(0) Her Majesty Queen Beatrix

In its National Water Plan 2010 the Netherlands has formulated its ambitions for its international water cooperation programme 2010 – 2015: 'Water Mondiaal ' (Global Water). In this programme the Netherlands seeks cooperation agreements with countries in delta areas, Bangladesh being an obvious choice for such an agreement.

Bangladesh and the Netherlands have a long tradition of cooperation in the field of water management. This cooperation will, as a result of the ambitious 'Global Water Plan', be broadened. A pre-identification mission is at present in Bangladesh to identify possible fields of cooperation between the two countries. Issues that will be discussed during their visit are 'Water Supply and Sanitation' ,'Water and Food and Ecosystems', 'Water and Safety', 'Climate Change Adaptation' and 'Water Governance'.

I am convinced that the fruitful cooperation in the water sector will continue to grow and I trust that the articles on the on the Dutch Water sector will provide you with an interesting insight on the Netherlands and its 'relationship with water'.

Alphons Hennekens,
Ambassador

(1) Ambassador Alphons Hennekens

The Dutch water sector: resourceful and cooperative.

Wind, water and wide open spaces have shaped the Netherlands and its history. To its inhabitants, the Dutch, water has always been both friend and foe. The country that is the Netherlands, often referred to as Holland, is a relatively small deltaic region in Western Europe. Three major European rivers, the Rhine, the Meuse and the Scheldt, fan out across the country before flowing into the North Sea.

As in many other deltas around the globe, fertile soil, natural transport routes and a strategic position for cross-border and overseas trade have made this low-lying region particularly attractive to many people: from early settlers (farmers and fishermen) to contemporary entrepreneurs in manufacturing and service industries. Not surprisingly, the Netherlands has long been a sea-faring nation with an international outlook.

Joining forces
In order to live here, the Dutch had to be both resourceful and cooperative. By systematically draining wetlands and lakes, building dikes around them and keeping them dry, they have created new land on which to farm and build. These polders are a well-known feature of the Dutch landscape. As far back as the 13th century, local communities developed district water boards to manage their water. Today these democratic institutions are still operational as regional water authorities. They are an example of how the Dutch have naturally joined forces to face a common enemy and find lasting solutions to water-related challenges.

Exporting know-how
As for resourcefulness, having lived in a delta for centuries, the Dutch had to become skilled water managers. They have learned by experience, both at home and abroad, and have long exported Dutch know-how for the benefit of others. As early as the 7th century, the Dutch helped to reclaim and cultivate land around the Elbe delta, in what is now Northern Germany. During the second half of the 19th century, Dutch engineers were invited to work on coastal land reclamation, irrigation schemes, river management and port construction in Japan and China. These and similar experiences across the world proved to be the basis for lasting relationships between the Dutch water sector and international counterparts, leading to the constant exchange of knowledge and application of water management expertise.

(2) From reclamation of the Zuiderzee... (Source: Rijkswaterstaat) [**for high resolution version, see CD-rom**]

Delta and water technology
Large-scale developments like the embankment of the Zuiderzee to create Lake IJsselmeer (1932) and the construction of the Delta Works in the second half of the 20th century generated new knowledge which was repeatedly applied abroad.
Over the decades, the Dutch have honed their expertise in widely varying aspects of water management, from land reclamation to water education. This expertise now encompasses a vast range of disciplines generally referred to as 'delta technology' (a term which encompasses hydraulic engineering, flood protection, port development, coastal zone management and dredging) and 'water technology' (including wastewater treatment, drinking water and sanitation). But the Dutch are equally at home in sustainable irrigation techniques and wetland conservation, in the use of ICT and GIS technology to enhance water management, and devising smart (i.e. small-scale, cost-effective) sanitary, water supply and treatment facilities to help improve living conditions.

Sustainable
On a different level, research, education, capacity-building and institutional development rank high on the Netherlands' international water agenda. The Dutch government is strongly committed to an international water management effort and has signed a number of bilateral agreements to advance integrated water management across the globe by exchanging knowledge and experience and cooperating in the sustainable development of water systems. The Dutch water sector covers every aspect of modern water management. It is therefore able to act as both a reliable and knowledgeable partner in the search for solutions to the world's water challenges.

