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Brody, Samuel; Kothuis, Baukje Bee; Lee, Yoonjeong

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CHAPTER 1

Introduction to the Coastal Flood Risk Reduction Program

Samuel Brody[a,b], Baukje Bee Kothuis[c,d], and Yoonjeong Lee[a,b]
[a]Institute for a Disaster Resilient Texas, Texas A&M University, College Station, TX, United States
[b]Department of Marine and Coastal Environmental Science, Texas A&M University, Galveston Campus, Galveston, TX, United States
[c]Department of Hydraulic Engineering and Flood Risk, Faculty of Civil Engineering and Geosciences, Delft University of Technology, Delft, The Netherlands
[d]Netherlands Business Support Office, Houston, TX, United States

Floods are the most deadly, disruptive, and costly natural hazard worldwide. Not a day goes by without news of some type of flood-induced disaster being reported across multiple media outlets. From chronic deluges of rainfall to 1000-year storm surge events, the toll of persistent inundation, especially in low-lying coastal areas, continues to mount. Increasing physical risk combined with rapid land use change and development in flood-prone areas has amplified the adverse economic and human impacts in recent years. Never before have the repercussions from storm events driven by both surges and rainfall been so damaging to local communities to the point that curbing their impacts has become, in many countries, a national priority.

Nowhere is the growing threat of floods to the economic well-being of society more apparent than in the upper Texas coast of the United States. In 2017, Hurricane Harvey brought record rainfall to this region causing catastrophic losses covering 49 counties, an area roughly the size of New England. Over 150,000 residential structures were inundated by floodwaters and damage estimates range in the hundreds of billions of dollars. Harvey simply followed a continuous string of storms delivering at least 6 in of rain, peppered with gigantic events with names such as Memorial Day, Ike, Rita, and Allison, and so on. For many households in the Houston area, floodwaters in one's home is an annual occurrence. Each successive flood episode inflicting the Texas coast with millions of dollars in losses exposes the underlying risk of placing millions of people in harm's way and sends a signal to other large metropolitan areas in similar situations that the problem is only getting worse.

In 2015, years before Hurricane Harvey broke every rainfall record in the book, a team of collaborators from universities in the Netherlands and the United States came together and hatched a 5-year research plan to address growing flood problems in the Houston-Galveston area as an example to the rest of the world. After all, the Dutch have long been renowned for their gritty ability to not just survive, but also thrive in the face of a persistent threat of floods. After their national flood disaster in 1953, the country made it the national priority to protect the welfare and safety of its population in perpetuity. The Netherlands

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and the upper Texas coast of the United States also make for a very useful comparison. Both regions are extremely flood-prone and have experienced continual adverse impacts throughout their histories. And, both are approximately the same size with similar populations, economies, and economic growth patterns. However, each country has responded to the risk of floods in fundamentally different ways, providing important points of comparison for those interested in becoming more resilient over the long term.

This international team of researchers, holed up for the day in a windowless conference room situated on a small barrier island clinging to the Texas coast, were working under several assumptions: (1) unlike some other natural disasters, floods are often exacerbated or even entirely created by human development decisions such as roadways, rooftops, parking lots, etc.; (2) floods problems persist in roughly the same place under the same conditions year after year. Their predictability makes them more fixable; (3) the rising cost of floods is not solely a function of changing weather patterns, sea-level rise, or a problem that can be solved through engineering solutions alone. Rather, flood risk and associated losses can only be understood and eventually reduced through integrated investigation across multiple disciplines, cultures, and international boundaries.

All of the researchers in the room that day, from engineers to architects, agreed that there is a critical need for program-level, trans-disciplinary inquiry in science and engineering that will lay a foundation for decision-making aimed at increasing the flood resiliency of communities in the United States and around the world. And, that any successful study must combine a diversity of physical and social science data, methods, and analytical techniques to form a more comprehensive understanding of flood risk.

This brainstorming session became the National Science Foundation Partnerships for International Research and Education (PIRE)—Coastal Flood Risk Reduction Program. Now in its sixth year, this collaborative research initiative activates an integrated, place-based education, and student exchange between multiple institutions in the Netherlands and the US Researchers from Texas A&M University, Rice University, Jackson State University, TU Delft, and VU Amsterdam, and others converge every year in the Netherlands to learn about cutting edge flood risk reduction techniques and then transport this knowledge to the Upper Texas Coast. Working with and learning from the brightest minds from a country that has set the benchmark for flood mitigation and protection is one of the best ways to address our national problem in the United States. So far, over 50 students from multiple universities have had transformative educational experiences in the Netherlands. Moreover, the program has spawned innovative research methods, improved understanding of flood risk reduction, and generated mitigation techniques that can be applied to Houston and other coastal urban areas.

The pages of this book are filled with insights, findings, and recommendations from dozens of experts formally participating in the PIRE program. Multiple case studies integrating the fields of engineering, hydrology, landscape architecture, economics, and planning address the following broad research questions: (1) what are the underlying characteristics of physical flood risks and how can they be predicted; (2) why are human

communities and the associated built environment so vulnerable to flood impacts; (3) how are physical, social, and built-environment variables interrelate to exacerbate flood risk; and (4) which mitigation techniques, both structural and nonstructural, are most effective in reducing the adverse impacts of floods? Chapters cover a range of issues, from engineering flood gates and landscape design, to risk communication and authentic learning practices. They provide a rare opportunity to look at flood problems from an international, comparative perspective over a multiyear time frame. Together, they represent a transdisciplinary and holistic approach to addressing flood problems in the Netherlands and the United States.

This edited book is outlined by five sections representing major thematic areas associated with flood risk reduction. Section I focuses on predicting floods based on environmental and physical underpinnings. The authors examine the factors often setting the boundary conditions for flooding and associated impacts. Special attention is paid to predicting risk via inundation from precipitation and tidal-based events, as well as other nonphysics-oriented methods for predicting flooding. Section II shifts to investigating the socioeconomic and political drivers of flood risk. Authors highlight economic impacts, cost–benefit analysis, insurance-related issues, and risk perceptions. Section III examines the role of planning, design and the built environment. Here, authors from both countries emphasize how development patterns, buildings, and critical infrastructure contribute to the degree of flood impacts. Nature-based planning, green infrastructure, and urban design are also explored as a way to address increasing flood risk over the long term. Section IV brings together themes of previous chapters to focus on finding solutions that enhance flood resiliency. Multiple mitigation strategies are presented and evaluated in detail, including coastal barriers, dune systems, property acquisition, flood-proofing, and risk communication. Finally, Section V is dedicated to assessing the impact of placed-based and authentic learning—a major goal of the PIRE program. The authors describe how this style of learning was implemented for students participating in the international multidisciplinary flood risk reduction research and education program. Specific examples and observational data are presented on the effectiveness of the educational approach over the 5-year time frame, including descriptions of (1) multidisciplinary and transformative education approaches and student-centered place-based learning; (2) the student exchange and specific outcomes/examples of work; and (3) observational impacts of place-based and problem-based on learning and resilient thinking. The book concludes with lessons learned from the large body of work produced and experiences undertaken throughout the PIRE program and sets an agenda for future collaborative work that will benefit flood risk reduction in both countries.

We hope this book provides critical knowledge and pathways to more flood resilient futures by comparing and contrasting the pursuits of two leading countries dealing with increasing flood risk. It is a valuable resource for decision-makers, researchers, experts, students, and others interested in reducing the adverse impacts of floods over the long term.