfront homes, should increase the value of the homes that now abut it, offsetting some of the lost waterfront tax revenue.

Table 4. Non-disaster related benefits for each mitigation measure

Item	Buyout	Levee
Lost tax revenue[6]	$367 042 per year	$120 042 per year
Value of greenspace (as increase in tax revenue in nearby homes)	$9 880 per year (Harnik and Welle 2009)	-
Increase in visitors	$1 468 200 per year	-

3.3 Externalities

The major externality for the levee involves downstream flow. During a flood, any water that fails to flood the town makes its way downstream, potentially making flooding worse further downriver. A rough estimate found that, the annualized additional cost of downstream flooding was $113 886[7].

Greenspace externalities typically involve increased tourism and environmental benefits. As increased tourism has been internalized in the analysis, it is no longer an externality. Many environmental aspects are already captured by the value of the greenspace on property value, however such hedonic pricing techniques fail to capture the impact on storm water management[8]. The use of greenspace is estimated to save roughly 200 000 USD annually in reduced wastewater pumping costs (Greater Dallas Planning Council 2015).

4 EDGe$ inputs

The following values are assumed for both alternatives. Note that the recurrence rate is now 1-year, due to the process of determining an equivalent annual rate.

Planning horizon – 75 years
Recurrence rate of Flood Event – 100 years
Real discount rate – 5 %
Value of a statistical life - 7 900 000 USD

[6] The analysis focused on tax revenue generated by homes, though total home value could be used just as easily. Doing so will change the final NPV and other key economic indicators, so it is important to define not only what key variables are important, but the appropriate way to measure them.
[7] This value is entirely fictional. There is no comprehensive literature on the economic impacts of increased downstream flooding due to upstream levees.
[8] Other known benefits include reducing peak flows during storms and higher water quality, but for simplicity only the storm water management aspect was included in the analysis. In practice, all realistic costs and benefits must be included to ensure an accurate and meaningful analysis, although externalities are optional.

The cost inputs for EDGe$ are summarized in Table 5. Operations, maintenance, and repair costs start accruing in year 1.

Table 5. Cost input values for EDGe$ for each mitigation measure

Cost Category	Cost	Buyout	Levee
Direct	Purchase of Homes	$59 897 500	$31 590 000
	Structure Demolition	$5 400 000	$2 400 000
	Levee Design	-	$2 250 000
	Levee Construction	-	$15 000 000
	Greenspace construction	$200 000	-
Indirect	Indirect Costs	$1 680 000	$4 500 000
OMR	OMR Costs	$15 000 annually	$63 871 annually

On-disaster benefits are presented in Table 6. These values are calculated using the values in Table 1, Table 3 and the profile of homes defined in the Narrative in Section 1.

Table 6. Flood related loss reduction input for EDGe$ for each mitigation measure

Loss Category	Buyout	Levee
Direct Loss Reduction	$219 838 182	$219 838 182
Indirect Loss Reduction	$8 880 021	$9 435 023
Response and Recovery	$971 252	$2 081 255
Fatalities Averted	18	19

Non-disaster related benefit inputs are presented in Table 7. Externality inputs are found in Table 8. Both NDRBs and externalities are assumed to begin accruing in year one.

Table 7. Non-disaster related benefit input for EDGe$ for each mitigation measure

Item	Buyout	Levee
Tax revenue[9]	($367 042) annually	($120 042) annually
Value of greenspace (as increase in tax revenue in nearby homes) [14]	$9880 annually	-
Increase in visitors	$1 468 200 annually	-

[9] The analysis focused on tax revenue generated by homes, though total home value could also be used just as easily. Doing so will change the final NPV and other key economic indicators, so it is important to define not only what key variables are important, but the appropriate way to measure them.

Table 8. Externality input for EDGe$ for each mitigation measure

Externality (Positive/Negative)	Buyout	Levee
Downstream Flooding (Negative)	-	$113 886 annually Owner – Downstream Communities
Reduced storm water management (Positive)	$200 000 annually Owner – Water Utility	-

5 EDGe$ Output

The results in Table 9 indicate that the buyout is the preferable option, as its *NPV* is over three times that of the levee option. Both options also have positive *NPVs*, thus they are better than the implicit *Do Nothing* option. Interestingly the levee option has a negative Non-disaster ROI, indicating that if no disaster occurs, the alternative may prove to be a loss.[10]

[10] Public perceptions of increased safety notwithstanding. Furthermore, these results are not generalizable.

Table 9. EDGe$ results for each mitigation measure using only 100-year loss reductions

	Buyout	Levee
Disaster Economic Benefits		
Response and Recovery Costs	$194 464	$416 708
Direct Loss Reduction	$44 015 901	$44 015 901
Indirect Losses	$1 777 954	$1 889 076
Disaster Non-Market Benefits		
Value of Statistical Lives Saved	$20 562 547	$22 144 282
Number of Statistical Lives Saved	9.75	10.5
Non-disaster Related Benefits		
One-Time	$0	$0
Recurring	$21 160 244	($2 286 257)
Costs		
Direct Costs	$65 497 500	$51 240 000
Indirect Costs	$1 680 000	$4 500 000
OMR		
One-Time	$0	$0
Recurring	$285 682	$1 216 453
Externalities		
Positive		
One-Time	$0	$0
Recurring	$3 809 094	$0
Negative		
One-Time	$0	$0
Recurring	$0	$2 169 013
Present Expected Value		
Benefits	$87 711 110	$66 179 711
Costs	$67 463 182	$56 956 453
Externalities	$3 809 094	($2 169 013)
With Externalities		
Net	$24 057 022	$7 054 245
Benefit-to-Cost Ratio	1.30	1.20
Internal Rate of Return (%)	6.95	5.71
Return on Investment (%)	0.40	0.27
Non-Disaster ROI (%)	-0.92	-1.34
Without Externalities		
Net	$20 247 928	$9 223 257
Benefit-to-Cost Ratio	1.30	1.16
Internal Rate of Return (%)	6.64	5.93
Return on Investment (%)	0.40	0.22
Non-Disaster ROI (%)	-0.92	-1.39

6 References

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