RONALD E. WATERMAN AND JAAP BROUWER

AQUAPUNCTURE©: SUSTAINABLE FUTURE OF INLAND WATERWAYS

ABSTRACT

Waterways have always been a focal point for settlements and economic activities and were used for a great variety of functions. All the inland waterways formed a slow waterway system, going through city centres and connecting them in a direct way. To a certain extent this changed with the rise of the much faster railway and road system through and around the cities. The waterway transport system became obsolete and its main function was taken over by land transport. The spatial relation between the waterway and urban development became neglected. Now the significance of this unique relation between the waterways and the adjacent urban and rural habitats is becoming apparent. Through the development of Aquapuncture© this waterway network is being rediscovered and revitalised.

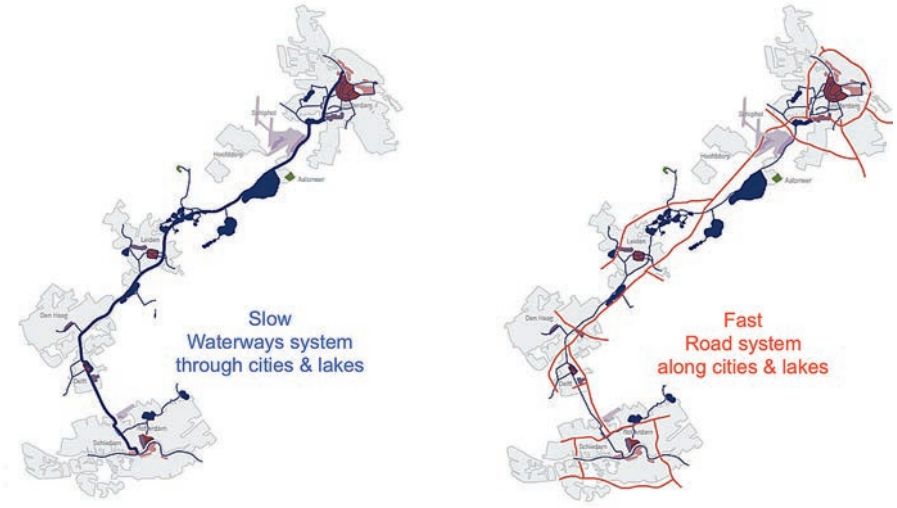


Figure 1. Slower waterways systems (left) vs. fast road systems (right).

INTRODUCTION

Aquapuncture is an instrument for the optimal use, adaptation and management of inland waterways and their waterfronts (Figure 1). It is an instrument for the benefit of safety, navigability, economy, employment, spatial quality and environmental values. Whereas Acupuncture is applied to revitalise the nervous system and the human organs, Aquapuncture is applied to revitalise the inland waterways and their waterfronts (Figure 2).

Above: The Vliet-Schie marina in Delft was the first project developed in the Netherlands following the principles of Aquapuncture. Guest berths for transient vessels were built and the waterfront enhanced, which stimulated the economy. At the same time it led to improvement of the water quality in the waterway system.

Inland waterways have always linked urban and rural areas. These waterways were always a focal point for settlements and economic activities. Worldwide a slow waterway system went through cities and lakes. These waterways were used for everything from drainage and irrigation, water level regulation, defence, drinking water supply, beer production, fishing, transport of persons and goods, but also as open sewers. Furthermore, many industrial activities along these waterways were present and resulted in added emissions in the water.

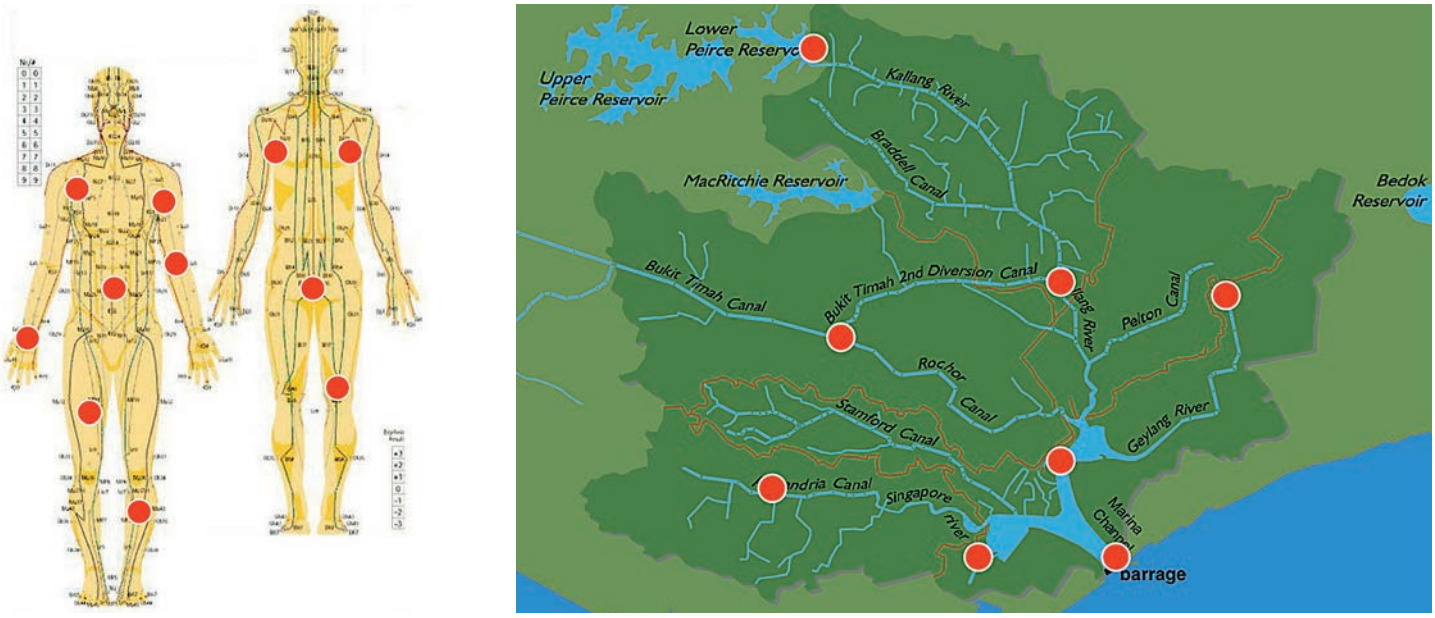


Figure 2. Left, Acupuncture: revitalises the human body. Right, Aquapuncture: revitalises waterways and their waterfronts.