(3)...to designing and building a floating city (Source: Dura vermeer) [**for high resolution version, see CD-rom**]

Solving delta dilemma's

Changes in the coming decades are expected to result in no less than 80% of the world's people living in urban areas adjacent to coasts or major rivers. However, space is at a premium and waterside locations present threats as well as opportunities. Especially in view of expected climate changes, the world faces a number of challenges in this respect. The Netherlands has solutions to offer, both at home and abroad.

Living in coastal regions and delta's is a risky business. The Netherlands is vulnerable not only to flooding, but also to water depletion, shortages of groundwater, subsidence, salt intrusion and pollution. A nation struggling to accommodate over 16 million people on a patch of land measuring only 33,800 km2 - with more than half of it lying under sea level - must necessarily find ways to ensure both productivity and safety. The Dutch solution is a combination of hard and soft measures. Innovative delta technology offers a wide range of methods to protect against flooding. In the Netherlands, delta engineering measures are always considered in relation to spatial planning, economic development and nature development. Delta technology encompasses all forms of hydraulic engineering and water control. This integrated approach ensures the sustainability of measures. The Netherlands uses delta technology not in response to change, but in anticipation of change.

The Netherlands

Total area:	41,500 km$_2$
Land:	33,800 km$_2$
Water:	7,700 km$_2$

Primary flood defences

Total:	3,500 km
River dikes:	1,430 km
Lake dikes:	1,017 km

Coastal defences: dikes (430 km), dunes (260 km) and a wide range of flood barriers, dams and weirs.

Threats and control

Dikes and dams can keep water out, but only up to a point and certainly not for ever. Living with water is a more sustainable approach than waging a constant battle against it. The Netherlands has always tried to strike a balance between the two. The result is a form of mutually beneficial give and take. Land reclamation (for example, to provide extra space for agriculture or industry) goes together with the deliberate surrender of some areas for purposes of water retention and storage. The building of massive storm surge barriers to hold back the sea goes hand in hand with 'building with nature': using valuable natural features as the starting point for the design of delta landscapes and coastal zones.

Engineering

The Dutch have specialised in hydraulic and civil engineering. As early as the 6th century BC, settlers built artificial mounds - 'terpen' - on which to seek refuge from floods and high tides. In the 15th century, windmills were used to pump away unwanted water. The Delta Works were constructed in the 20th century. This series of massive dams and barriers designed to protect the Dutch Delta against the sea, is famous around the world. Today, Dutch engineers are designing entire climate-proof floating cities. Whatever the challenges, the Dutch always respond by developing new techniques and technologies to manage water and use it in sustainable ways. They are born innovators.

Building barriers

Dutch expertise in the design and construction of storm surge barriers has been put to good use both at home and abroad. As recently as 2002, an inflatable dam was constructed at Ramspol: a flood barrier consisting of three huge bellows made of rubberised cloth, which fill with water and air when flooding is imminent. This provides effective protection against the rising water, does not obstruct shipping and is relatively cheap. It is the only inflatable dam of this size and operating on such a scale anywhere in the world. Because storm surge barriers offer a more flexible method of protection

against flooding than dikes or dams, Dutch experts are consulted on projects around the world. Teams of consultants and engineers have been involved in the development of protective barriers in Venice, London and St. Petersburg. From carrying out feasibility studies and environmental assessments to the actual construction of water defences, the Dutch water sector covers every aspect of flood control.

New land

In densely populated areas, where space is at a premium, the construction of new land creates exciting and necessary opportunities. In many of the world's coastal areas, Dutch dredging companies are involved in broadening beaches, extending ports or industrial areas, and even creating entire new islands. Modern dredging methods are increasingly being used to fight coastal erosion. Keeping the coastline in its current position is a process of constant measuring, monitoring and planning to ensure that the right amount of sand nourishment takes place in the right places. Sand supplementation is not just a way of keeping beaches intact; it is a fundamental measure to protect land against the force of the sea. Not surprisingly, sand nourishment is increasingly being used to provide a 'soft' defensive line in several places all around the world. But why stop at maintaining the coastline? At present, the Dutch coastline has some weak spots which need to be improved in order to meet current safety requirements. At the same time, the Netherlands faces rising sea levels and heavier use of the coastline for recreational and wildlife purposes. A broader, stronger coast would provide an answer to these challenges. As part of an innovative approach, the sandy beach could be reinforced by more substantial sand supplementations. If the extra sand is deposited in the right places offshore, the current and waves would automatically spread it along the coast in such a way a naturally balanced coastline will be created. This is regarded as a promising approach, using natural processes to create more space for wildlife and reinforce coastal defences in a sustainable, low-maintenance way. An example of what the Dutch like to call 'building with nature'.

