Groundwater the leading factor in densely populated deltas

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Deltares

Groundwater the leading factor in densely populated deltas

The Netherlands is a densely populated delta where, as in other deltas in the world, there are more and more claims on the subsurface, with challenges related to water supplies, housing, the energy transition, nitrogen emissions, and agriculture and nature. At present, for example, two-thirds of the drinking water in the Netherlands comes from groundwater. The groundwater system and the ecosystems that depend on it, as well as future water supplies, are under increasing pressure as a result, and climate change is amplifying that pressure.

To conserve water, groundwater and soil for future generations as well, it is important to work with these natural resources differently. Since 2022, Dutch government policy has identified water and soil as leading factors. This means that interventions and adaptations in water and land use must be adapted to the natural water and soil system as much as possible. That certainly includes groundwater.

We are conducting two important studies for the Ministry of Infrastructure and Water Management to establish a national picture of difficulties and opportunities with regard to groundwater. Both projects get stakeholders involved to share knowledge or provide feedback about the results.

In addition to a study of the National Groundwater Reserves, we conducted an Integral Groundwater Study that presented the agendas, concerns and possible solutions for ground-water on the national scale to a general public.

This information will help policymakers, groundwater managers and major users to develop ‘water and soil as leading factors’ policies.

In interviews here, the various Deltares experts involved in the studies reiterate the report’s principal recommendations.’

Marco Hoogvliet - Expert stedelijk water en ondergrond

Look closely at the soil structure and groundwater regime

Particularly in low-lying areas of the Netherlands, where the soil is soft, the water table is close to the surface level during wet periods. ‘The water table is regulated as much as possible through level management in watercourses and with drainage pipes, and the construction of buildings and infrastructure is tailored to specific groundwater levels,’ says Marco Hoogvliet, an urban water and subsurface consultant at Deltares.

But the researcher notes a number of developments that make this groundwater level in the city fluctuate more. And not all buildings and infrastructure can cope with this factor. First of all, our approach to water level management and the weight of structures mean we have already been undergoing land subsidence for a long time. ‘As a result, groundwater is becoming an increasingly disruptive factor,’ says Hoogvliet. Furthermore, as a result of prolonged water shortages and torrential rain in the summer, and more precipitation in the winter, climate change is resulting in groundwater levels that are both higher and lower than those we are used to.

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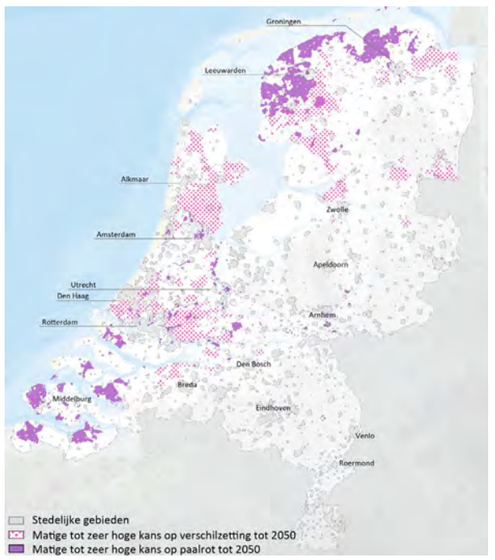
> Marco Hoogvliet



This would all seem to cast a dark shadow over the new construction challenge facing the Netherlands. But Marco Hoogvliet is not pessimistic in that respect. ‘I am happy to see that, in the planning process for new building locations, and particularly in difficult locations such as the Zuidplas and Rijnenburg polders, there is an increasing focus on water and soil. For example, the deepest, softest locations are being earmarked for rainwater storage. If you were to build in a traditional way here, that would result sooner in the familiar problems and associated costs.’

Consider active groundwater-level management

Active groundwater-level management can be used to ensure that groundwater levels are not too high or too low. It involves an intriguing underground system of pipes through which water is moved in and out of an area. If the soil is suitable, this system can prevent damage to foundations caused by excessively low groundwater levels. ‘It’s quite expensive, but it works. The construction costs can be cut if this work is done during the renovation of sewage systems. A major factor in climate adaptation and the redevelopment of our cities is how to properly determine which measures we take with an effect on groundwater levels, and where. ‘Groundwater regimes already vary significantly within individual cities, and climate change is exacerbating those differences. If, on top of that, we fail to keep a clear track of the effects measures have, it becomes increasingly difficult to maintain a picture of what is happening with the groundwater and avoid surprises.’