Later on the faster railway and road transport systems in and along cities came into being. To a certain extent the inland waterway systems became obsolete and their main transport function was taken over by the faster rail and road system. The spatial relation between the waterway and urban development was neglected. Nowadays the significance of this unique relation between the inland waterways and the adjacent urban and rural habitats is again gaining attention. In the meantime the water quality has been improved considerably through various measures and regulations. Therefore rediscovering and revitalising the waterway

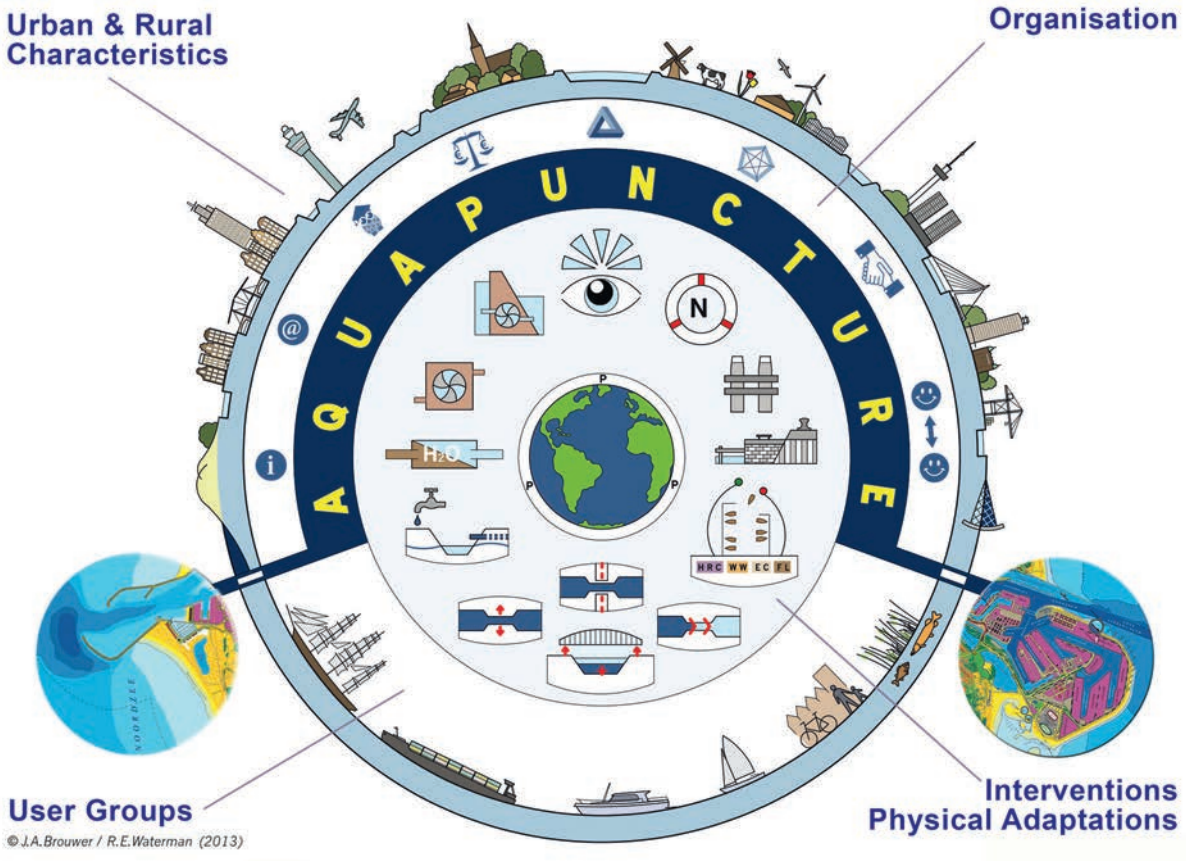


Figure 3. Aquapuncture: Waterways as a vital backbone in the urban and rural landscape.

RONALD E. WATERMAN
MSc, PhD is dedicated to finding answers to the question how can we develop well-balanced and integrated solutions in the fields of space, economy and environment to existing and future challenges as regards (1) sustainable coastal and delta zone development based on the principle of Building with Nature®, and (2) the sustainable use and adaptation of inland waterways and their waterfronts based on Aquapuncture©, a concept developed in cooperation with Jaap Brouwer, MUrb.

JAAP BROUWER
studied Spatial Planning graduating with a degree in engineering from the Hogeschool, Utrecht, the Netherlands and then received a Master of Urbanism from the Academie van Bouwkunst Amsterdam. He worked from 2003-13 at Soeters Van Eldonk Architects, Amsterdam and is presently an advisor at Waterrecreatie Nederland and a partner at Aquapuncture, which advises, designs and does research for waterways.

network and their waterfronts through Aquapuncture for the benefit of six potential user groups is being proposed. Waterways are a vital backbone in the urban and rural landscape (Figure 3).

URBAN AND RURAL CHARACTERISTICS OF INLAND WATERWAY SYSTEMS

Aquapuncture is based on a thorough analysis of the urban and rural characteristics of the inland waterways and their waterfronts. This means that first of all the characteristics, history, typology and classification of the waterway itself (river, canal, lake), must be studied, followed by a study of the waterfronts and adjacent territories. Good plans have their roots in the past and are pointing towards the future. With regard to the waterfronts a study includes the presence and characteristics of residential areas, leisure parks, tourist and recreational facilities, museums and monuments, commercial and industrial zoning, infrastructure, agricultural areas, landscape and nature.

