



2018



Deltares
Enabling Delta Life 

Foreword

*Deltares is as solid as a rock:
an authoritative research
institute in the field of water
and the subsurface*

Sometimes dreams come true. We saw that at the tenth anniversary of Deltares. During our open days and symposium, more than 800 employees showed our business contacts that we have fulfilled the ambitions set out for us at the time of our foundation. Deltares is as solid as a rock: an authoritative research institute in the field of water and the subsurface. That means we can make an even larger contribution to meeting concrete social challenges. We remain true to our basic principles: building excellent knowledge, visible impact and strong connections between knowledge and practical application. We are eager to share our knowledge transparently, for example through our open source software.

This report presents a number of these high-impact projects from 2018. Innovative solutions for climate and water, a sustainable living environment and future-proof infrastructure. You can read, for example, about a sheet piling trial that will help to make dike upgrades in the Netherlands more

effective. And how we generate international impact. For example in Bangladesh, where we are not only introducing new technologies in the field of water management but, above all, also establishing a dialogue with users about application. Or how we used machine learning to process 1.9 million satellite images and identify 50,000 sandy coasts to assess where the coasts are eroding. That is vital for good coastal management.

We are continuing to dream and act in order to achieve our ambition of **'Enabling Delta Life'**. Above all, that means not working in isolation but in partnership. Deltares is at the heart of a knowledge community that wants to make an impact. In this way, we want to be an open and accessible research organisation that belongs to us all. Including you!

Deltares board of directors
Maarten Smits, Erik Janse, Ron Thiemann



Contents





'We collected data in this trial to make it clear how steel sheet piling really works in a dike during high water. That will be a great help in any event on dike upgrades in the future!'

Joost Bredeveld | Deltares project manager

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Sheet piling failure trial will help on future dike upgrades

Steel sheet piles are used regularly to improve dike stability. But to use this approach more efficiently, we need to know more about how dikes strengthened in this way behave in extreme load conditions. How strong is this dike exactly, how can we get steel and the ground to work together more, and how large are the deformations in the dike? The sheet piling trial in Eemdijk, which was organised as part of the Macro-stability Cross-Project Study (POV) programme, answered these questions.

Understanding deformation behaviour

During the Eemdijk trial in March 2018, a test dike that had been reinforced with sheet piling was collapsed to learn more about actual

deformation behaviour and the strength of this kind of dike. A few weeks earlier, a dike without sheet piling had already been collapsed. Comparing the two made it possible to identify differences between dikes with and without sheet piling. Continuous monitoring took place during the trial to establish a range of datasets.

Homogeneous soil

At the trial site, two 60-metre-long test dikes were built with their backs to each other and a 'river' between them. The test dikes were then collapsed by saturating the dike cores in controlled conditions. Eemdijk had been selected as a location because of the homogeneous soil structure here, which made it possible to limit the number of variables and obtain the most reliable test results.

Project team

The project team consisted of Deltares and Witteveen+Bos, who designed and supervised the construction of the test dikes, the execution of the trial

and the repairs on behalf of the Macro-stability POV. The other partners in the trial were the Vallei en Veluwe water authority, F.L. Liebrechts, Fugro and ArcelorMittal.

Data

All the data collected provide the researchers and the partners with a wealth of information for research in the future. They will also make it possible to further refine the current design and assessment methods used in the Netherlands.

Flood Protection Programme assignment

In the years to come, the Dutch Flood Protection Programme (HWBP) will face the challenge of completing the largest dike upgrade operation ever. The Macro-stability POV is part of the national HWBP, which is a collaboration between Rijkswaterstaat and the water authorities.



More info

Partners

Witteveen + Bos | Vallei en Veluwe Water Authority | F.L. Liebrechts | Fugro | ArcelorMittal | Flood Protection Programme | Rivierenland Water Authority

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Water innovations with Bangladesh community

The coastal area of Bangladesh offers enormous opportunities for projects of national importance. It is a good region not only for fishing and shrimp farming but also for the cultivation of all kinds of crops. However, the coastal zone is also very sensitive to natural disasters such as cyclones, storm surges and coastal erosion. Other challenges include a lack of drainage facilities, drought, flooding and salt intrusion.

Human factors

Many of these problems are man-made. The vulnerability of coastal communities is further exacerbated by other difficulties such as poor communications, lack of education and health facilities, and a persistent shortage of adequate supplies of clean drinking water.

Local communities on the west coast

Deltares and the Institute of Water Modelling (IWM) from Bangladesh teamed up with other partners in 2018 to develop 'The Water Management Knowledge and Innovation Programme' with the aim of improving the welfare and livelihoods of local communities on the west coast of Bangladesh through innovations and knowledge in the field of water management.

Innovations in four areas

In collaboration with our partners, we aim to develop innovations and knowledge for:

- Improving drainage and water disposal
- Improving operational water management and monitoring
- Managing and protecting rivers and riverbanks
- Participatory water management aimed at involving disadvantaged groups in management.

The research programme is being financed by the Dutch embassy in Bangladesh. It began in early 2018 and it will continue for a total of three years.



'As a research institute, our mission is not only to develop and transfer the technology but also, and primarily, to establish a dialogue with users about how they want to apply the innovations. That's the only way we can really make an impact'

William Oliemans | Deltares project manager



More info

Partners

IWM, Blue Gold Programme | Wageningen University & Research | Centre for Natural Resource Studies (CNRS)

3 Beaches worldwide on the map



'To validate our new method, we made a comparison with coasts where extensive measurements have been made such as those in Australia, the Netherlands and the United States.'

Arjen Luijendijk | Deltares coastal expert

Deltares analysed all the world's sandy coasts in 2018. We looked at how beaches have evolved over the last thirty years: has there been erosion or is there now more sand? Coastal areas are vulnerable because of changes in waves, wind and sea level rise, and the increasing influence of human activities.

