more manifest that people are starting to call for integrated, sustainable solutions.'

That's when we call the Dutch.
'We talk to English, Danish and Australian organisations here, too. They are good at architecture, drought and sharing water. But what you hear most here when there are problems with water is: bring in the Dutch! It is not for nothing that we have a Dutchman at the head of the Hurricane Sandy Rebuilding Taskforce. Nobody knows as much about this as you.'

Doesn't water management require government to adopt a completely different mindset?
'In the Netherlands, the government can intervene in far-reaching ways when that is needed to prevent flooding. In America, you run up against constitutional difficulties. Our constitution gives the states much more freedom. So in rich states like Texas, you can build impressive flood defences. But resources are limited in poorer states like Louisiana. That means you have to convince taxpayers throughout America that they should contribute to building a dike in Louisiana. That's a very sensitive issue here. So we are already doing a lot. But you can't just change the constitution.'

What can Dutch experts learn from America?
'You enjoy complaining about the rain but you have a very moderate climate and you should be happy about that. By helping us, you can learn a lot about extreme weather and how that affects water management. Our experience with extreme weather means we know a lot about infrastructure maintenance after storms. The Netherlands is a laboratory for America, but we are increasingly a laboratory for you.'

You have your own Water Institute now as well, an independent research and knowledge institute in Louisiana. Why do you think independence is so important?
'With that institute, following the Deltares example, Louisiana has taken a firm step down the right road. A lot of funding has been generated for the restoration of the Louisiana coast. People are determined to spend it in the right way. Government authorities are not always the best at bringing in the very smartest knowledge resources and, in big countries like America, there can be overlap in some areas, while other things don't get done at all. The US Army Corps of Engineers is usually involved in this type of research but they work in 49 states from their base in the Pentagon and things can take a very long time. You can concentrate resources in an independent institute without somebody having too much control.'

And there is a new Water Campus. Is it just for Louisiana, or also for the rest of the world?
'Of course, the initial focus will be on Louisiana. But we hope to use everything we learn there in the rest of the world.'

What is your advice for the planet?
'It is crucial to share and improve water-related knowledge throughout the world. The Dutch know a lot about long-term solutions and forecasting models; in Southern Asia they know a lot about extreme weather. Americans are good at efficient problem-solving. There is already a lot of collaboration and that is generating major benefits. I would like to imagine going one step further: a single, independent, scientific global institute. The challenges facing us are big enough.'

Dale Morris: 'In America, the attitude towards water management is clearly changing.'

D

DOSSIER
Water scarcity

More than 70 per cent of our planet is water; just 30 per cent is dry land. So there should be enough water for the globe's 7 billion inhabitants. But water is becoming scarce in more and more places. This is sometimes a passing problem but, increasingly, it is a fact of life. The reason is that population growth and economic growth are consuming more than nature can provide in some areas. Water scarcity will become a more pressing problem over the next fifty years, not just as consumption continues to increase but also, and mainly, because of climate change, putting a brake on economic growth and pushing up prices. Large groups of people will be unable to pay for basic necessities like food and water.

WATER SCARCITY

'ONE OF THE MOST ACUTE SOCIAL PROBLEMS OF OUR TIME'

For more than ten years now, Marc Bierkens, a professor of hydrology at Utrecht University and a senior researcher with Deltares, has been studying water scarcity at the global level. He sees cause for concern: there is a serious threat that water supplies will be depleted permanently in more and more regions. Is a water crisis on the way? And what are the implications for our food supplies? 'It is a creeping process. And even though that means there is time to take action, political will is still needed.'

BY CARMEN BOERSMA

Looking at freshwater supplies on the planetary scale, there wouldn't seem to be a problem. In broad terms, there is enough water to meet the needs of the Earth's seven million inhabitants. But the difficulty becomes clear when we zoom in on particular locations. Because water is subject to the same economic principle as other resources: when demand exceeds supply, shortages result.
And this is already clear to see in various places. Human demand here exceeds natural supplies, leading to what is known as water stress. This may be a temporary situation because supplies are unevenly distributed across the year but, increasingly, more water is being consumed than replenished. It is expected that water stress will become more acute in the coming decades. The growing population and the expansion of economic activity will push up water demand. And in areas where water supplies are already tight, the impact of climate change will make them even tighter.