The mantra remains: less drainage and less extraction

Perry de Louw – groundwater and drought expert

The problem has been known for decades. Particularly in the high-lying areas with sandy soils, nature suffers enormously from aridification. Sandy soils in higher-lying areas do simply drain freely, says Perry de Louw, a groundwater expert at Deltares. The water flows away easily and it is much more difficult for municipal and water authorities to control it.

Forty-year-old reports already mention the aridification of nature due to this dewatering. Major water shortages in the spring and summer of recent years have added to the problem. ‘The dense system of watercourses and ditches drains groundwater far too quickly’, is something De Louw knows better than most. ‘As a result, groundwater levels have been falling systematically for years. During dry periods, the water table falls even further. So brooks are not replenished as much and some even run dry.’

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> Perry de Louw

The problem now, says the researcher, is that every drop extracted from the subsurface, regardless of depth, has to be replenished from above. Because it is not possible to redirect water to these areas. ‘All the users together pull the water table down. And who suffers? Nature, in the top five metres,’ says De Louw. In addition, groundwater extraction results in weaker seepage flows, or even their elimination, and precious nature depends on that water.

Water buffers are very promising

The researcher believes that the active infiltration of water to offset the effects of extraction is a very promising option. ‘This is because there is a surplus of rainwater and river water in the winter that flows to the sea unused. But you can store that water below the surface and then use it in the summer.’

The challenge of restoring the groundwater system is a major one: it requires redesigning the shape of the country and changing water management. De Louw advises tackling the areas around nature areas first. A lot can already be achieved in that way. ‘In buffer zones several hundred metres or larger in size – we are still investigating the distances more precisely – the groundwater level has to be raised considerably by making drainage less intensive and not extracting groundwater. That makes these areas too wet for traditional agriculture. However, other forms of agriculture may emerge, such as wetter crops or green-blue services. And the great thing is that these buffer zones for water are the same as the buffers used to protect natural areas against factors like nitrogen deposition. We have to seize that opportunity now,’ says De Louw.

Hilde Passier, soil and groundwater quality expert

Stop the ‘greying’ of groundwater by using more soil processes

The quality of the groundwater in the Netherlands certainly leaves something to be desired. A large number of different parties, from drinking water companies to farmers and the general public, use that water. Indirectly, groundwater is extremely important for nature and leisure because it feeds brooks, for example. The problem is that this pure water, which is crystal clear after centuries in the soil, has been heavily polluted during the last century, notes Hilde Passier, a geochemist at Deltares.

Passier: ‘At first, the soil was polluted by large point sources such as gas factories, dry-cleaning plants and petrol stations. Groundwater was then affected in turn. Later, more diffuse sources such as traffic, agriculture and discharges from homes and industry began to play a role. They led to the leaching of fertiliser (containing nitrogen and phosphate), pesticides, pharmaceuticals and industrial compounds, and therefore the ‘greying’ of surface water and groundwater.

We have been transporting river water from the Lek near Nieuwegein all the way to the dunes for decades. There, due to the purifying effect of sand and bacteria – and pre- and post-treatment – it is transformed into excellent drinking water within two months. We do need to bear in mind the quality of the water we can allow to enter the ground in which locations, and where we cannot. You could make the knowledge relating to this type of process more widely applicable, allowing for scaling up and the stimulation of this self-cleaning mechanism. Another great example is the use of the announced buffer zones on agricultural land alongside ditches to prevent the further leaching of nutrients by stimulating the purifying effect of reeds and other marshy conditions in the edges of the ditches. That improves water quality, enhances biodiversity and brings the fulfilment of the objectives for the European Water Framework Directive a step closer,’ thinks Passier.

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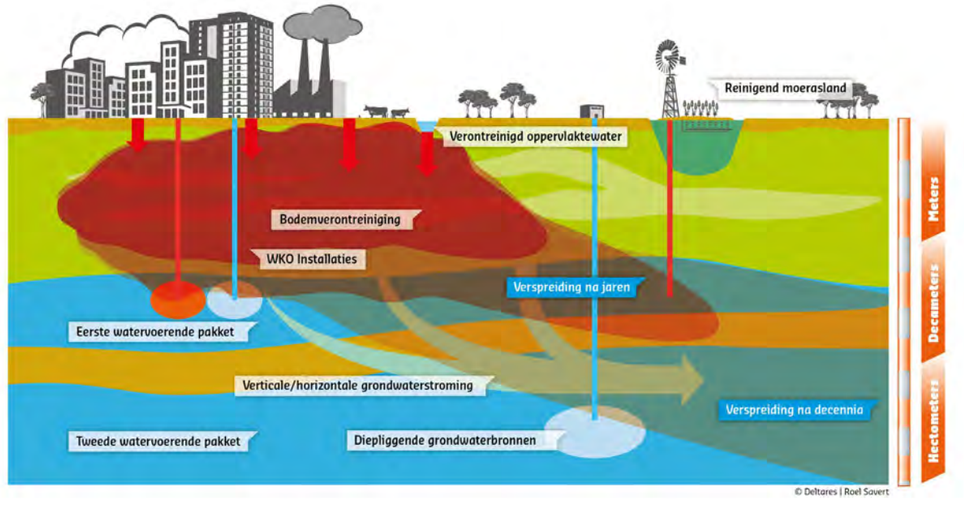
Spare the vulnerable locations