Conclusion: more beaches

For years, two-thirds of all beaches were being eroded. However, our analysis shows that, on a global scale, the sandy coastline is not eroding that rapidly at all. Indeed: on average, there are more beaches growing than shrinking. In addition to the natural expansion of river deltas, it emerges that people are well able to maintain the coast in several places in the world. In the Netherlands, the coast has grown at an average rate of 2.8 metres a year since 1984, mainly due to the addition of new sand (suppletion). Nevertheless, many beaches are still eroding: more than 5 metres of beach are being lost annually on 12,000 kilometres of coastline.

Research method

Machine learning was used to detect 50,000 sandy coasts on the basis of 1.9 million satellite images. This large dataset was analysed using Google Earth Engine. The analysis covered the years after 1983, which is when the first satellite images from NASA became available.

Deltares has processed all the data and made it available in a public viewer: <http://shorelinemonitor.deltares.nl>. Everyone can now use this tool to study the dynamics of his or her favourite beach.

Challenge for the future

At the global level, we generally have erosion under control thanks to good coastal management. However, problems have been identified at the regional and local levels, particularly in the United States and Africa. Local factors can be related to things like the construction of ports or other infrastructure, which can sometimes negatively affect the natural coastal dynamics. Sand is not always available locally to protect the coast. The main question for the future is whether there will be enough sand available to maintain all beaches.



4 Blockchain in land subsidence



If the expression 'in the water up to our necks' applies anywhere, it applies in the Dutch city Gouda. It is a real problem for inhabitants of this beautiful historical city: buildings are subsiding, cellars are being flooded and sewage systems are breaking. The difficulties for society and the economic damage are enormous but so are the costs of any solutions to the problem. Not surprisingly, then, there is a lack of confidence sometimes between the public and government.

What is blockchain?

- Blockchain technology makes digital records unique.
- It copies and distributes data/metadata many times over and stores them with the participants in the blockchain.
- A copy is called a node and each node contains the same data as the other nodes in the network so they all always contain exactly the same information.
- Each node checks whether the other nodes contain the same data.
- It is only possible to add data to a blockchain. Changing or deleting data is not an option.

Blockchain technology

Deltares saw opportunities to improve trust between all parties through the use of blockchain technology. This approach was used by Deltares for the first time in 2018 to look at land subsidence in Gouda. The blockchain approach is used to ensure that all information is public, transparent and beyond doubt and so, in any event, it puts an end to debate and questions about the reliability of the underlying data.

Collecting data

By using blockchain, all the parties involved - the municipality, the water authority, the public and companies - get the same information, as well as a clear picture of where the information comes from and how it is processed. Gouda has been collecting data about land subsidence for a long time now, for example with seventeen monitoring wells that measure the groundwater level in the city and display it online. Everyone can now see exactly which groundwater levels have been measured and how these data are processed.

Focus

The blockchain application is available through <https://geoblockchain.nl/blockchain>. The project focuses not only on establishing a reliable dataset on land subsidence in Gouda but also on whether the blockchain approach actually helps to bring government and the general public together. The results of this evaluation are expected in spring 2019.

'This helps to avoid getting bogged down in discussions about where data come from'

Bob Hoogendoorn | Deltares project manager

Partners

Municipality of Gouda | Rhineland Water Authority | Watergilde | Provincial Authority of South Holland | Wareco | Blockchain developer Xurux



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Faster and better emergency aid in the Philippines

How do aid workers in the Philippines know which type of emergency aid is most needed? Tents or clean drinking water? A field hospital or fast evacuation? To save as many lives as possible and prevent more suffering, the ability to respond quickly and effectively is vital. Deltares and 510, an initiative of the Dutch Red Cross, launched a project in 2018 for the 'data-driven prioritisation of humanitarian aid'.

The project combines two types of data. First of all, the historical data on various cyclones in the Philippines: the wind speeds, the course followed by the storm, where the storm landed, and the amount and nature of the damage. The meteorological data in the theoretical model still come from past storms. However, in time, they will be available from a local meteorological service that delivers forecasts about an approaching storm. In addition, 510 has data on risks for all local areas in the Philippines such as the number of houses

in a particular region or village, the material used to build those houses, and the residents' income and education levels. 510 has developed a machine learning model that uses meteorological and risk data to predict the damage per area of an approaching typhoon by learning from past typhoons. This model was used in the emergency response to three typhoons in 2017 and 2018. In collaboration with 510, we are looking this year at how this forecast can be made even better and more detailed, and how it can be put into practice.

The idea is that the model will actually be operationally embedded in the Philippines this year by the local Red Cross. In addition, the option is being investigated of using a similar approach in Bangladesh in the foreseeable future.

'I think it is precisely the combination of the new big data models and the more traditional physical models that will deliver added value. Deltares can accurately model the behaviour of a physical system, such as a flood caused by a storm, but that requires very specific knowledge. Admittedly, the new big data models are often less accurate but they are relatively fast and so they are cheap to produce'

Dennis Wagenaar | Deltares project manager

'The question is not whether we should arm ourselves against sea level rise but above all when we will start to feel the impact of that rise'

Marjolijn Haasnoot | Deltares climate adaptation researcher



6 Consequences of accelerated sea level rise for the Netherlands

Sea level rise could be much faster than expected after 2050.

This is a possible scenario that the Netherlands must take into account. The ice on Antarctica is melting and breaking off more and more quickly. In this scenario, major flood defences will become inadequate sooner, more sand will be needed to maintain our coastline, and more and more salt water will enter our country through the rivers.

More salt will also penetrate into the soil and demand for water will increase even though there will be no change in how our land is used. The current Delta Plan in the Netherlands assumes a sea level rise of 1 metre in 2100 but it does not take into account the possibility of an acceleration from 2050 onwards that results in a higher rise in 2100. The Delta Commissioner asked Deltares to map out the possible implications for the coast, flood risk management and freshwater distribution.