A water crisis would seem to be on the way.
Marc Bierkens: 'A crisis is an urgent situation that arises suddenly; at best, you see it coming at the last moment. Water scarcity is different. It is a creeping problem that develops slowly over many decades. With the water and climate models we have available, we already know where the problems are, both permanent and temporary. We have also worked out how stocks of groundwater and surface water will develop over the next 50 to 100 years. We already know where the situation is worsening, or where we can expect shortages.'

In which regions should people be concerned?
'The main areas where permanent water scarcity is already a problem are Northwest India, Northeast China, parts of the Middle East and the Midwest of the United States. In Europe, Southeast Spain is extremely vulnerable. Climate change means that the situation here can only get worse over the next fifty years. '
'Not only that: occasional shortages in a number of countries will become permanent. In addition to Southeast Spain, other Mediterranean areas such as Italy and the south of France will be faced with permanent water scarcity. But Eastern Europe will be affected as well. Countries like Romania and Bulgaria have plans to grow crops for biofuels on a large scale in areas where water supplies during the growing season are already low.'

What will be the main effects on society of increasing water scarcity?
'The social impact is enormous. The most important effect of all will be rising prices for water and food, with drastic consequences for the very poorest. They will be unable to afford basic necessities such as food and drink. This means that water scarcity is one of the main social problems of our time and so we are all responsible for finding solutions.'
'Less water also means that the remaining water gets warmer, an effect that is exacerbated by global warming and that has negative implications for water quality. Bacteria that cause diseases flourish in warm water.'
'And when water is warm, it cannot be used as cooling water for power stations. A study by Wageningen University has shown that power stations that take cooling water from rivers will see their capacity cut by between 10 and 15 per cent from the summer of 2030 onwards. That doesn't sound like much, but it can push up prices drastically.'
'If there is a shortage of surface water, more and more groundwater will have to be pumped up. But groundwater extraction

1.8 billion

In 2014, approximately 700 million people in 43 countries are suffering from water scarcity. If no action is taken, that number will increase to 1.8 billion people by 2025.

Water scarcity has natural and human causes. Natural supplies are spread unevenly across the year and the planet. But a lot of water is wasted, polluted and unsustainably managed (source: UNDESA).

2x

Water consumption has increased twice as fast as the population over the last century. Even though there is more than enough water worldwide, an increasing number of regions are suffering from chronic water shortages (source: UNDESA).

EU

Water scarcity affects every continent, even those that are not thought of as being dry, such as Europe. Almost 20 per cent of people in the EU and 12 per cent of European rivers are now affected by water scarcity (source: EU).

Marc Bierkens (1965) is Professor of Hydrology at Utrecht University and a senior researcher with Deltares. His research focuses on areas that include the large-scale modelling of the hydrological cycle affected by climate change and direct human intervention. Using a planetary hydrological model and statistics, his group was the first to determine where, and how much more, groundwater is used worldwide for irrigation than is replenished by nature.

PHOTO: SAM RENTMEESTER

$< 1700\ m^3$

'Water stress' means that there is less than 1700 m^3 of fresh water available per person annually.

$< 1000\ m^3$

We use the term 'water scarcity' when that amounts drops below 1000 m^3.

$< 500\ m^3$

'Absolute water scarcity' is the point at which there is less than 500 m^3 of water per person. (source: UN)

on a large scale leads to land subsidence, which makes flooding in coastal areas more of a threat. A familiar example is Jakarta, where many residents are exposed to flood risks on a permanent basis.'

What options do we have to tackle the problem?