Room for the river

A similar new approach is being used in the field of river basin management and flood control. It takes the spatial claims and natural values of the river as the starting point. In view of anticipated climate changes, it is thought likely that the rivers in the Rhine delta will have to accommodate ever-higher peak discharges. Until recently it was standard policy to maintain the required level of flood protection simply by increasing the height of the dikes. This is now seen as ineffective. The new policy is to increase the capacity of river basins by positioning dikes further away from rivers or by deepening washlands to reduce river levels at times of peak discharge. More space can also be created by enlarging the river channel within the dikes. In addition, action is being taken to prevent activities which increase peak river discharges, such as the building of houses and recreational facilities on flood plains. The aim is to strike a balance between present and future spatial requirements, seizing every opportunity both to enhance flood protection and to improve the environment. In other words, to work with, rather than against, nature.

Delta Works: a series of innovations

The first of the Delta Works was already in operation in 1958. This was the storm surge barrier in the Hollandse IJssel river. This barrier (not a dam) was of great importance because it protected the densely populated Western Netherlands conurbation. By 1976 seventeen 60-metre-wide sluices were operational in the mouth of the Haringvliet, draining off excess water from the Rhine. The Brouwers Dam, situated south of the Haringvliet Dam, was finished within the next year. Also in 1976, the government agreed to build an open barrier, the Eastern Scheldt storm surge barrier, containing a number of sluices to protect the Zeeland delta and preserve the saltwater habitat of the Eastern Scheldt. The sluices were only to be closed when storms and high water levels made it necessary. To maximise the amount of salt water passing through the sluices and maintain tidal movement, the 3,000-metre-long barrier (completed in 1986) has 62 openings, each of them 40 metres wide. It is still one of the biggest structures in the world. The Maeslant barrier in the Nieuwe Waterweg is the final part of the Delta Works masterplan. Completed in 1997 it consists of two swing gates that can be closed at will to protect about one million people in the province of Zuid Holland.

(4) Eastern Scheldt storm surge barrier (Source: ©iStockphoto.com/Klaas Lingbeek- van Kranen) **[for high resolution version, see CD-rom]**

Moving earth

When it comes to dredging, the Netherlands has an outstanding reputation. Two Dutch dredging companies account for some 40% of the global market. From primitive forms of dredging and land reclamation have sprung sophisticated techniques and methods, now used in the construction and maintenance of ports and waterways, the protection of coasts and shores, and the creation of new land. The Netherlands itself still acts as a testbed for even more efficient, innovative or sustainable dredging techniques. At a dredging sludge depot on the Maasvlakte (De Slufter), for instance, primary separation of sediment is achieved by combining separation techniques. Part of the resulting product is sand of such high quality that it can be used immediately as a construction material. The remaining sediments can be re-used following treatment in an extractive cleaning plant.

(5) State-of-the-art creation of new land (Source: Boskalis) **[for high resolution version, see CD-rom]**

Deltares: enabling delta life

In order to concentrate and apply relevant knowledge and experience, the Dutch water sector has established the Deltares Institute for Delta Technology. The purpose of this independent institute for applied research and specialist advice is to assist in the sustainable development of densely populated delta regions. By bringing together expertise on water, soil and the subsurface, the institute seeks to meet the challenges posed by the physical planning, design and management of vulnerable deltas, coastal areas and river basins throughout the world.