Adjusting tipping points on the basis of new insights into sea level rise

In addition to investigating the possible contribution of Antarctica to sea level rise, the recommendation is to explore alternative measures to cope with

higher and faster sea level rise. The research report 'Possible consequences of accelerated sea level rise for the Delta Programme' looked at 'tipping points': the points at which sea level rise or the rate of rise will require new or additional measures to be taken. The faster the sea level rises, the sooner the tipping points will be reached and the shorter the lifespan of certain measures. The benefit of this approach is that, when there are new insights about the rate of sea level rise, changes will only be needed to the timing of the tipping points. The analysis makes it clear that decisions about measures depend vitally on not only the extent of sea level rise but also on the rate, particularly when major investments with a long lifespan are involved.

Importance of keeping a close eye on sea level rise

It is still not clear whether sea level rise will indeed accelerate in the future. Organisations such as the Royal Netherlands Meteorological Institute (KNMI) and the IPCC, the climate panel of the United Nations, will be researching this area in the years to come. Because of the far-reaching implications for the low-lying Netherlands, it is important to closely monitor the breaking-up and melting of land ice in Antarctica and the resulting sea level rise.

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New Orleans resilient to climate change

New Orleans subsides by an average of 6-8 mm annually and most of the city is below sea level. Hurricane Katrina resulted in floods that caused considerable damage. New Orleans received 141.3 million dollars from the Department of Housing and Urban Development for its plan 'Reshaping the Urban Delta', which is intended to make the city resilient, but above all safe again.

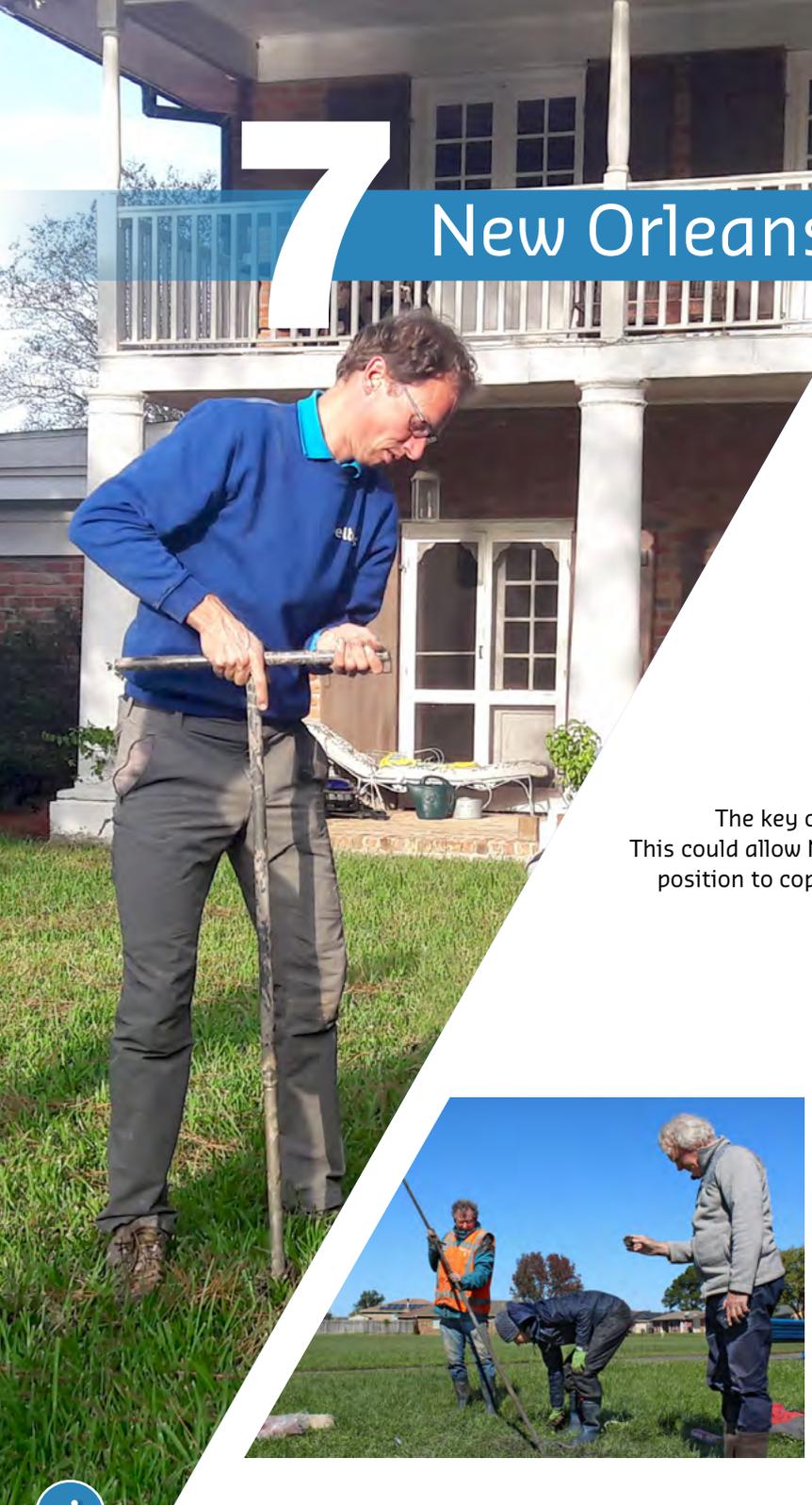
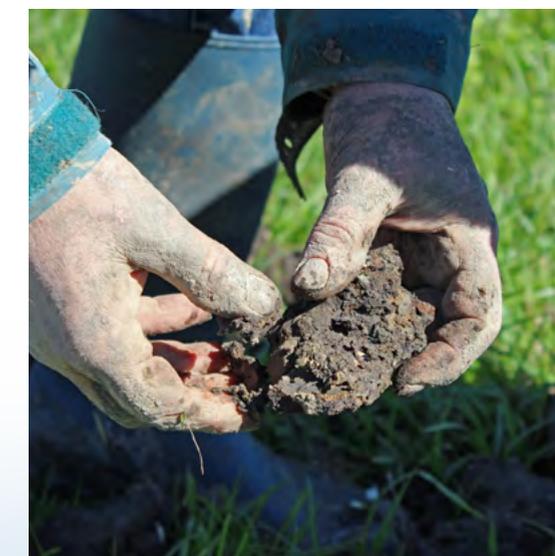
The key component of the plan is investment in spatial planning. This could allow New Orleans to become a resilient city that is in a better position to cope with the current water and land subsidence problems. Deltares is involved in the implementation of the plan.