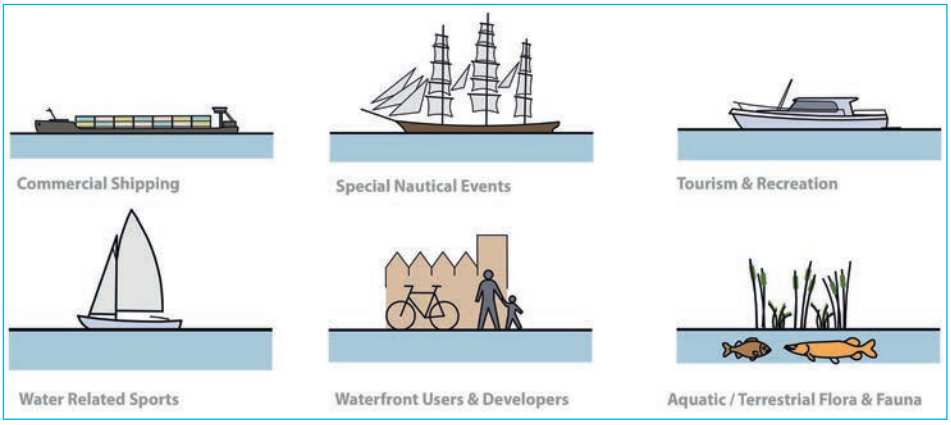


Figure 4. The six user groups in and along waterways.

USER GROUPS

For the optimal use, adaptation and management of the waterways and their waterfronts the six actual and potential user groups in and along the waterways should be considered (Figure 4). These User Groups in and along the waterways are:

1. Commercial shipping for persons and goods
2. Tourism and recreation
3. Special nautical events ("Sail", floating flower shows, regattas of heritage ships, dragon boat races, concerts on water, special cruises)
4. Water related sports (sailing, surfing, rafting, rowing, canoeing, fishing, swimming)
5. Waterfront users and developers
6. Aquatic / terrestrial flora and fauna and micro-organisms

PHYSIAL ADAPTATIONS (INTERVENTIONS)

To achieve Aquapuncture for these user groups, physical adaptations (interventions) (Figure 5) and organising measures are necessary (Figure 6).

Physical Adaptations / Interventions in and along the waterways are:

1. Height of bridges above water level
2. Dredging depth via environment-friendly dredging
3. Expanding sluice capacity and bridge and sluice servicing
4. Dike / Levee adaptation, River/Canal widening - Room for the River
5. Aqueducts and boat conveyors
6. Water level regulation via sluices, pumping stations & weirs
7. Facilities for drainage / irrigation
8. Pier / Jetty / Quay wall / Moorings and Berths with facilities
9. Loading/unloading platforms
10. Yachting harbours and inland container terminals
11. Introduction of environment friendly banks / shores
12. Waste Water Purification
13. Implementation Water Framework Directive for physical, chemical, biological quality
14. Introduction of hotel, restaurant, café/ pub, museum, companies along the waterway
15. Linking inland waterways
16. Urban Development with connecting waterways
17. Infrastructure, including bicycle lanes and footpaths and parking space along the waterway
18. Enhancing blue-green spatial qualities of urban & rural areas
19. Restoring & purposeful using cultural heritage values in and along the waterway
20. Introduction of environment-friendly powered vessels
21. Nautical safety.

ORGANISATION FOR WATERWAY AND WATERFRONT DEVELOPMENT

Organising measures (Figure 6) are:

1. Stakeholder analysis and participation
2. Public-private partnership (PPP)
3. Societal costs-benefits analysis
4. Cooperation with 5 levels of Government
5. Trias Politica: legislative, executive and judiciary system
6. Knowledge and education

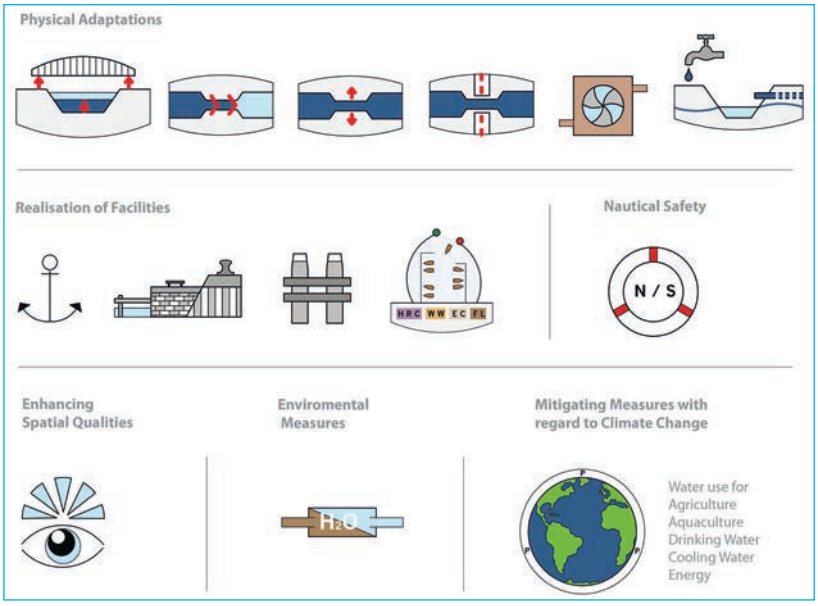


Figure 5. Physical adaptations and interventions.

Figure 6. Organisation for waterway and waterfront development.

7. Information, awareness, promotion
8. Communication tools (e.g., Internet and Apps)

Societal Costs & Benefits Analysis

For the physical adaptations / interventions in and along the waterways initial investments are necessary. These are followed in a later stage by revenues of various types and from various sources. These may be:

- Water Quantity revenues (flood prevention, surface water and groundwater regulation, drainage, irrigation for agriculture and aquaculture, drinking water supply, cooling water, process water, water flow energy);
- Water Quality revenues (improvement of water quality, beneficial to environment, nature & health);
- Navigability revenues (transport of persons and goods, water related sports, tourism and recreation);
- Waterfront attraction revenues through increased liveability, economic activities and increased value of property;
- Spatial Quality revenues (improved urban and rural environment, preservation and restoration of cultural heritage, attractive residential areas, leisure parks, sustainable industrial parks; overall sustainability also with regard to climate and climate change).

