

Water management in the Netherlands

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Overview. In a time of global warming and rising sea levels the Netherlands faces a hard ordeal. Three of Europe's biggest rivers debouching into the sea here and already half of the country and the homes of 10 million people are below sea level. Survival would be at stake, if it wouldn't have a highly advanced water management system.

What is being organized? The primary resource being organized in this system is the water in the Dutch rivers, canals, lakes and ditches, as well as the sea water around the Dutch coasts. To be able to do so, other resources are added to this originally natural system, namely about 200 miles of dikes and dams, 70 weirs, 4 immense flood barriers and countless pumps. By the use of sensors, cameras and human checks digital information about them is entered into the system. This information is used for models and calculations that directly influence the physical resources, making the system an integrated mixture of physical and digital resources.

By rainfall and snowmelt throughout Europe, the rivers are fed with new water constantly, while storms and ocean currents influence the sea level, causing a continually change in resources. At the same time digital interaction resources are created through ongoing interaction between the water and the measurement resources.

Why is it being organized? In the first place the system is designed to disable the water from flooding the country and drowning the Dutch citizens, which makes preventing an interaction the main goal of the system, a social goal. This social goal is institutionalized, since the government took over the responsibility of interacting with the system.

Water as the main resource of life, supports many interactions, therefore the government distinguishes two other goals for this system. An economic goal is to provide a valuable infrastructure for the shipping industry by dredging the rivers and seabeds and digging canals to industrial areas. The third one is to facilitate natural and recreational uses like preserving and supporting plant and animal habitats and the historical Dutch landscape and ensuring the water quality, while building new artificial resources to maintain the system.

How or by whom is it being organized? The Ministry of Infrastructure and Environment has given the governmental institute 'Rijkswaterstaat' the special task to manage this water system and its resources. It does so by maintaining the system by dragging and strengthening the dikes and it controls the flood barriers, weirs, interactive pumps and even movable dikes. These enable Rijkswaterstaat to manipulate the exact location of all the water, making this one of the biggest physical human controlled organizing systems in the world.

Two famous prestigious examples of these operations are the 'Afsluitdijk' and the 'Deltaworks'. The 'Afsluitdijk' in the north of the Netherlands, a 20 mile weir and road that controls the water level of a large part of the North Sea by separating it from the open sea and therefore turning it into a lake. The 'Delta works', a construction of flood barriers in the south of the Netherlands, can close the entire delta of the rivers the Rhine and the Meuse in case of exceptional high sea levels. In this way it controls the water levels of the last part of these rivers and allows the river dikes to be tens of feet lower.

Decisions about the organization of the water, by physically manipulation of the resources, are made by professionals, supported by advanced computer methods and algorithms that also partially

organize the system automatically. Weirs close automatically and pumps that regulate the groundwater level, react directly to sensor information, minimizing the need for interpersonal contact and therefore the risk of human mistakes.

Another important organizer of the system is Mother Nature. The climate interactions are purely physical and consist of adding resources by letting water flow into the rivers and vary the sea level and affecting the artificial resources.

Unique is the fact that the Dutch citizens do not directly interact with the system, which is very different from other cities and countries that are vulnerable to water floods, like the Maldives, Venice and New Orleans. In these regions the governments have created fewer possibilities to interact with the water system, unfortunately resulting in more enabled interactions for their citizens and their homes. Besides users (or victims) of the system the citizens of those areas are still organizers by actively protecting their homes with improvised dikes.

How much is it organized? Water is a liquid resource, and no specific unit can be uniquely identified, which makes digitization harder and models more vulnerable to uncertainty. To measure the resource water, it is geographically categorized into open water and groundwater under land areas. The open water is further divided into the different seas, rivers, lakes, canals and ditches and in each of them, with different granularity, the difference in centimeters with the regular water level in Amsterdam, the so called 'NAP' level is tracked. Their precise measurement system allows Rijkswaterstaat to track these water levels on a scale of a square meter in critical areas. Combined with detailed knowledge about the water quality that is stored, this empowers the required high level of interoperability with the system that provides drinking water in the Netherlands.

The great importance of the persistence of the man-made resources results in detailed data about its maintenance. Since preventing interactions is the main goal, the maintaining phase of the system is the most important part of the systems lifecycle.

Another form of interoperability due to the high level of organization and description of the resources can be seen in the landscape architecture of the country. Human controlled natural resources are used to serve as protection against the water where possible. Low playgrounds and recreational lakes are created in villages to capture water in rainy seasons, to reduce the need for pumps to prevent basements from flooding.