Mapping the subsurface

Deltares began on an analysis of the subsurface in New Orleans in mid-2018. What do we know about the subsurface and groundwater flows, and what effects can be expected as a result of climate change, sea level rise and ongoing land subsidence? Drilling was conducted to obtain samples in 73 locations in the city with the aim of establishing a picture of how effective solutions are. Experts went to New Orleans to collect all the available bore samples in a database and to compile a 3D subsurface model for model calculations. After the subsurface had been mapped out, the researchers looked at possible solutions such as less drainage and more groundwater feed, including green solutions such as water-permeable streets and rain gardens: how much do they cost, how effective are they really and what is needed in terms of, for example, maintenance? Residents and other stakeholders are involved to find out what they can do themselves to prevent problems with water and land subsidence.

High on their wish list: a real-time drainage system

A groundwater-land subsidence model is being built that allows for the design and installation of an integrated water monitoring network. Ultimately, the authorities in New Orleans want a real-time automated drainage system that uses weather forecasts.



'We can't know whether measures will be effective if we don't know how the system works so we had to map that out first'

Roelof Stuurman | Deltares groundwater expert



More info

Partners
The Water Institute of The Gulf | Tulane University | Deltares USA Inc.

8

Studying interrelations between water, peace and security



'Data must be the trigger for actions to anticipate the disaster'

Henk Ovink | Dutch water envoy

We do not yet know exactly how climate change, water shortages, conflicts and migration are interrelated. But the potential consequences are so far-reaching that action is needed now. Information systems based on current knowledge can help decide where, when and how we should intervene. At the same time, research is continuing to improve our understanding of the conditions in which drought or water shortages can lead to famine, conflicts or flows of refugees.



Early information for adequate action

An important project within the Deltares water scarcity programme is the water, peace and security. Water shortages can have major social consequences, for example when people lose the source of their livelihoods or food becomes unaffordable due to drought or change in the upstream water use. The pilot project was launched in 2017 on behalf of the Dutch Ministry of Foreign Affairs. Together with the partners, Deltares completed the data analysis in 2018 and made

prediction models that can provide a picture of where water scarcity may occur, what the social consequences can be and, very importantly, which interventions can help to prevent or mitigate negative effects. We use a range of tried and tested scientifically proven hydrological and water distribution models on the local and global scales. In addition, we use open data such as satellite images and Google Earth. As a result of this project we position the water, peace and security issues more prominently on the local and global agenda's.

As a result, the water scarcity issue was discussed in the United Nations Security Council in New York on Friday, 26 October 2018.

Water, peace and security in the field

We will be working on case studies in Mali and Iraq in the course of 2019. With the local government and the local people, we will be looking at how to use water scarcity data in the best possible way to supply information and design interventions tailored to local needs. In this way, we aim to develop tools that empower effective action to prevent or reduce imbalances in water distribution, famine, conflicts and migration in unstable countries worldwide.



More info

Partners

World Resources Institute | IHE Delft Institute for Water Education | The Hague Centre for Strategic Studies | Wetlands International | International Alerts | IOM

9

Brackish water is the new fresh water

*'Join the dots, find the connections.
That's how we can strengthen COASTAR's
position as a promising measure'*

Wim Kuijken | former Delta Commissioner

The COASTAR knowledge programme has been developed in recent years by the research institutes Deltares and KWR Water Research, and consultancy firm Arcadis. After thoroughly preparation, key partners from the Top Sector Water committed themselves in 2018 to this knowledge programme, which is supported by a broad consortium of private bodies and government authorities. The programme underpins structural freshwater distribution in, among other places, the West Netherlands throughout the seasons. After proof of concept, COASTAR can be applied around the globe.

Fresh water stored, salt water at a distance

COASTAR (Coastal Aquifer Storage and Recovery) is an innovative concept consisting of a range of measures: the subsurface is used for freshwater storage and distribution in salt-water areas. In that way, we can use freshwater resources better and solve regional problems such as flooding, water scarcity and salinisation.

Another COASTAR measure is the extraction and use of brackish groundwater near, for example, polders

or freshwater reservoirs in the dunes. This reduces the salinisation of the polders and provides a larger freshwater buffer in the dunes, creating new sources of drinking water after desalinisation.

COASTAR therefore keeps 'fresh water stored and salt water at a distance' and it can also be used in other delta regions in the world. Former Delta Commissioner Wim Kuijken stressed the importance of the COASTAR coalition (May 2018).

International pilot projects

In addition to the pilot projects in the Netherlands, a COASTAR pilot project will be launched in Chile in 2019. The GIRAgua trial is being organised in the Chilean Coquimbo region. Meltwater from the mountains is collected in reservoirs above and below the ground, potentially making it possible to reverse the decline in groundwater levels in Chile in the future.