When industry is relocated, we should spare locations that are vulnerable to groundwater pollution. In addition, the purifying effect of soil and natural protection in the subsurface can go hand in hand with the correction of land use on the surface. Passier concludes: ‘We first have to stop emissions as much as possible there and adopt a circular approach to substances.’



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Adopt a 3D rather than a 2D perspective to look at opportunities for soil energy

Annemieke Marsman, groundwater and energy expert

The subsurface is already crowded, but congestion is also increasing because there are so many relatively new users. During the past twenty years, many aquifer thermal energy (ATES) systems have been installed, particularly in urban areas.

There are two different types: an open system with two vertical pipes that discharge into two underground aquifers. In summer, cool water is pumped from one aquifer and hot water is returned to the other. The process is reversed in winter. And in a closed system, a fluid is pumped round a closed system of pipes in the ground to manage heat transfer. An even newer system goes even deeper underground. At a depth of one to two kilometres, there are excellent opportunities for geothermal energy to play a role in the energy transition of the Netherlands. This water, which is heated by the hot breath of Mother Earth, has a temperature of about eighty degrees or more when it reaches the surface.

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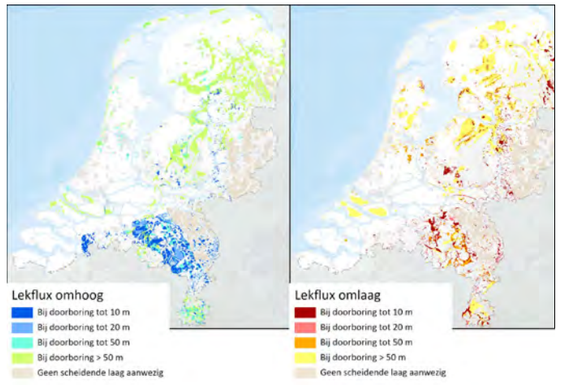
> Annemieke Marsman

But it’s not all good news. In addition to the enormous expense – exploratory drilling alone for geothermal costs a million euros – drinking water companies have been seriously concerned since the outset about possible leaks from the pipes or the disturbance of the soil. ‘The thinking is that this would have an impact on, or even pollute, groundwater,’ says Marsman. She understands the concern. ‘Drilling for both aquifer thermal energy and geothermal energy sometimes goes straight through impermeable clay layers, with groundwater flowing away or getting polluted as a result. Leaks are a possibility, particularly if the holes in the clay layers around the borehole are not properly sealed.’

Even so, Annemieke Marsman thinks the debate so far has been too black and white. ‘The discussion is dominated by a choice between ‘groundwater or soil energy’. I think much that, increasingly, both are possible.’ How can that be done? Marsman: ‘If all the stakeholders, municipalities, project developers, soil energy system suppliers and drinking water companies could learn to look at the subsurface more in a 3D rather than a 2D perspective, listen to each other’s concerns and look for solutions together.’



The regional maps available in this report for the deeper subsurface already provide stakeholders with extensive information about the thickness of the clay layers and groundwater flows – and therefore the pressure on groundwater bodies, explains Marsman. ‘Further research can provide a clear picture of the main risks for local projects.’

Dimmie Hendriks, drought and groundwater expert

No more flushing of the lavatory with drinking water and being frugal with groundwater stocks

We have to be frugal with groundwater and use it primarily for high-grade applications such as drinking water and food preparation. But in the Netherlands, we still flush our lavatories or wash our cars with clean drinking water,' says Dimmie Hendriks, a groundwater and drought specialist at Deltares. 'Our Flemish neighbours have got the idea better. They are required by law to collect rainwater in tanks in the garden to flush the lavatory.'

This is seen directly in the figures of drinking water consumption in the two countries. Over the last five years in the Netherlands, that figure rose from 119 litres per person per day to 129 litres; in Belgium, it fell from about 120 litres to 100 litres per person per day over a similar period. Agricultural groundwater use has also risen sharply in the Netherlands in recent years since the 2018 drought, says Hendriks. 'Projections from VEWIN and the Freshwater Delta Programme show that, if we don't actively change policy, water demand will continue to increase in the decades ahead.'