(6) The Meuse, combining flood protection with the creation of new conservation areas and the improvement of wildlife habitats (Source: Rijkswaterstaat) **[for high resolution version, see CD-rom]**

Flood Control 2015

Companies and knowledge institutes have joined forces in the Flood Control 2015 programme to maximise the world's ability to prepare for flood events. Model data, continuous monitoring and real-time information provision are coupled to provide a basis for superior risk assessment, enabling effective short-term decision-making and hence
improved disaster management. Data on water levels, dike strength, meteorological expectations and forecast consequences of expected flood events are combined to produce an integrated picture, on the basis of which accurate predictions can be made and appropriate measures taken: all a question of the right information at the right time.
(7)

Solving water dilemma's

From the connection of the first homes to a basic sewerage system in the 19th century to the supply of high quality drinking water to 99% of the nation by means of an efficient and secure mains system, the Dutch have come a long way. Over the decades, the development of water technology has provided the Netherlands with sustainable systems for the production and supply of water for both private and public consumers and for the collection, treatment and partial reintroduction of 'used' water into the water system. In search of more sustainable, environmentally friendly and widely available solutions to the world's water problems, the Dutch water sector is researching, producing and applying some of the most cutting-edge products and services in the field of water resources management and sanitation.

Production and treatment

At the heart of Dutch water technology expertise is the need to treat, purify and distribute various water flows in order to minimise pollution and risks to public health and to provide domestic, industrial and agricultural consumers with drinking and process water. Through an elaborate and highly efficient system of pipes, pumps, valves and mains, drinking water companies supply clean tap water to almost everyone in the Netherlands. They employ a variety of methods to make water safe - i.e. remove micro- and other organisms, chemicals and other unwanted substances – and to improve its taste, smell and colour. From the established method of 'artificial recharge' (pumping surface water into the ground and using soil as a natural filter) to the more revolutionary application of membrane filters to remove pollutants and ions (salts), the production and provision of high quality water meeting the demands of a range of users is a constant drive for innovation. In the Netherlands, water supply and sanitation have long been linked. Wastewater and rainwater are collected and transported in a sewerage system to which almost the entire community is connected. Sewerage is conveyed directly to wastewater treatment plants. Almost all communal wastewater (98%) is treated before discharge into the rivers and canals that constitute the Dutch water system. Some industrial users provide their own treatment facilities. Experience of its own extensive sewerage and water supply system has made the Netherlands an important supplier of materials for the transport of water through pipes and piped networks. In the changeable and subsiding delta soil, the Dutch have constructed a reliable water mains system approximately 116,000 kilometres long and supported by some 233 pumping stations. Not only is a constant flow of water guaranteed - as pumping stations and water towers create mains pressure - but leakage losses are extremely low (some 4% on average).

Frontrunner

From an international perspective, the Netherlands is a frontrunner in the development of water purification, pretreatment and treatment technologies, including membrane technology, anaerobic water purification (UASB) and Anammox technology. Membrane technology can be used simultaneously to soften water and to remove colour and pesticides. Water treatment using ozone, hydrogen peroxide and ultraviolet (UV) light is also practised, mainly as a primary disinfection method. This technology makes it possible to eliminate virtually all hazardous substances and organisms.

Meeting MDG7

Shortages of fresh water, pollution of groundwater and surface water, lack of access to safe drinking water - people face the same range of problems world-wide. And water is essential to life. The UN believes that access to safe water and sanitation, as described in Millennium Development Goal 7, is an essential precondition for the achievement of other development goals. The Dutch water sector endorses this view and aims to provide clean water and effective sanitation for 50 million people within a decade. The Dutch government, NGOs, and other Dutch water sector representatives are working together with local stakeholders around the world to establish the best options

for both technological and institutional solutions. Low-tech, low-price facilities for water harvesting, water conservation and water re-use seem to offer the best potential.

Small-scale
Countries lacking basic infrastructure can benefit from small-scale, stand-alone facilities for water harvesting, purification, treatment or recycling. Various sustainable technologies and products are being developed to offer potable water to the many at low cost. These include mobile water purification units such as the Perfector-E, which produces high quality potable water from polluted surface water. Another example is the Naïade unit, which uses solar energy to do the same. The Dutch Rainmaker uses wind energy to condense potable water out of air or to turn salt, brackish or polluted water into drinking water. On a domestic scale, various sanitation concepts have been developed to reduce the need for fresh water through the re-use of household wastewater. Separating the different types of water flow in the home can enable household wastewater to serve as a source for energy and nutrient recovery or simply to be re-used to reduce household water consumption. 'Grey water' (water discharged from washing machines, showers, baths, sinks and kitchens) has a relatively low concentration of pollutants and can therefore be recycled relatively easy (for household, irrigation and infiltration purposes). 'Black water' (faeces and urine) can be treated and used as the basis for the recovery of nutrients and for bio-energy production. New sanitation concepts developed by the Dutch water sector are based on separation at source and community on-site transport and treatment. They include a range of low-cost, de-centralised applications suitable for use world-wide.