Partners

KWR Water Research | Allied Water | Arcadis | Dunea | Evides | Oasen | Glastuinbouw Nederland | Delfland water board | Rijnland water authority | Municipality of Westland | Province of South Holland | Ministry of Infrastructure and Water Management | City of Rotterdam | Partners for Water/RVO

10

Drinking water for fast-growing metropolis Dhaka

The Dhaka Water Supply and Sewerage Authority (DWASA) supplies drinking water to an area of approximately 400 square kilometres in Dhaka and the surrounding region. Those supplies are highly dependent on groundwater as a source. However, because of the rapidly falling groundwater levels, the current approach of groundwater extraction is under severe pressure. More than 40% of the water supplies must therefore be obtained from the Meghna by 2021 to provide drinking water to approximately ten million people.

The population is still growing and DWASA plans to expand its service coverage even further. In the future therefore, surface water must be used as a source of drinking water. However, the water quality in the rivers in and around Dhaka is inadequate.

The Meghna River thirty kilometres east of Dhaka has been designated as one of the major new sources for water supplies. The Asian Development Bank supports the sustainable realisation of this plan.

Analysis and extensive monitoring programme

To prevent the deterioration of the water quality in the Meghna and to safeguard sustainable water distribution in Dhaka, it is crucial to upgrade water quality management at the local level. The main player here is the Department of the Environment (DoE). We processed the historical data for the river, analysed it and conducted an extensive monitoring programme. The knowledge about future developments in the catchment and the identified pollution sources was then used as a basis for predicting future water quality. In addition to advising, modelling and guidance in the planning process, our knowledge has been transferred through an extensive training programme for the DoE and DWASA.

Pollution can be reduced significantly with small investments

In response to our recommendations, some of the river has now been designated an ecologically critical area. We have shown that pollution from companies can be significantly reduced with small investments. A special task force is now responsible for the implementation of this recommendation.



'We don't want the Meghna River to become the next Buringanga. So the measures and recommendations from by the project should be implemented'

Mr Engr Taqsem A Khan | Managing Director DWASA

11

Groningen Clay Ripening Pilot Project

Ports or waterways need to be deepened regularly. When building or raising dikes, clay is needed to seal the dike body and to protect it from erosion. Why buy the clay you need when it's on your doorstep? As in the Eems-Dollard, where too much sludge enters the harbours. A clay ripening facility was therefore set up at two locations nearby in 2018.



You can't just deposit the dredged material straight onto the dike. It's too wet and too salt, it still contains all kinds of organic material and it is certainly not strong enough. Deltares is testing a range of strategies in the ripening facilities as part of the EcoShape knowledge consortium to make dike clay from dredged material. The tests look at a range of parameters such as layer thickness, the presence of drainage, the number and type of processing stages and the presence of vegetation.

More knowledge about ripening clay

On behalf of EcoShape, Deltares conducted the preparatory literature and laboratory studies that were used to select the processing methods. That involved examining the knowledge acquired about ripening during the construction of the IJsselmeer polders and the tests with Euroclay: clay made from dredged material taken from the port of Rotterdam in the 1980s. However, little is known about ripening salty dredged material to produce clay. Which is why researchers are conducting practical trials in the clay ripening facility to determine the best approach. During the implementation phase, we are monitoring and reporting on ripening in a range of test sections. We are coordinating the annual monitoring campaign that collects parameters for all the sections and at different depths. We use drone measurements to monitor the changes in the height of the dredged material in the test sections to the nearest centimetre. This is an important indicator of how the material is consolidating.

There are many benefits associated with the recycling of dredged material

If we know exactly how clay ripens, we can maximise efficiency in terms of space and costs, and identify the right conditions for ripening so that we can establish a business case for ripening clay. Annually, 1 million tonnes of sludge have to be dredged out of the system. This new approach allows that material to be re-used locally.



'We tackle two things at once by ripening clay: we put the circular economy into practice and we enhance ecological value'

Wouter van der Star | Deltares researcher

12

Adjusting offshore wind to reduce costs and risks



'The improved predictions of wave and wind conditions for the short and medium terms improve safety and help to optimise offshore wind. That takes us one step closer to accomplishing the energy transition, in which offshore wind plays an important role'

Jan-Joost Schouten | Deltares offshore manager

Offshore wind energy is an essential part of a successful energy transition for Western European countries bordering the sea. But countries like China, Taiwan, Vietnam, Japan, South Korea, Japan and America are also embracing offshore wind energy as a renewable source of energy. With wind farms under construction and in operation, safety and the reduction of costs per kWh are the factors that determine success. Costs or losses can mount up quickly if the wind turbines have to be shut down. Deltares conducted a range of studies in 2018 to reduce the risks associated with the development and operation of offshore wind farms.

Reducing power cable failures

Approximately 80% of insurance claims in the offshore wind industry are linked to cable failures. To reduce failure levels, Deltares teamed up with DNV GL, ECN, WMC, BREM, VanderHoekPhotonics and other partners in a Joint Industry Project (JIP): Cables Lifetime Monitoring. The aim of this study is to reduce the risk of power cable failures in offshore wind farms. Analyses have shown that cable failures are attributable to manufacturing, design and installation errors. Sand waves, for example, can expose the cables, which can then be easily damaged. One of the ideas developed in this project is the continuous monitoring of the power cables through the advanced use of optical fibre sensors. This monitoring system and knowledge about the failure mechanisms of power cables will be included in the new design guidelines and standards.

Optimisation of monopiles

Monopiles are the most widely-used foundations in offshore wind farms. Studies of scour protection around monopiles were extended last year to include nature-inclusive design. Against this background we conducted experiments in the Deltares flumes with scour protection structures that also provide added ecological value. The results are being included in the handbook for the design of scour and cable protection. The different methods are being assessed to determine hydraulic stability, morphological effects, durability and ecological effects. In addition, a start has been made on studies looking at the removal or replacement of monopiles. The central question is how this can be done efficiently and safely. In collaboration with a range of partners, Deltares is working on new research in our Water-Soil Flume. The aim is to show whether hydraulic extraction is a feasible option.