'Desalination or supplies of fresh water from elsewhere are possibilities, but expensive ones. So there is now a focus on smart technologies for retaining water locally and using it during shortages. This is generally done in reservoirs on the surface, but groundwater infiltration below the surface is also possible. More efficient irrigation methods such as drip or underground irrigation are also options. And we might wish to consider solutions like growing crops that consume less water, such as maize. Or modifying crops so they can cope with salt water.'

Are these options already being used?

'Not on the large scale needed. Not by a long way. In many countries, particularly in the emerging economies, governments prioritise economic growth as long as water shortages don't present an obstacle to prosperity. That shows that tackling water scarcity is not just a question of technological solutions. Political will is needed, too. As I pointed out earlier, water scarcity is a creeping process. The upside is that we have time to take action. The downside is that people fail to grasp the urgency of the problem, and postpone the search for solutions.'

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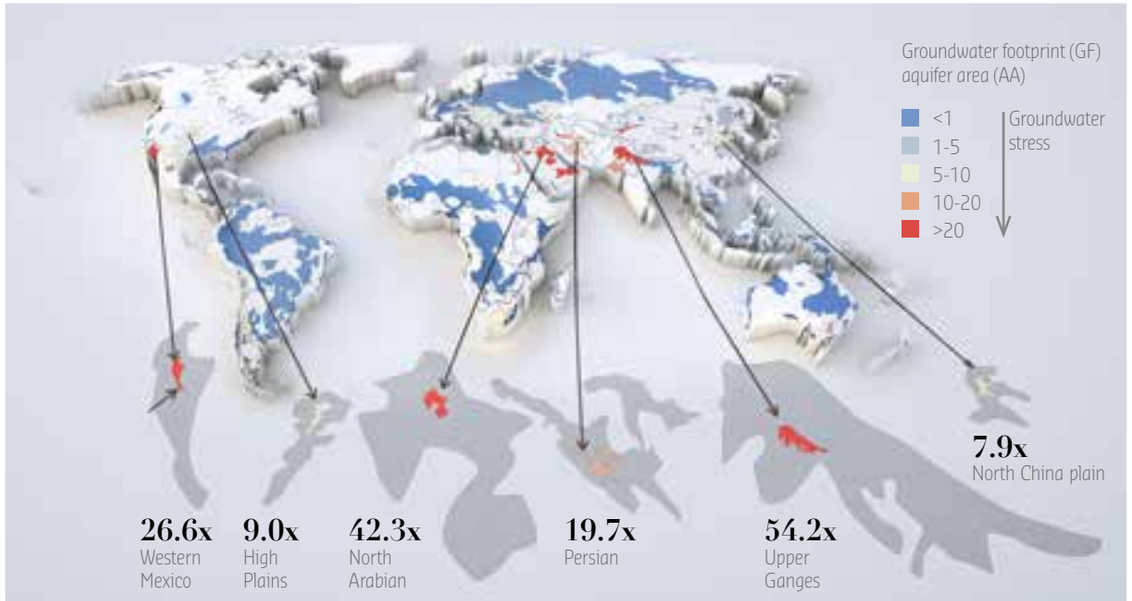

The dark-blue areas have a groundwater footprint of less than 1; groundwater extraction is sustainable here in the long term as well. The red areas in Northern America and Asia have a much larger groundwater footprint. The footprint of the Upper Ganges, for example, is actually 54 times larger. The area would have be 54 times larger to capture the precipitation needed to sustain current groundwater extraction.
Source: Gleeson, Wada, Bierkens and Van Beek, Nature, 2012.

DELTARES, SEPTEMBER 2014

WATER SCARCITY BIGGEST THREAT FACING BUSINESS

Companies that fail to take the threat of water shortages seriously will be badly affected: problems with production and disappointing financial results lie in wait. Can anything be done? Certainly. There are companies that do give a higher priority to the issue and that have already taken specific action.