Where is it being organized? Rijkswaterstaat is located in the city of Rotterdam. The water management system itself is controlled from Lelystad, a city built on land reclaimed from water the systems main servers that contain the informational resources are also located here. Throughout the country local departments, external parties and local governments collaborate to execute the systems processes and maintenance.

In a European collaboration, with among others neighboring countries Germany and Belgium, the Netherlands participates in a network of interoperable water management systems to control the flow of the rivers and exchange related climate information. The example of the port of Antwerp, Belgium's largest port, that is deprived of international access if the Netherlands closes the flood barriers of the 'Deltaworks' points out the importance of the collaboration.

When is it being organized? The Dutch war against the water started about 500 years BC, when the first permanent inhabitants of this fertile sea-deposited clay protected themselves against floods by building their homes on artificial dwelling hills. The first dikes and even the first rerouting of rivers

date back to the Roman invasion in the first centuries. The famous Dutch Windmills were introduced as predecessors of the current electric water pumps to dry wet field and reclaim water from rivers and sea for agricultural use in the late Middle Ages. The foundation of Rijkswaterstaat in 1798 and the Kingdom of the Netherlands in 1813 resulted in the first nationwide water management system.

The current highly advanced organizing system dates back to the beginning of the 20th century, when rising sea levels caused an increased number of floods and the 'Afsluitdijk' was built to stop the ocean from claiming land. In 1953 for the last time a big flood afflicted the Netherlands, killing 2000 people and taking the homes of a 100.000. It meant the start of the largest renovation of the system and the building of unprecedented flood protection projects as the 'Deltaworks'.

Nowadays digital interaction enables a more detailed organization of the system than ever before and the with constant supply of resources and a changing environment organization takes place every second to keep the water away and extend the maintaining phase of the system's lifecycle forever.

Other Considerations. Rising sea levels are not only a problem for the Netherlands. It is worldwide threat with important consequences for different cities and countries. In the table below I will compare them to see the differences and similarities in the level of action the government has taken to create a water management system and the response of citizens to interaction with these systems.

	The Netherlands	Venice	The Maldives	New Orleans
Surrounded by:	<i>Sea:</i> North Sea <i>Rivers:</i> Rhine, Meuse, Scheldt and Eems	<i>Sea:</i> Mediterranean Sea <i>Lagoon:</i> Venetian Lagoon	<i>Ocean:</i> Indian Ocean	<i>Lake:</i> Lake Pontchartrain <i>Sea:</i> Gulf of Mexico <i>River:</i> Mississippi
Above sea level:	Average: 16 ft.	Average: 57 in .	Average: 4 ft. 11 in. Maximum: 7 ft. 10 in.	6 ft. below sea level Maximum: 20 ft. above sea level
Special:	Country with largest part of its land under sea level, while having one of the highest population densities	High historical importance. The city sinks about half an inch every year.	Lowest country of the world, famous for its coral islands.	Vulnerable for Hurricanes and still sinking.
Man-made protection resources	Dikes dams, weirs, flood barriers and pumps	Port dams separating the Venetian Lagoon from the sea.	Small dikes	Pumps and dikes.
Under construction:	-	MOSE flood barrier. Separates the Venetian Lagoon from the sea.	-	IHNC Lake Borgne Surge Barrier. Closes the water ways of Lake Pontchartrain in the north and the Gulf Intracoastal Waterway on the west side of the city

Last flood:	1953	2012	2016	2016
# floods in past 10 years:	0	5	12	2
Citizens reaction to flood:	No interactions between citizens and the water.	Getting used. Place special plates in the door frame and clean their home after the flood.	Escape to higher places and leave the islands. Often move to other islands after the flood.	Evacuated in advance if possible. Interaction is not supposed to happen, peoples believe in the system prevents them from evacuation. Build up their homes again after the flood and return to the city.
Government reaction to rising sea level	Maintaining the current water management system and increasing the dikes.	Building the MOSE flood barrier that will protect the city for storms that increase the sea level with 10 ft. when closed. Considering final separation of the Venetian Lagoon from the sea and dredging the lagoon partially if Venice will sink further.	Level up the heights of the lands when new homes are build and moving the population to higher islands. Dike are not build because they ruin the coast and therefore the tourism. They let complete island disappear and are actually negotiating about the purchase of new lands to continue their country when all islands will flood by higher sea levels.	Construction of new surge barriers with the largest pump station of the world. Renovating the dikes and forbidding living in certain areas.



'Delta Works'



'Afsluitdijk'



The Netherlands below sea level