Apart from initial investments, maintenance and operational costs have to be reckoned with. In all cases the combined involvement of governments (central, regional, local), private enterprise, research institutes, educational institutes, and environment – nature – landscape – society is necessary.

Hydrological Cycle

This first discussion has focused on the usage, adaption and maintenance of inland waterways and their waterfronts. The role water plays can be described on macro, meso and micro levels. In all cases the starting point is water in all its forms and expressions as a central element in the hydrological cycle and the role water plays in the climate cycle, biological cycle and the environment in general. Aspects like water retention, water storage and drainage, irrigation, drinking water supply, cooling and process water, water purification have to be taken into account. Prevention of waste dumping into the water is absolutely necessary.

The role of water in and around the cities needs special attention. The quick run-off of water, due to a high percentage of sealed surfaces in urban areas, especially in periods of heavy rainfall, is what causes the danger of flooding and this has to be remedied. In dry periods the potential use of retention basins proves to be of great importance. Therefore, the aim is to improve the situation by sensible interventions and at the same time stimulate recreation, tourism and inspirational experiences.

Blue-green arteries are valuable assets in the urban fabric and the surrounding rural landscape for sustainable climate-proof liveable cities. They are slowing down the water flow, provide a habitat for bio-based diversity and are connecting people. In the end they improve the environment and strengthen simultaneously directly and indirectly the economy. Their existence is a source of inspiration and education.

In close cooperation with artists, architects, landscape architects and engineers, Herbert Dreiseitl and his studio/workshop have introduced water in all its forms and expressions in and around built-up areas. He retains the water for a longer period, allows it to circulate in a special ways visibly, audibly and tangibly and plays with the water. He increases the drainage surfaces by creating beautiful parks and roof gardens. He combines well thought-out integral water management and urban beautification, while promoting the awareness of water as life bringing element in the hydrological cycle. Furthermore, Dreiseitl is of the opinion that in a city playing with water by children (and their parents) serves an educational purpose and proves to be beneficial all around. His views have been applied worldwide.

WORLDWIDE APPLICATION OF AQUAPUNCTURE

The method of Aquapuncture is applicable to rivers, canals and lakes, both in coastal and delta areas as well as in the existing hinterland in all of the five habitable continents. Active introduction of the method has already taken place in Europe and other parts of the world.

Figure 7. The Frisian Lakes Project: Traffic waiting for a sail boat to pass through a canalised waterway.

Figure 8. Aerial view of the Frisian Lakes Project: The new roadway goes under the canal which improves traffic flow.

A selection of case studies is presented below.

The Netherlands: Aquapuncture for Liveability and Economy

The Frisian Lakes Project – Water Leisure Paradise

The Frisian Lakes Project (Figures 7 and 8) aims to make Fryslân (as Friesland is known in its own language) even more attractive as a water sports area. In doing so, the Frisian economy and employment will also be stimulated. The project was initiated in 2000 and will be completed in 2015. The total project costs were estimated at € 495 million.

The objective of the Frisian Lakes Project is anchored, amongst other things, in the improvement of employment in the Frisian water sports branch. The target is to realise 30% more employment versus the reference date in the year 2000. Furthermore, the Frisian Lakes Project wishes to improve liveability and to attract more business to Fryslân, through, for example, improved road traffic flow and shorter waiting times for bridges and locks. Nature and the environment play a central role, as does recreation. In other words, the project is good for everybody: whether you are a resident, visitor or holidaymaker.

Since the start of the Frisian Lakes Project, employment in the Frisian water sport sector has grown by 22.7% (2009 figures). In terms of jobs, this translates as 844 structural jobs (fulltime and part-time). Furthermore, the project has already been beneficial for recreational boating: new sailing routes and areas, new aqueducts, new mooring facilities, bridges, locks and harbours. It has also meant less waiting times for bridges and locks. The Frisian Lakes Project has also helped reduce traffic in many tourist villages thanks to the construction of ring roads and aqueducts. Car drivers in Fryslân have also profited from an improved traffic flow, thanks to the raised bridges and aqueducts. Of course improved accessibility of water sports centres and villages is a benefit for the residents themselves.

Achievements of the Frisian Lakes Project include:

- 1600 moorings
- 36 new, raised or movable bridges
- construction of 5 new aqueducts
- 462 km of sailing channels have been dredged for maintenance
- 164 km of sailing channels have been deepened for upgrading for navigability
- 146 km of extra channels have been created for "large" boats
- 6 water sports centres and 15 marinas have been constructed or improved
- 31 km of new cycle paths and footpaths

Holland Lake District – Entrepreneurs Activating the Waterway Network

The Holland Lake District is situated in the heart of the metropolitan area of the Netherlands. The waterway network is defined by eight different lakes with mutual corridors, complemented with urban canals of Amsterdam, Utrecht, Haarlem and Leiden (Figure 9). The Lake District offers many unique opportunities for recreational and tourist activities on and along the water (Figure 10) although the area is still less well known to the general public in comparison with the Frisian Lakes.

Therefore the Entrepreneurs Platform Dutch Lakes (OPHP) was formed. This alliance of business organisations with interest in recreation and water sports in and around the Holland Lake District, has the overall objective to enhance the regional and local economy along the waterways. Two ways to achieve this objective are: to increase awareness of the area via marketing and promotion and to improve the physical accessibility via the project "Map of Opportunities" (Figure 11).

The "Map of Opportunities" is a strategic document outlining how to enhance the waterway network of the Holland Lake District. From a long list of interventions the entrepreneurs of the OPHP selected the ones with the most potential. This resulted in a list for each lake and an overall Priority List:

1. Harmonisation of operation times for bridges and locks in several provinces and municipalities and extension of operating times, especially during the tourist season. This leads towards an extended use of the waterway network.
2. Necessity of a network of high-quality moorings for visitors. These moorings

Figure 9. A collage of water sports and marine activities in the Holland Lake District.