BY DIMMIE HENDRIKS

Water scarcity is the main threat to the activities and financial health of many multinationals, claims the 2013 Global Water Report (Carbon Disclosure Project). However, Triodos Bank found this year that most companies are still doing very little to reduce their water consumption levels. An earlier report from KPMG in 2012 made this painfully obvious: only 1 per cent of multinationals report on water consumption in production, fewer than half have actual plans to save water, and only one in ten have a strategy for the future.

Benchmarks

Are Dutch companies already aware of the problem? Roy Tummers, the director of VEMW (the knowledge centre and lobby organisation for energy and water consumers) believes that industry is increasingly anticipating the reduction in water supplies. 'Because water availability in the future is expected to decline as a result of climate change and increasing production, companies are taking steps to be more economical with water and to make their production more water-efficient. This involves, for example, recycling water, optimising treatment processes, raising employee awareness and introducing benchmarks. That has cut water consumption drastically in a number of sectors in recent decades.'

Risks in the picture

Shell is one of the companies that has been looking at water scarcity actively for a number of years now. Frank Niele, a Shell policy consultant, explains why: 'Shell makes enormous investments. Lead times for projects are often very long, sometimes decades. So we must have a clear picture of our risks in any given area. Water availability is one of those risks. Even now, supplies of fresh water are declining in some areas, while demand is on the increase. The models we have at the moment are inadequate when it comes to establishing a picture quickly of water availability at the local level. That is why we are currently developing a new *rapid screening* method with Utrecht University and Deltares. If we find that not enough water will be available, we look at possible solutions. And we always take the requirements of the local population into account here: we don't want our consumption patterns to cause shortages for them.'

Taking action in time

'In some countries, water availability is already a challenge: Qatar is one example, but there are also difficulties in Canada and the Netherlands. Depending on the production method and the local conditions, we are developing solutions that may involve recycling and re-using water, or using more desalinated water or treated waste water from municipal sources. We are also introducing new production technologies to use water more efficiently.'
'Here at Shell, we have been tackling water scarcity actively for some time now. It would be good for every company to be more *water aware*. You should know what your needs are, how much water is available, and how the situation will develop. If there is the possibility of a problem in the future, you can take steps in good time now.'

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SOLUTIONS FOR FRESHWATER SCARCITY

The mismatch between freshwater supply and demand is steadily worsening. If no steps are taken, competition between the various users will simply intensify. Fortunately, there are ways of tackling the problem. Delta Life has drafted an overview of a number of solutions. From information systems and underground storage to controlled drainage and governance concepts.

1 FORECASTING SYSTEMS

Drought forecasting systems can be used to predict periods of water scarcity or drought well in advance. This allows water managers and users to respond in good time. They can, for example, make adjustments to crop planning and reservoir management, or make preparations to allocate water differently and/or introduce water intake restrictions.
Deltares is developing Drought Early Warning Systems based on Delft-FEWS for seasonal forecasts of available water. Delft-FEWS is a software system that is used worldwide by water managers for operational hydrological forecasts. Combining weather forecasts with hydrological models for snow volumes, soil moisture, groundwater and river discharge rates makes it possible to develop a Drought Early Warning System which can be used for, among other things, Rijkswaterstaat's Water Management Operational System. The system supports national decision-making processes during periods of drought by supplying real-time forecasts about groundwater and surface water.

2 WORLDWIDE INFORMATION SYSTEM FOR WATER SCARCITY

It is important to have forecasts about water resources and water scarcity throughout the world so that steps can be taken in time. The EU project GLOWASIS (Global Water Scarcity Information Service), in which Deltares plays a leading role, has studied global water resources and water scarcity, resulting in a planetary forecasting service for drought and water scarcity that links water consumption to hydrological models and satellite data. The follow-up project eartH2Observe (2014-2017) is quantifying all parts of the water cycle (precipitation, evaporation, discharge rates, soil moisture, groundwater, reservoirs) with the aim of quantifying all the planet's water resources. This is done using a range of global models, satellite data and local data, and it is an important step on the road to the operational quantification and forecasting of water resources and water scarcity.