Precious energy
The Dutch water sector is putting great effort into the development of so-called Blue Energy. This hinges on the difference in salt concentration between seawater and river water. By mixing seawater and river water and separating positive and negative ions by the use of ion-specific membranes, it is possible to generate energy. The advantages are obvious: no fuel costs and no emissions other than brackish water. In order to advance the development of Blue Energy and desalination technology, the Dutch public and private sectors have recently set up WetSalt, a joint research site dedicated exclusively to this purpose.

Coordination
Dutch efforts to develop and apply solutions to water problems in the Netherlands and abroad are driven by two desires. Firstly, the desire to manage water resources efficiently and sustainably, while constantly improving the methods and means by which this is done. Secondly, the desire to share and apply Dutch expertise around the world in order to improve local living conditions (in particular to reduce the number of people without access to safe drinking water and basic sanitary facilities). The Dutch water sector believes that its efforts in this direction will be most sustainable if the introduction of technology goes hand in hand with capacity-building and local entrepreneurship. To achieve this, all parties - government, the private sector, knowledge organisations and NGOs - need to coordinate their efforts and complement each other's abilities. This is an area in which the Netherlands has broad experience. The Dutch water sector is keen to use this experience in the future and to apply its expertise to the solution of waterrelated dilemmas around the world.

(8) Completed in 2004, the Sulaibiya Wastewater Treatment plant in Kuwait is one of the largest of its kind in the world (Source: Norit) **[for high resolution version, see CD-rom]**

MBR

Membrane technology is fast becoming both a standard option for wastewater treatment in the Netherlands and a major export product. A highly innovative approach to wastewater treatment is the combination of membrane technology with biological treatment methods. Because the membrane filters out the sludge, the biological system can cope with greater throughput: the membrane bioreactor (MBR) can therefore be smaller. The effluent is much cleaner than that from a conventional biological treatment system. MBR combines small scale with high quality.

(9) Biological wastewater treatment, Carrousel Geestmerambacht (Source: DHV) **[for high resolution version, see CD-rom]**

Sustainable solutions

The sustainability of wastewater collection and treatment is being improved by differentiating levels of pollution and re-using both treated water and by-products. A huge research and development effort has focused on the search for more environmentally friendly, sustainable and widely accessible treatment technologies and expertise. At the same time, new ideas about water recycling and re-use are being turned into valuable applications that can help meet some of the world's water challenges. Seawater desalinisation, the use and re-use of groundwater and wastewater, and the use of water to produce energy are subject to a similar trend.

Research for better technology

To promote the development of water technology, Dutch private and public sector partners have initiated a Technological Top Institute for Water Technology. The research institute focuses the combined strengths of industry and renowned universities on the search for practical answers to global water problems. It does so via a concentration on the multidisciplinary use of biotechnology and separation technology. The current research programme includes themes such as desalination and re-use of salts, improving the performance of membrane bioreactors, preventing the biofouling of membranes for the preparation of drinking and process water, and generating energy from water. www.wetsus.nl.

(10) WetSalt, research site (Source: Wetsus, centre for sustainable water technology) **[for high resolution version, see CD-rom]**

Wastewater is not wasted

Various technologies are used in Dutch treatment plants to polish and recycle industrial wastewater. The polishing of biologically treated wastewater by sand filtration methods has proved highly successful. Combining membrane or other treatment technology with activated carbon and environmentally friendly oxidation (UV, ozone) has made it possible to turn wastewater into a valuable source of high quality process water. Effluent from a wastewater plant often requires only limited purification to be re-used as industrial boiling, cooling or cleaning water. This so-called 'grey water' (relatively clean but not suitable for drinking) can also be used for many non-industrial purposes, such as flushing toilets, washing cars and irrigating gardens. There are places in the Netherlands where effluent from a wastewater treatment plant is being used in fire-fighting (sprinkler systems), in irrigation or for infiltration in the drinking water collection area. The Dutch water sector can offer tailor-made water supply infrastructure and post-treatment technology for the reintroduction of process water and wastewater into the industrial process.

(11) **[for high resolution version, see CD-rom]**