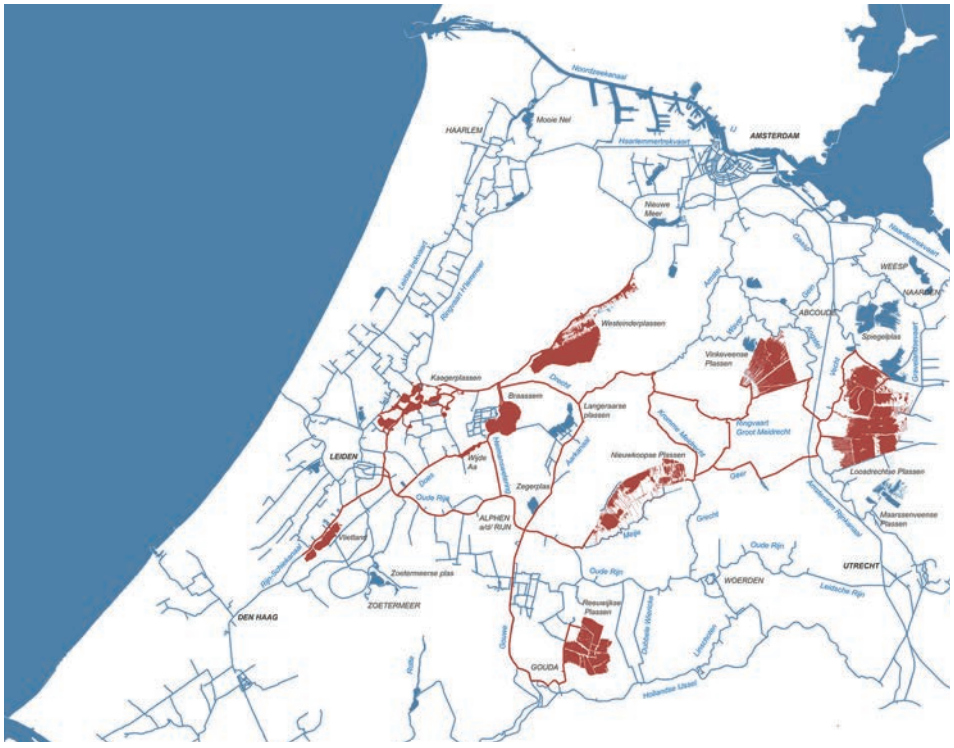


Figure 10. Overview map of the Holland Lake District. Waterways and bodies of water in red.

Figure 11. Holland Lake District "map of opportunities" pinpoints interventions to enhance the water network.

should be located in the landscape and in the various city centres.

3. Adaptation of low fixed bridges by pivoting or raising them. In this way a larger area of the waterway network will be navigable.
4. Necessity of nautical signs along the waterways and of better general and tourist information, in combination with multimedia (Internet and Apps).

Watervision Greenport Boskoop – Seizing Opportunities

Greenport Boskoop is an area for horticulture. Based on a survey of the waterways and all the bridges a potential waterway network was visualised with several 'Aquapuncture' points. From three different scenarios the town council choose to preserve the existing navigable waterway network in good condition and enhance it as soon as new opportunities appear (Figures 12 and 13)..

This resulted in:

- Keeping intact two locks which connect the polder with the regional waterway network;
- Accepting the tasks and responsibilities of managing the waterways;
- Making new bridges pivoting on strategic locations;
- Stimulating the usage of waterways for the promotion of the Greenport (including Floating Flower Shows).

Heineken: Inland Container Terminal

Heineken as one of the largest breweries in the world has the ambition to become the greenest brewery with the smallest global footprint. This means striving for a climate-proof, sustainable economy with regard to mobility and logistics (intermodal shift from road to waterway transport); energy (wind,

Figure 12. Overall impression of Waterway Greenport Boskoop.

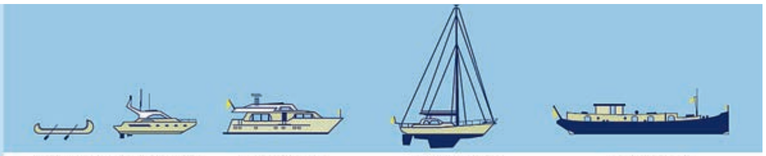
solar, biogas); water (water supply, water storage, water purification); raw materials (barley, hop, yeast, water); liveability (environment – nature – landscape – society).

Heineken is exporting bottled beer from one of its large production centres in Zoeterwoude via the ports of Rotterdam and Antwerp, originally using 100,000 truck rides. Through a public-private partnership a decision was made to create an inland container terminal (OTA "Overslag Terminal Alphen"). This was coupled with an intermodal shift from road to waterway transport by using container vessels, leading to a large environmental gain (Figure 14). These waterways are also used for the import of barley and hop. The residue of the beer production is used as feed for the cows in "het Groene Hart" (the Green Heart), the agricultural district near Zoeterwoude. The resulting manure is used for the production of biogas. Biogas and wind energy are applied by Heineken factory. Attention is paid to water supply, water storage and water

Figure 13. The Master Plan of Waterway Greenport Boskoop.

Figure 14. An inland-waterway container ship.

Figure 15. Vliet-Schie marina in Delft: guest berths for transient vessels.



DESIGNATION	OPEN BOAT	CABIN CRUISER	MOTOR YACHT	SAILING BOAT	MOTOR BARGE
CLASS	RA	RB	RC	RD	I
MAX . LENGTH (M)	5.5	9.5	15.0	15.0	38.5
MAX. BEAM (M)	2.0	3.0	4.0	4.0	5.05
DRAUGHT (M)	0.5	1.0	1.5	2.0	1.8 – 2.2
MIN. HEIGHT UNDER BRIDGES (M)	2.0	3.25	4.0	30.0	4.0

Figure 16. River / Canal Classification for recreational boating.

purification. Special care is taken with regard to nature development in "het Groene Hart" with flowering plants and fertilising insects (bees with honey production, butterflies) as well as predatory insects. Adaptation of the inland waterways through Aquapuncture plays a significant role in the total concept for achieving a smaller global footprint.

Association Region Water (Vereniging Regio Water): Vliet-Schie Transient Marina
The Association Region Water promoted the realisation of a transient marina harbour in Delft along the Vliet-Schie waterway. The purpose was to create berths for transient ships complete with facilities for drinking water and electricity supply, intake of wastewater, restrooms and a harbour office.