For more information:
http://glowasis.eu and
http://earth2observe.eu

3 SURVEY OF WATER RESOURCES

For effective water management in coastal areas, which are popular locations for drinking water extraction and agriculture, it is important to have a clear picture of the amounts and distribution of salt and fresh groundwater. This makes it possible to take better decisions about water management and identifies opportunities in areas like Aquifer Storage and Recovery (ASR). Large amounts of data are needed to establish reliable prognoses. Because traditional methods are expensive and because the information they collect about particular areas is very broad-brush, it was recently decided to start working with an Airborne Electromagnetic (AEM) survey. This approach involves using a helicopter to collect data. One of the benefits is that AEM surveys are quick and cost-effective, providing area-wide information about salt/fresh distributions in groundwater.

4 UNDER-GROUND STORAGE

The underground storage of fresh water is one way of maintaining freshwater supplies in deltas and coastal areas. This involves storing water underground during periods when there is excess water and using the stocks built up in this way during dry periods. A study is being conducted in the GO-FRESH Testing Ground in the province of Zeeland (NL) to determine the extent to which local measures can be used to enhance freshwater availability in rural areas. By combining knowledge about water systems, smart drainage techniques, innovative on-line monitoring technologies and the participation of all stakeholders, progress is being made towards the establishment of robust regional freshwater supplies.

5 MULTIFUNCTIONAL WATER STORAGE

Storing water above ground is a familiar form of preparation for dry periods in many countries. The inland shore concept is a new type of surface storage. An inland shore is an area that is linked to the main water system. It combines water storage with economic and ecological functions that can cope with changes in water levels and also maintain water quality.
The first inland shore has been established in the Koopmanspolder in the province of North Holland. Water management here focuses not only on storing water but also on natural functions, fishing and recreation. A pilot study will be launched soon in the Wieringermeer polder, combining water storage with agricultural engineering projects such as floating horticulture and aquaculture.

6 CONTROLLABLE DRAINAGE

By adopting a different approach to controlling drainage themselves, farmers can help to improve water distribution over the course of the year. The current approach to drainage often involves removing excess rainwater very quickly, and this leads to a shortage of fresh water in the summer months. Making drainage controllable allows farmers to manage the water regime on their land much better and to store rainwater for the growing season. There are several different methods available for controllable drainage systems. In the province of Twente (NL), controllable drainage is being used to retain water for longer on agricultural land, an approach that generates benefits for nature in the vicinity at the same time.
In the province of Zeeland, controllable drainage is being used to increase the size of the freshwater lens and therefore to enhance water stocks.

7 MULTI-RESERVOIR MANAGEMENT

In many countries, reservoirs with surface water are used for water supplies when water is short or for specific purposes such as hydroelectric plants. There can often be several reservoirs in an area that serves different functions and users, and the increasingly scarce fresh water needs to be used optimally. Proper management of these reservoirs requires the intelligent control of the available water. Deltares is developing advanced knowledge and software, and we make this available through the open software framework of RTC tools (RTC stands for Real-Time Control) to make the most of scarce water resources.

8 WATER HUSBANDRY

Bringing in fresh water from elsewhere is one way of tackling water shortages, but it is not cheap. The concept of Water Husbandry was developed for areas that want to be self-sufficient (at least in part). It involves the establishment of a partnership for water users in a particular area. Together, farmers, local inhabitants, municipal authorities and water management agencies manage (in other words, collect, store *and* deliver) the water so that no extra supplies are needed from elsewhere. The concept was introduced for the first time on the Walcheren peninsula in the province of Zeeland (NL). The behaviour of all the stakeholders was transformed from a focus on individual interests to joint action. The farmers of the Walcheren Water Husbandry have now pooled their efforts and established a foundation, introducing the first joint measures to improve freshwater supplies: underground storage, separating fresh and salt ditches, and changes to water management.

