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In Europe, High-Tech Flood Control, With Nature's Help

By **WILLIAM J. BROAD**

On a cold winter night in 1953, the Netherlands suffered a terrifying blow as old dikes and seawalls gave way during a violent storm.

Flooding killed nearly 2,000 people and forced the evacuation of 70,000 others. Icy waters turned villages and farm districts into lakes dotted with dead cows.

Ultimately, the waters destroyed more than 4,000 buildings.

Afterward, the Dutch - realizing that the disaster could have been much worse, since half the country, including Amsterdam and Rotterdam, lies below sea level - vowed never again.

After all, as Tjalle de Haan, a Dutch public works official, put it in an interview last week, "Here, if something goes wrong, 10 million people can be threatened."

So at a cost of some \$8 billion over a quarter century, the nation erected a futuristic system of coastal defenses that is admired around the world today as one of the best barriers against the sea's fury - one that could withstand the kind of storm that happens only once in 10,000 years.

The Dutch case is one of many in which low-lying cities and countries with long histories of flooding have turned science, technology and raw determination into ways of forestalling disaster.

London has built floodgates on the Thames River. Venice is doing the same on the Adriatic.

Japan is erecting superlevees. Even Bangladesh has built concrete shelters on stilts as emergency havens for flood victims.

Experts in the United States say the foreign projects are worth studying for inspiration about how to rebuild New Orleans once the deadly waters of Hurricane Katrina recede into history.

"They have something to teach us," said George Z. Voyiadjis, head of civil and environmental engineering at Louisiana State University. "We should capitalize on them for building the future here."

Innovations are happening in the United States as well. California is experimenting with "smart" levees wired with nervous systems of electronic sensors that sound alarms if a weakening levee threatens to open a breach, giving crews time to make emergency repairs.

"It's catching on," said William F. Kane, president of Kane GeoTech Inc., a company in Stockton, Calif., that wires levees and other large structures with failure sensors. "There's a lot of potential for

this kind of thing."

While scientists hail the power of technology to thwart destructive forces, they note that flood control is a job for nature at least as much as for engineers. Long before anyone built levees and floodgates, barrier islands were serving to block dangerous storm surges. Of course, those islands often fall victim to coastal development.

"You'll never be able to control nature," said Rafael L. Bras, an environmental engineer at the Massachusetts Institute of Technology who consults on the Venetian project. "The best way is to understand how nature works and make it work in our favor."

In humanity's long struggle against the sea, the Dutch experience in 1953 was a grim milestone. The North Sea flood produced the kind of havoc that became all too familiar on the Gulf Coast last week. When a crippled dike threatened to give way and let floodwaters spill into Rotterdam, a boat captain - like the brave little Dutch boy with the quick finger - steered his vessel into the breach, sinking his ship and saving the city.

"We were all called upon to collect clothes and food for the disaster victims," recalled Jelle de Boer, a Dutch high school student at the time who is now an emeritus professor of geology at Wesleyan University. "Cows were swimming around. They'd stand when they could, shivering and dying. It was a terrible mess."

The reaction was intense and manifold. Linking offshore islands with dams, seawalls and other structures, the Dutch erected a kind of forward defensive shield, drastically reducing the amount of vulnerable coastline. Mr. de Haan, director of the water branch of the Road and Hydraulic Engineering Institute of the Dutch Ministry of Transport, Public Works and Water Management, said the project had the effect of shortening the coast by more than 400 miles.

For New Orleans, experts say, a similar forward defense would seal off Lake Pontchartrain from the Gulf of Mexico. That step would eliminate a major conduit by which hurricanes drive storm surges to the city's edge - or, as in the case of Katrina, through the barriers.

The Dutch also increased the height of their dikes, which now loom as much as 40 feet above the churning sea. (In New Orleans, the tallest flood walls are about half that size.) The government also erected vast complexes of floodgates that close when the weather turns violent but remain open at other times, so saltwater can flow into estuaries, preserving their ecosystems and the livelihoods that depend on them.

The Netherlands maintains large teams of inspectors and maintenance crews that safeguard the sprawling complex, which is known as Delta Works. The annual maintenance bill is about \$500 million. "It's not cheap," Mr. de Haan said. "But it's not so much in relation to the gross national product. So it's a kind of insurance."

The 1953 storm also pounded Britain. Along the Thames, flooding killed more than 300 people, ruined farmland and frightened Londoners, whose central city narrowly escaped disaster.

The British responded with a plan to better regulate tidal surges sweeping up the Thames from the North Sea. Engineers designed an attractive barrier meant to minimize interference with the river's natural flow. It went into service in 1982 at Woolwich, about 10 miles east of central London.

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