Flood risk reduction systems optimization

Protecting Galveston Bay shores and the Barrier Islands

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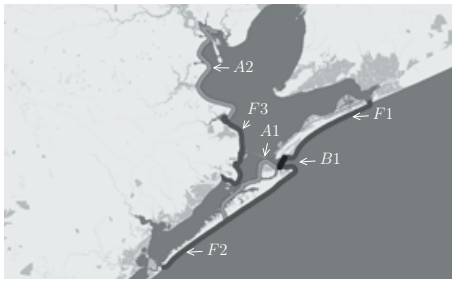


Figure 1.
Galveston Bay area with contours indicating the defense types for the hypothetical application. from OpenStreetMap (©OpenStreetMap contributors, http://www.openstreetmap.org/copyright).

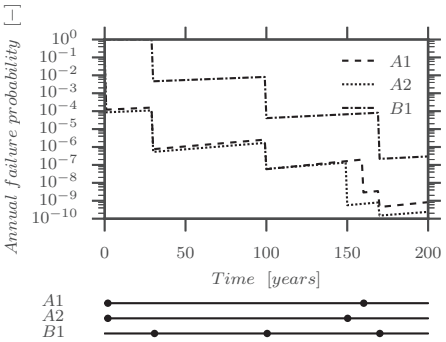
Three types of defenses:
A1, A2: a rear defense
B1: a front defense
F1, F2, F3: a defense with a fixed safety level
(Note that the contours are indicative)

Table 1 and 2.
Optimal investment scheme for the Galveston Bay example using the numerical framework for the simplified optimization problem, with (left) and without (right) the influence of a front defense.

With influence of a front defense		
Year	**Defense**	**Height increase**
0	A1	From 0 to 5 meter
160	A1	From 5 to 7 meter
0	A2	From 0 to 7 meter
150	A2	From 7 to 10 meter
30	B1	From 0 to 7 meter
100	B1	From 7 to 11 meter
170	B1	From 11 to 15 meter

Without influence of a front defense		
Year	**Defense**	**Height increase**
0	A1	From 0 to 6 meter
70	A1	From 6 to 9 meter
130	A1	From 9 to 12 meter
190	A1	From 12 to 15 meter
0	A2	From 0 to 9 meter
80	A2	From 9 to 13 meter
160	A2	From 13 to 17 meter

Figure 2.
*Safety values in tie for flood defenses B1, A1 and A2 of Table 4, **with** the influence of a front defense. The corresponding timing of the investments per defense is shown as well.*



Guy Dupuits

FLOOD RISK REDUCTION SYSTEMS OPTIMIZATION

PROTECTING GALVESTON BAY SHORES AND THE BARRIER ISLANDS

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(Tentative) dissertation title:
'Economic optimization of flood defense systems with multiple lines of defense.'

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Many alternatives can reduce the flood risk around Galveston Bay (for an overview, see page 146). But which combination of alternatives suits the society most? This is, no doubt, a political decision, with various interests each playing a role. Nevertheless, we can always ask which combination is most attractive from an economic point of view.

In my research, this question is answered by minimizing the total costs of 'multiple lines of defense'. In such an approach, for example the 'front defense' reduces the hydraulic load on the flood defenses that ultimately protect the vulnerable areas. The outline of the optimization approach is given in Figure 3, where the different variables are presented. The application is based on work from a real, ongoing case study in the Galveston Bay area near Houston. However, the actual decision-making problem is simplified in order to investigate the principles behind optimization of multiple lines of defense. Therefore, the results are primarily useful for a comparison between an application with and an application without multiple lines of defense.

The Houston-Galveston Bay area consists of a large bay with barrier islands; millions of people live here, and the area represents large economic value. Though the region does not have yet an integral flood defense system, the feasibility is being investigated as the area is hurricane prone. In the simplified optimization problem, a number of defenses have been set to a fixed level: F1, F2, and F3 (Figure 1). Only a single system configuration is considered in this case study, but this assumption will not have a large impact on the conclusions as in these locations of the flood defenses are already built, and it would require a huge amount of resources to relocate them.

Consequently, as we can see in Figure 1, this leaves us with only three defenses which will be part of the economic optimization: a single front defense in the form of a storm surge barrier (B1), and two rear defenses (A1 and A2). Tables 1 and 2 show the outcomes of the simplified case study: Table 1 with the front defense, and Table 2 without the front defense. It can be concluded that the front defense reduces the hydraulic load dramatically, and that it is cost effective in this case to have multiple lines of defense.

Figure 3.
Overview of necessary steps in the numerical framework used to obtain economical optimal values for a coastal flood defense system