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TRADITIONAL PORT

Lack of interest in nature development
The focus is on industry, trade and transport, with little interest in nature development. That results in a lack of biodiversity, and ecosystem services are under-exploited.

Extensive industrialisation
Industrial growth has priority and, partly because of a lack of know-how, there are hardly any environmental requirements. The pollution of air, water and soil deteriorate the environment and living conditions.

Deprived areas
Housing is cramped and below standard. Incomes and levels of education are generally low.

Space for growth at a premium
With the harbour squeezed into the city, room for expansion is almost non-existent and it is impossible to cope with rising levels of marine transport.

Inadequate coastal protection
Coastal defences are not designed to cope with the effects of climate change such as sea-level rise and powerful waves.

Poor accessibility
The port infrastructure is not designed to cope with high levels of freight haulage and passenger transport: roads and railways are congested.

Harbour silts up quickly
Design and construction fail to take morphology and ecology into account, and wave and current models are not used. Fairways silt up quickly and daily dredging is needed: that is an expensive approach that also disrupts the ecosystem.

Environment-unfriendly ships
There are no standards for engines or fuel, and so emission levels are high.

CENTRAL ECONOMIC PRIORITY

Older seaports were built at a time when there was an exclusive focus on local trade, industry and transport, and little interest in public health, the environment and sustainable port development. Concrete and steel ruled, and ports were squeezed into the city. Harbour activities and development generally have a negative impact on the ecosystem.

Older ports cannot cope with the rapid rise in international container transport, ever-larger seagoing vessels and increasingly stringent environmental requirements. Connections with the hinterland are not designed for current economic growth and so it is difficult to manage the goods flows. Their competitive position is weakening rapidly.

Is it possible to establish ports that can cope with economic development but also comply with current environmental requirements and safeguard the functioning of the ecosystem?

GREEN PORT


Cleaner ships
Port authorities use the Environmental Ship Index (ESI) to determine the contamination levels of individual vessels. Harbour fees are set accordingly, encouraging the use of clean engines and diesel.
Room for aquaculture
The area is structured so that there is room to use the ecosystem for things like aquaculture.
Better link with the hinterland
There is enough infrastructure to cope with increases in freight and passenger transport.
Appealing residential areas
Residential areas are spacious and make the most of the appealing waterside location. The residential and work facilities for the local people are adequate and the infrastructure is up to standard.
Sustainable living environment
Green infrastructure and optimal water management create a sustainable living environment that has beneficial knock-on effects on public health and the environment.
Adaptability to climate change
Coastal defences use natural barriers such as sand, salt marshes or mangroves. They help to dampen waves and capture silt, and they also provide a natural habitat.
Renewable energy
There is room for wind turbines that can generate renewable energy for local inhabitants and companies.
Open harbour
An offshore port island, where large sea-going vessels can moor so that the goods flows can be handled efficiently.
Less dredging
The port design is based on current, wave and wind models, reducing sedimentation and the need for dredging. That is good for the environment and it cuts costs.
Room for recreation
Foreshores can be used as recreational areas.
Monitoring biodiversity
The impact of the port on biodiversity is modelled beforehand and calculations are made to ensure that a healthy ecosystem is established. The system is monitored continuously after construction has been completed.
MAERSK LINE

BALANCING THE ECONOMY AND ECOLOGY

In recent years, there has been a rise in interest in 'green ports' as a way of achieving sustainable economic growth. During design and construction, economic growth, climate change and the ecosystem are taken into account. The port is designed in close consultation with local stakeholders so that it becomes an attractive place to live and work.

The impact of human intervention on the natural system is worked out beforehand and established using simulations, resulting in a clear picture of the effects on the ecosystem. The port infrastructure can manage rapid growth in container transport and ever larger ships.

Coastal defences are built to withstand climate change, with nature-based engineering such as sandy foreshores and mangroves playing a prominent role. Features like this can also be used for recreation, aquaculture, fishing and nature development. There is a better balance between economy and ecology. **For more information:** cor.schipper@deltares.nl