Predicting wave and wind conditions

Good forecasts of wind and wave conditions are essential for many operations in and around offshore wind farms. The decision support tool MeteoDashboard for wind farm managers has been expanded to include forecasts for ship movement and seasickness. MeteoDashboard helps wind farm managers to decide whether to go to sea or stay in port. It is a web-based dashboard that allows the farm manager to look two days ahead with detailed forecasts of wind speed, wave height and current strength for individual offshore wind turbines.

Partners

TKI Offshore Wind | GROW | JIP Haspro | JIP Cables | JIP O&M II | MARIN

13 Albania invests in climate-resilient road network

'We work with managers to determine the risks that are socially and economically feasible, and which measures we can link to them. This provides managers with ways to make the entire road network climate-robust. We help the government to prioritise investments in the road network'

Mike Woning | Deltares geotechnical expert

Albania is one of the world's top-ten countries with the highest economic risks owing to the combination of a range of possible disasters. The country is susceptible to hydro-meteorological hazards such as flooding, drought, heavy snowfall and extreme temperatures, and to geological hazards such as earthquakes and landslides.



Albania has invested heavily in bridges, tunnels, motorways and railways in recent years. More and more severe rainfall, landslides and floods caused by climate change could destroy some of that infrastructure. Planned new investments must be 'future-proof' and therefore 'climate-proof' as well. This is also a requirement of the World Bank for investment in Albania's road network.

Investment strategy and risk modelling
Deltares worked with local parties to develop an

investment strategy in 2018 with the aim of making the main road network and engineered structures such as culverts and bridges climate-proof. The climate risks and seismic vulnerabilities of the main road network were identified in collaboration with SEED Consulting, an Albanian engineering firm and a range of government authorities. The work included not only the direct consequences (damage to the road itself) but also the cascade effects (damage resulting from the road being put out of commission).

Both the direct damage and the cascade effects were used to identify priority locations and link them to measures that make the roads more climate-proof. These measures can be implemented not only on the new roads Albania wants to build but also for the maintenance of existing roads.



14

Scale model of new lock in Terneuzen

At 427 metres long, 55 metres wide and 16.44 metres deep, the new Terneuzen lock will be one of the largest locks in the world. It is located between the salt water of the Western Scheldt and the fresh water in the canal linking Ghent and Terneuzen.

Deltares made a scale model in 2018 which is 31 times smaller than the actual lock to study the levelling system. This is the system used to fill and empty the lock depending on the water level on the other side of the lock. The aim was to determine the optimal levelling time and measure the forces on the ships during that process. Because salt water is heavier than fresh water, flow differences are created that are difficult to calculate. Those flows were also studied using the scale model.

The scale-model tests were completed in late January 2019. The design of the levelling system for the new lock is currently being finalised and construction has now begun. More than 100 tests in total have been completed and the results will also be used to decide on how the lock will be operated. In addition, there were complementary measurements designed to provide the lock contractor with the information needed to dimension specific parts of the lock. We looked at pressures on the levelling valves for the valve design and flow rates near the bed.

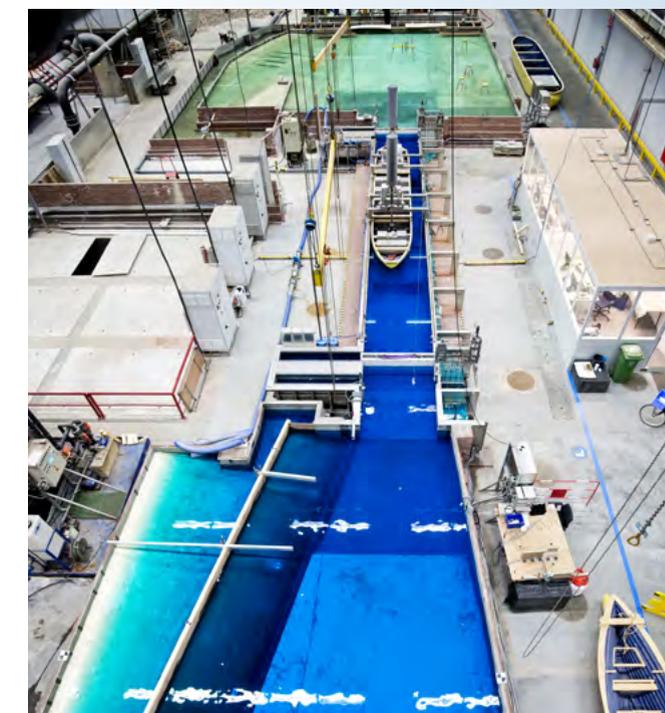
The first ships are expected to pass through the new lock in Terneuzen in late 2022. The new lock is part of Rijkswaterstaat's Locks Programme, which involves the renovation and construction of seven locks throughout the country.

'We can make accurate calculations for a lot of individual components. It is quite difficult to include all those aspects in a single computer model. A scale model is the solution'

Arne van der Hout | Deltares project manager

Terneuzen lock complex

The lock complex in Terneuzen consists of three locks: the Middensluis, the Oostsluis and the Westsluis. The Middensluis (central lock) - the smallest of the three - is being demolished to make way for the new lock. A larger lock will increase the capacity of the complex and allow larger seagoing vessels from the Western Scheldt to pass through the Ghent-Terneuzen canal.



15 Willows as breakwaters



'In this study, we will be looking at how we can use systems that are already present naturally to mitigate flood risks. Furthermore, there is a lot of demand around the world for innovative solutions for flood risk management. Particularly against the backdrop of climate change and the growth of the global population'

Bregje van Wesenbeeck | Deltares ecologist and coastal expert

Follow-up

Now the trial has been completed, another step has been taken in the development of indispensable knowledge. Follow-up research is needed to determine whether and where the damping effect of vegetation opens up opportunities for management and policy in the Netherlands. In addition, steps are being taken to see whether similar experiments can be conducted for mangroves. These trees can play a crucial role in flood risk management in coastal areas elsewhere in the world.