The initiative was very successful since the people aboard the ships went shopping, visited the old city of Delft with its museums, pubs, restaurants and hotels, thus stimulating the economy and employment. At the same time it led to improvement of the water quality in the waterway system, fitting in the EU Water Framework Directive. With the help of the Province of South-Holland this was the first successful project of Aquapuncture within the Association Region Water (Figure 15).

In all the aforementioned cases River / Canal Classification has shown to be a valuable instrument for Aquapuncture to develop both maintenance and upgrading plans (Figure 16).

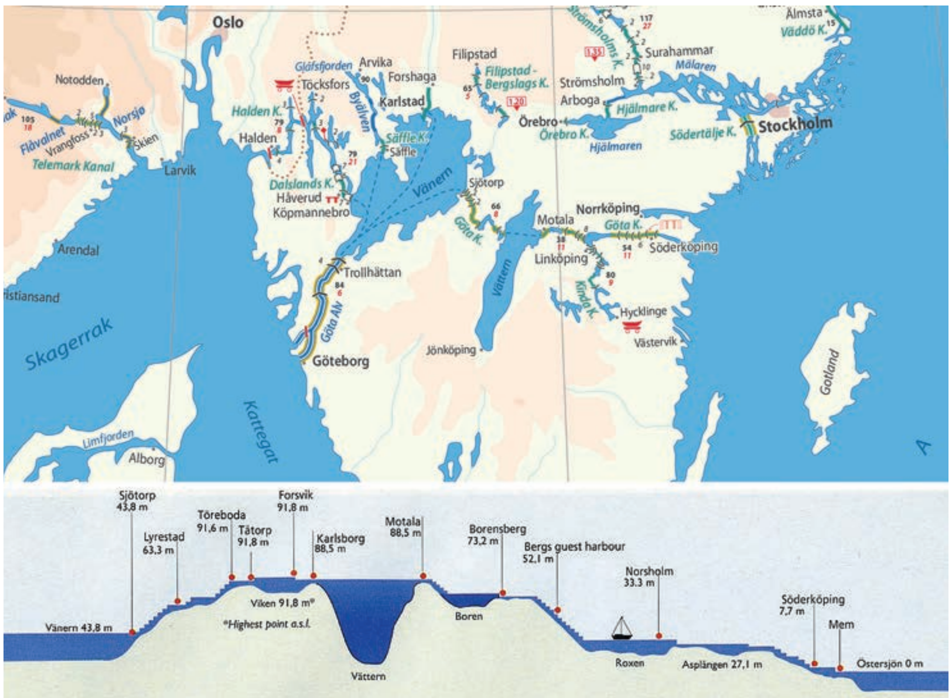


Figure 17. Cross-section adaptations will give Sweden a Sea-to-Sea connection. (Courtesy David Edwards-May / Euromapping).

Sweden: Sea-To-Sea Connection

For the optimal adaptation, safety and use of the waterway connection in Sweden between Kattegat and the Baltic Sea Aquapuncture can be applied. This long, 614 km waterway connects Kattegat - Göteborg - Göta älf - Trollhätte kanal - Vänern - Göta kanal - Vättern - Göta kanal - Söderköping - Baltic Sea (Figure 17). This sea-to-sea connection transverses Sweden running through beautiful landscapes and waterscapes. It is ideally suited for tourism and recreation.

Specifically for freight transport between Göteborg and the ports along the shores of Vänern the waterway has to have cross-section and sluice adaptations. An intermodal shift from road transport to water transport can thus be achieved with substantial environmental gain. To promote tourism and recreation along the waterway use can be made of multimedia, including Internet & Apps. One thinks of "Nils Holgerssons underbara resa genom Sverige", the story of Nils Holgerssons' journey on the neck of a goose across Sweden, written by Nobel Prize winner Selma Lagerlöf (1914), who lived in that area. It gives a fantastic overview of the whole region, seen from the air and it gives the opportunity to zoom in on all the attractions and special sites along and near the water.

Germany: Transformation of the Ruhr Area

The Ruhr Area as a polycentric metropolis was developed as a major bastion for the economy and employment with intensive mining activities and related heavy industries. However, in due time this area was confronted with serious environmental problems. This was illustrated by the deplorable transformation of the once meandering clean Emscher River into an open sewer in a concrete gutter, flowing through

the heavily polluted, densely populated industrial mining area. As a result, a decision was made to stop out-dated industrial and mining activities and to stimulate the service sector and clean production industries.

Parallel to this, a plan was developed to convert the affected area into a beautiful nature park with a restored Emscher River, meandering through the park with important recreational functions. Industrial heritage elements like blast furnaces, gas storage tanks and mining compounds were transformed with new functions like climbing towers, diving facilities, museums and art galleries. At an earlier stage a vast underground sewer system had to be constructed, coupled to wastewater purification units. The Emscher Park with its renewed relationship between water, greenery, nature and recreation is a great success and shows clearly that through the application of Aquapuncture a once deplorable area can be changed into a very attractive territory.

Scotland: Innovative Canal Connection

Edinburgh and Glasgow were once connected through the Union Canal and the Forth & Clyde Canal; these were mainly used for transport of coal, iron and other materials & goods. These two canals were connected by a series of 11 locks with a difference in height of 35 m. By the 1930s the canals had fallen into disuse and the locks were dismantled in 1933.

In the 1990s British Waterways made plans to regenerate these canals (Figures 18 and 19).