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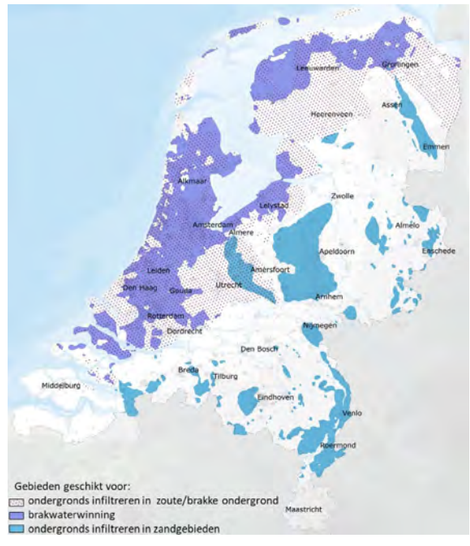
In urban areas, straightforward measures that are currently popular include eliminating paved surfaces and reducing soil compaction. This allows rainwater to seep into the soil more easily. Disconnecting rainwater from the drains systems in new housing developments and homes is als o becoming more commonplace. 'And following Belgium's example, some municipal authorities such as Tilburg already require mandatory rainwater collection in new buildings,' says the researcher.

When infiltrating and retaining water in the subsurface in this way, we do need to be aware of possible downsides like groundwater contamination. As far as that is concerned, the guiding principle is that as much local water as possible is much preferable to water from outside the area, such as river water. And there is also a second effect to consider. 'Storing more fresh water in sandy soils is good for nature and replenishing groundwater stocks, and it can push out saline groundwater in coastal areas. Nevertheless, in urban areas, it can lead to more flooding.' With the maps in the report, the researchers hope to show policymakers where water can be easily retained and infiltrated.



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Geert-Jan Nijsten, groundwater management expert

Sophie Vermooten, expert subsurface and groundwater quality, regional coordinator Europe

Protecting National Groundwater Reserves in the Netherlands

The Dutch subsurface contains enough high-quality groundwater to supply homes and industry with clean water. But we have to use these resources sparingly and intelligently in order not to place an unnecessary burden on our surroundings and to keep this natural capital available for future generations. ‘Demand for drinking water is expected to increase in the decades ahead. In order to be in a position to continue meeting demand for drinking water in the future, the Dutch provinces have designated Additional Strategic Reserves (ASVs),’ explains Geert-Jan Nijsten.

The National Groundwater Reserves (NGRs) complement current groundwater protection policies and the ASVs. They are deep, clean, fresh and brackish groundwater stocks that serve as natural capital. NGRs could be used in the future if there are large-scale crises lasting a number of years in which the current sources are unusable or inadequate.

Since early 2022, Deltares and TNO have been establishing 3D maps of groundwater stocks in the subsurface of the Netherlands that could potentially be used as NGRs. This

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> Geert-Jan Nijsten

includes looking at the geological structure, the fresh-brackish-saline interfaces and the age of the groundwater. In addition to the 3D maps, surveys are being conducted to determine the current uses of the groundwater stocks and the possible future earmarking of areas that should be taken into account in the demarcation of NGRs and/or in the development of any policies to protect NGRs. They include, for example, areas where there are opportunities to develop geothermal energy as part of the energy transition.

Nijsten: ‘Because the groundwater system is dynamic, we are also looking at how it may be affected by long-term developments (with 2100 as a time horizon). We are studying the extent to which those developments may affect the demarcation of the NGRs.’

An analysis of the extractability of these groundwater stocks is being carried out in 2023. It will also look at other possible groundwater resources such as seepage water from polders, groundwater under the IJsselmeer area and artificial infiltration/recovery. It is important to have a picture of these alternative sources because this could limit the possible future use of NGRs.

Only important for the Netherlands?

No, all the experts say the groundwater management challenges facing the Netherlands are characteristic of many other densely populated delta areas inside and outside Europe. The general principles and methodologies from these studies can therefore be applied in other regions to safeguard the availability of adequate amounts of clean groundwater for the future. It is indeed important to start with the regional and local characteristics of the subsurface, climate, land and water use, the socio-economic situation and groundwater governance structures.

Sophie Vermooten: ‘As the years go by, I am seeing how the groundwater knowledge developed for the Dutch context is becoming more and more relevant for different parts of Europe . Managing underground water stocks in intelligent ways during the energy transition and when water scarcity only increases. This piece of the puzzle must not be for-gotten if we are to achieve the ambitions of the EU Green Deal.’

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