Vegetation has the potential to reduce the wave load on many kilometres of dike in the Dutch river area. That potential has not yet been fully mapped out, in part because of knowledge gaps in the area of wave mitigation with vegetation.

Willow woods of 40 metres

In order to obtain valuable measurements, a consortium conducted a unique experiment in the Deltares Delta Flume, where full-scale experiments can be made, in the summer of 2018. The flume is three hundred metres long, five metres wide and nine metres deep. A 40-metre-long willow wood was built in this research facility. The wood included 32 trees that were fifteen years old. The trees were exposed to waves of up to one and a half metres high and they coped with these conditions surprisingly well. The reduction of the waves depends on the water levels and wave conditions in relation to the density of the willows. A lot of hard work is now going into the analysis of the results.



More info

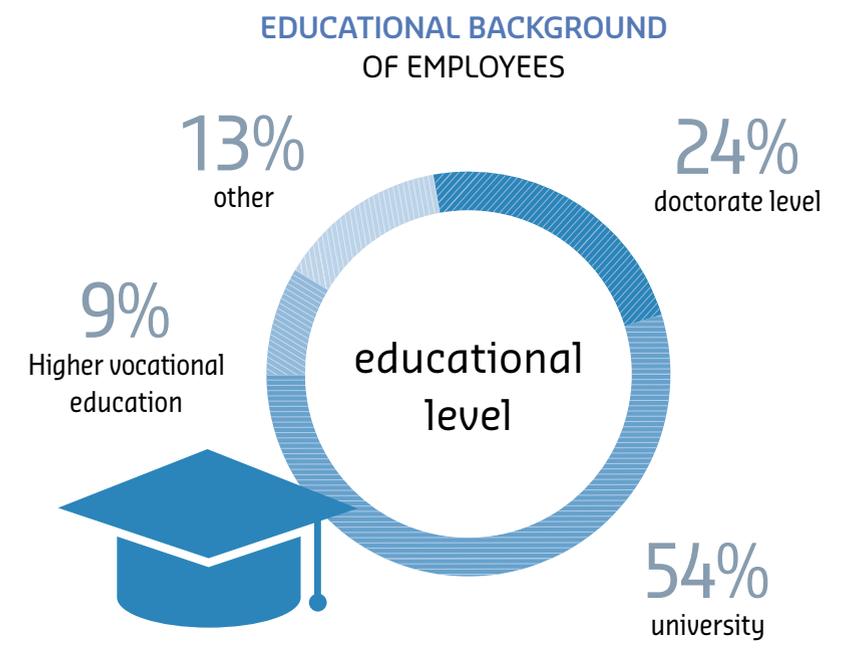
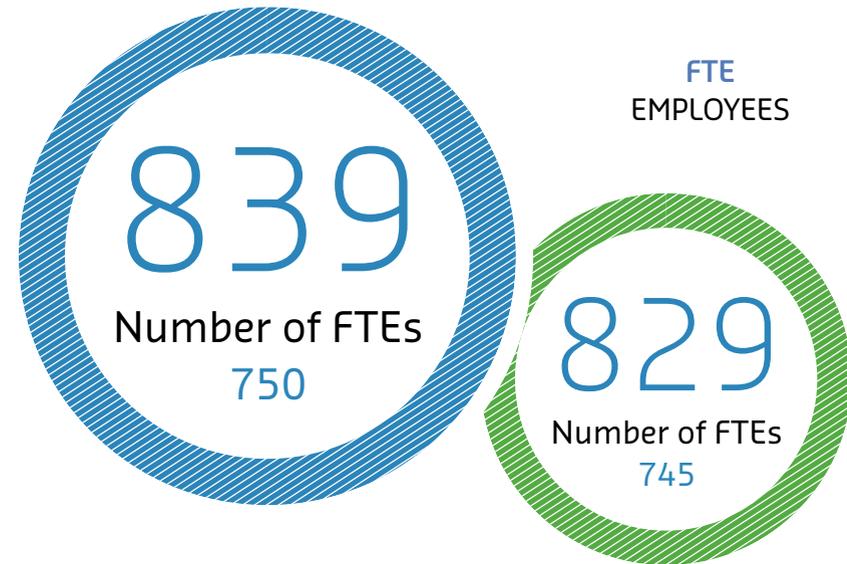
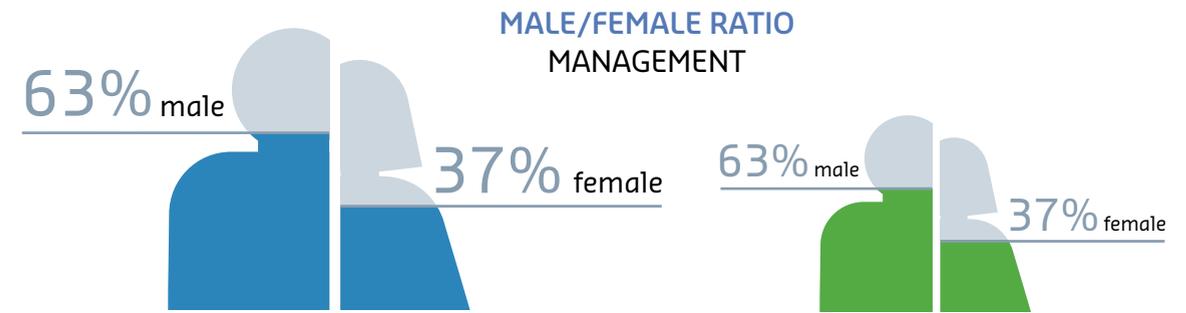
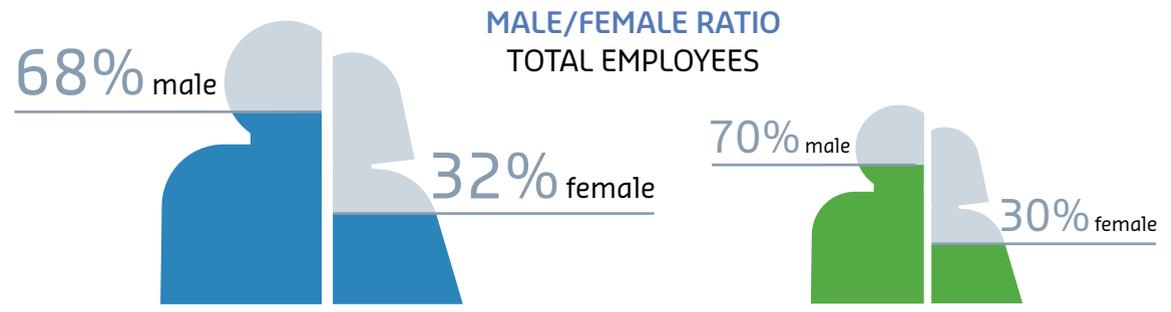
Partners