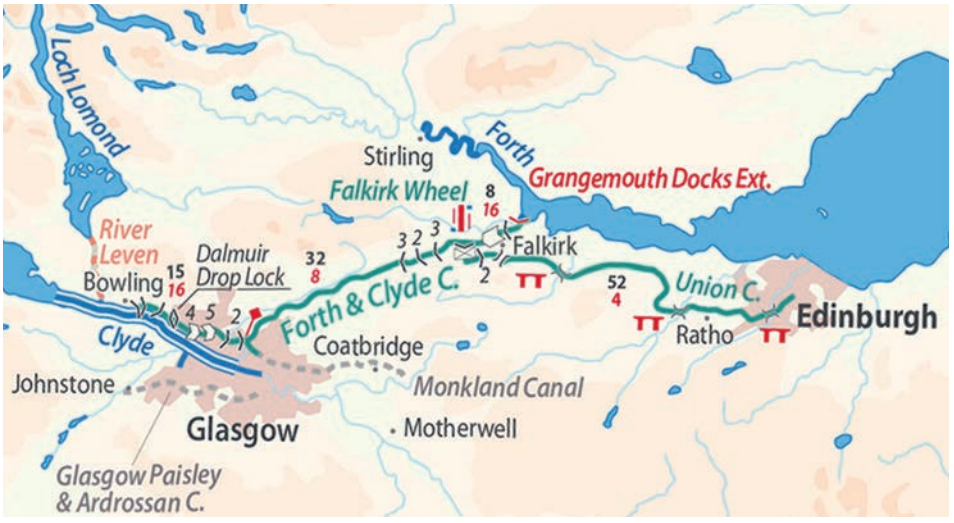


Figure 18. Waterway Connexion Edinburgh-Glasgow. (Courtesy David Edwards-May / Euromapping).

Figure 19. The Falkirk Wheel a rotating boat lift in Scotland, connects the Forth and Clyde Canal with the Union Canal. The lift, named after the nearby town of Falkirk, opened in 2002.

They became part of an overall strategy to reconnect Edinburgh and Glasgow with a navigable waterway, complete with a landmark fitting for the 21st century. Thus, the concept of the Millennium Link came into being. A brilliant design was made to replace the 11 locks by a boat conveyor in the form of the Falkirk Wheel. For the realisation of the Millennium Link many public and private parties were successfully involved. The waterway is mainly used for tourism and recreation. Interestingly, the Falkirk Wheel

Figure 20. Milan with Navigli Lombardi (Courtesy David Edwards-May / Euromapping).

Figure 21. The historic Da Vinci Canals are now being used for tourism.

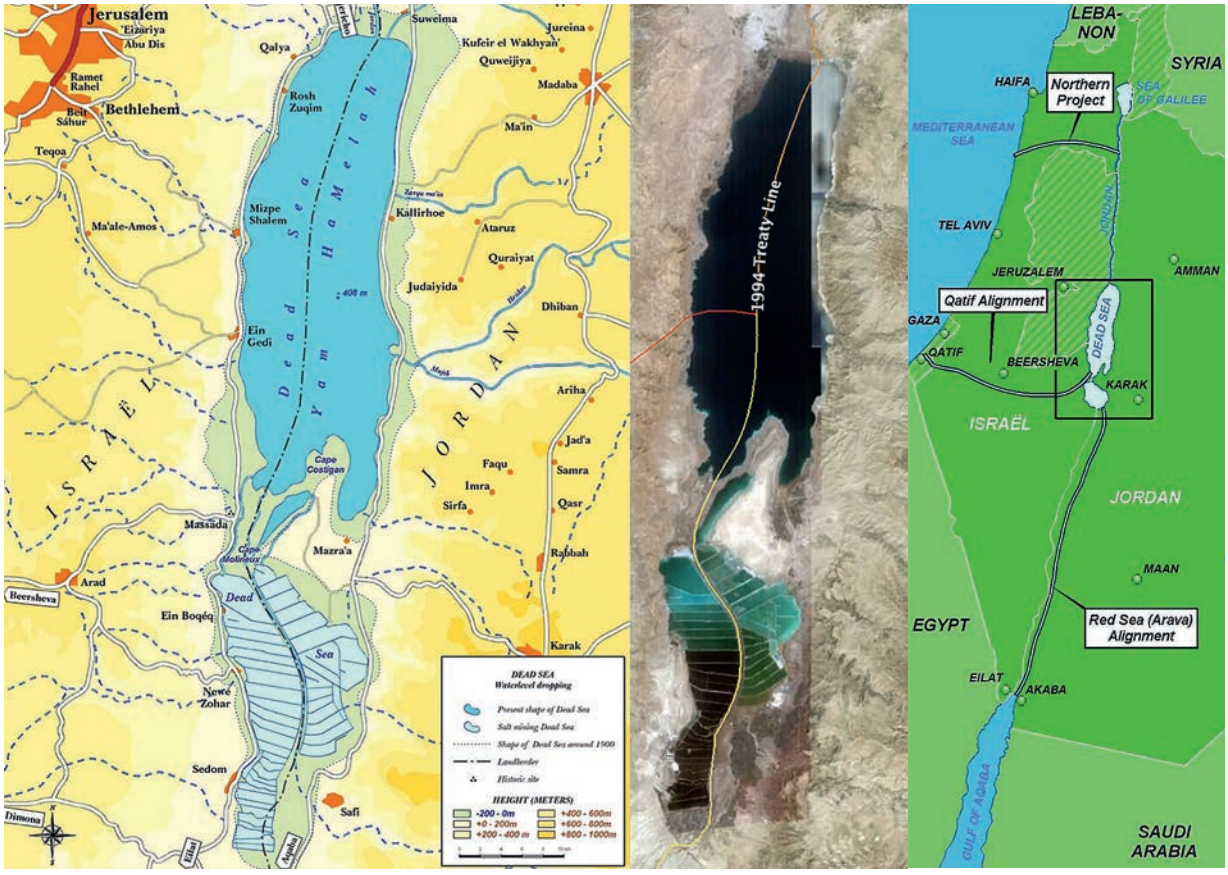


Figure 22. Map of the Dead Sea indicating shorelines now and in 1900 and a satellite photo. Right, the three pipelines connecting the Mediterranean, the Dead Sea and the Gulf of Aqaba and Red Sea. The choice was made for the Red Sea-Dead Sea Connection.

itself became a great tourist attraction as well as the areas parallel to all the waterfronts which were appealingly developed, including cycle and footpaths.