Rijkswaterstaat | Boskalis | Van Oord | Netherlands Institute for Marine Research (NIOZ) | Delft University of Technology | VP Delta | WWF | Netherlands Enterprise Agency (RVO) | STOWA



31|12|2018
31|12|2017

16 Employees

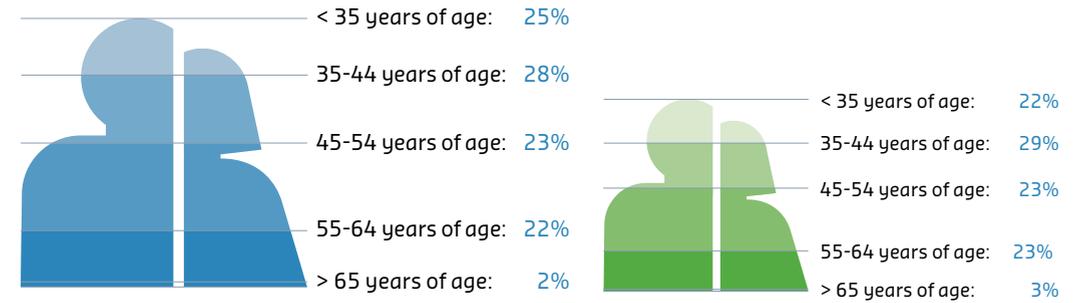


31|12|2018
31|12|2017

16 Employees

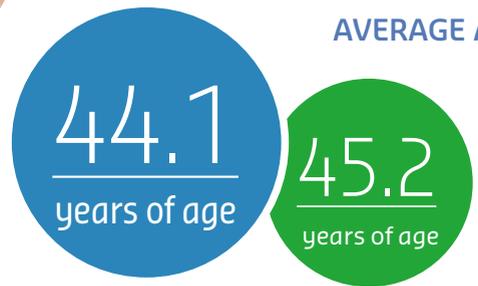


AGE PROFILE

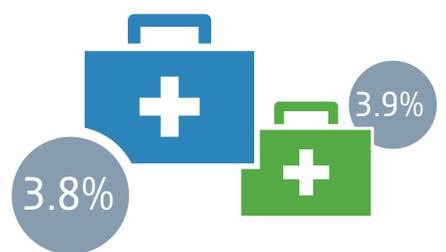


40
NATIONALITIES

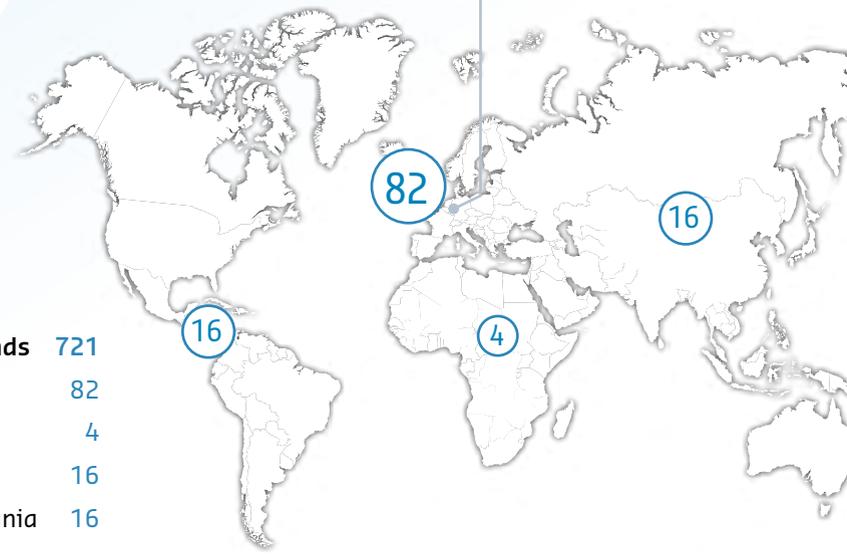
AVERAGE AGE



ABSENTEEISM



INCOMING AND OUTGOING



Netherlands	721
Europe	82
Africa	4
America	16
Asia/Oceania	16

17

Provisional figures for 2018

In 2018, we continued to invest in new knowledge software, models, facilities, alliances and people in order to strengthen our position. Revenue in 2018 was € 114 million, € 18 million of which was outsourced to other research institutions and market parties. The net result was € 1.7 million, € 1.3 million higher than in 2017. The gross margin increased by € 3.5 million by comparison with 2017.

Financial data for 2018

The downward trend in revenue from the Dutch government in recent years was reversed in 2018. In 2018, this source of revenue rose by € 6.8 million by comparison with 2017. Revenue from the private sector rose in 2018 by € 0.3 million to € 24.7 million (22% of our revenue). The amount of revenue from international projects rose by € 4.2 million by comparison with 2017 to € 33.3 million (29% of revenue).

The balance of financial income and expenses rose to € 0.6 million negative in 2018, mainly because the exchange result was € 0.5 million higher than in 2017.



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