Italy: Revitalisation of the Navigli Lombardi

The city of Milan is, through a number of canals, linked to the Ticino & Lago di Como, the Adda & Lago di Maggiore and the Po. These canals are called Naviglio Grande, Naviglio Martesana, Naviglio di Paderno, Naviglio di Bereguardo and Naviglio Pavese. Leonardo da Vinci played an important role in the design of several of these canals and in the construction of elements, related to these canals, like locks, dams, mills, ferries and such. Therefore most of these canals are named together the Da Vinci Canals (Figures 20 and 21).

Originally these canals were mainly used for irrigation, defence and transport. The transport concerned marble, granite, stone, salt, grain, wine, manufactured goods, manure, ash, live stock, cheese, hay, coal, lumber, sand. Much later when the faster road and railroad came into being, the canals became to a certain extent obsolete; parts were covered and filled in. Nowadays the important cultural heritage value of these original waterways and their waterfronts is recognised. Through revitalisation they are being adapted, promoted and used for tourism and recreation.

Israel–Jordan: Peace & Prosperity via the Red Sea–Dead Sea Connection

The Dead Sea is a large inland saltwater body with an original surface area of 950 km^2 and an internal volume of 155 km^3 as measured in 1900. The Dead Sea borders Jordan, Israel and the Palestinian Authority. Its main water source is the Jordan River. Since this river has been used increasingly as a source for irrigation and for drinking water the natural balance between the evaporation rate and the water inflow with regard to the Dead Sea has become completely disrupted. As a result the original water level of -390 m MSL declined to -429 m MSL, the surface area shrank to 600 km^2 and the Dead Sea volume was considerably reduced (as measured in 2014). This process continues. The receding seashores also create major environmental problems, causing sinkholes that endanger structures, roads, flora and fauna (Figure 22).

A Red Sea-Dead Sea connection restores the original surface area and volume of the Dead Sea and can use the hydrostatic difference for the production of desalinated seawater through membrane filtration. In this way, an important partial solution for the existing and predicted water deficit for the region, including Israel, Jordan and the Palestinian Authority can be achieved. The projected alignment is a Red Sea-Dead Sea connection, starting at Aqaba. The project consists of a sea intake lagoon and canal, pipelines, pumping stations, hydropower station and near the Dead Sea a desalination plant. This plant is using the process of hydrostatic reverse osmosis through membrane filtration. In this way desalinated seawater is produced for drinking water supply, while the resulting brine is used to bring and keep the Dead Sea at its original level. Consequently, a major part of the desalinated seawater would be

pumped through a pipeline to Amman, the capital of Jordan; another part would be pumped to Jerusalem and Hebron.

In 2005 a tripartite agreement was signed between Israel, Jordan and the Palestinian Authority to jointly conduct a feasibility study for the Red Sea-Dead Sea connection as a "Peace Water Carrier". The study will examine at least four main subjects.

- The environmental impact on the Gulf of Aqaba / Eilat from pumping out water
- The environmental impact on Wadi Arava from the transit of water
- The feasibility of a seawater desalination facility at the Dead Sea, especially to meet the water demands of Jordan and Palestine
- The impact on the water quality of the Dead Sea by an influx of seawater residue.

The proposed project provides a sustainable source of fresh water to Israel, Jordan and the Palestinian Authority. Furthermore, it raises the water level in the Dead Sea to the required level and will then stabilise this water level. It stimulates the economic development in the Jordan Rift Valley. The projected lagoon near Aqaba with its waterfront gives unique possibilities for the development of Aqaba. In addition, it promotes the peace process in the whole region. The World Bank, the USA, Japan and several European countries have expressed interest in participation in this ambitious project.

Further detailed research is necessary, concerning, e.g., the impact of the change in chemistry and chemical concentration of the Dead Sea on the mineral recovery process. The location and shape of the intake along the seashore have to be examined in their relation to the marine eco-system. Hydro-geological surveys in the Wadi Arava / Arava Valley have to be executed. Risk management is absolutely necessary to prevent leakage, sabotage and other attacks. Instead of integrating land into sea, this truly unique project is integrating the intake of seawater into the existing land-water system.

Indonesia: Sustainable Land-Water Solutions for Jakarta

Jakarta, capital of Indonesia, is the diamond clasp linking together 17,500 tropical emerald islands. The city has a very high population density, having over 10 million people on a surface area of 650 km2. It is situated in a vulnerable, lowland delta of 13 rivers and Banjir Canals with 35 km coastline, facing the Bay of Jakarta. Adjacent in the hinterland are the neighbouring cities of Bogor, Depok, Tangerang, Bekasi (Figure 23).

The greater metropolitan area of Jakarta has a population of around 30 million. The scarcity of space for living, working, infrastructure, recreation and tourism is acute. At the same time the need to preserve or expand valuable environment, nature and landscape is important. Furthermore, Jakarta is in a very vulnerable position because of climate change, resulting in sea level rise, a higher frequency and intensity of storm surges and rainfall (with intermittent periods of drought), salt water intrusion and land subsidence, mainly caused by too much groundwater extraction and a too high percentage of hard surfaces. Potential earthquakes and volcanic activities have to be taken into account. The situation is aggravated by dumping of waste into the rivers and narrowing them by building obstructions in the rivers. A scarcity of blue-green arteries within the city makes a difficult situation worse (Figure 24).
Using Building with Nature® and Aquapuncture concepts, three solutions have been proposed to address the scarcity of space:

1. making better use of the third dimension (high-rise and underground development) combined with the multifunctional use of the existing space and better use of the fourth dimension (e.g., transformation of buildings and building sites);
2. using space in the existing hinterland of DKI Jakarta, insofar possible;
3. extending Jakarta through land reclamations into Jakarta Bay.

The answer will most probably be a combination of all three. The best solution for the scarcity of space is a series of well-designed land reclamations in the Jakarta Bay, using the method of Integrated Coastal Policy via Building with Nature®, striving for new flexible dynamic equilibrium coastlines with a minimum of solid seawall elements and a small maintenance factor. The series of land reclamations should and must be combined with adequate water resources management and with Aquapuncture. This means removing all obstacles in the rivers and drainage canals, stopping emissions of liquid and solid waste into rivers and canals, introduction and improvement of sewer systems and wastewater purification, environment-friendly dredging, widening several rivers and canals,

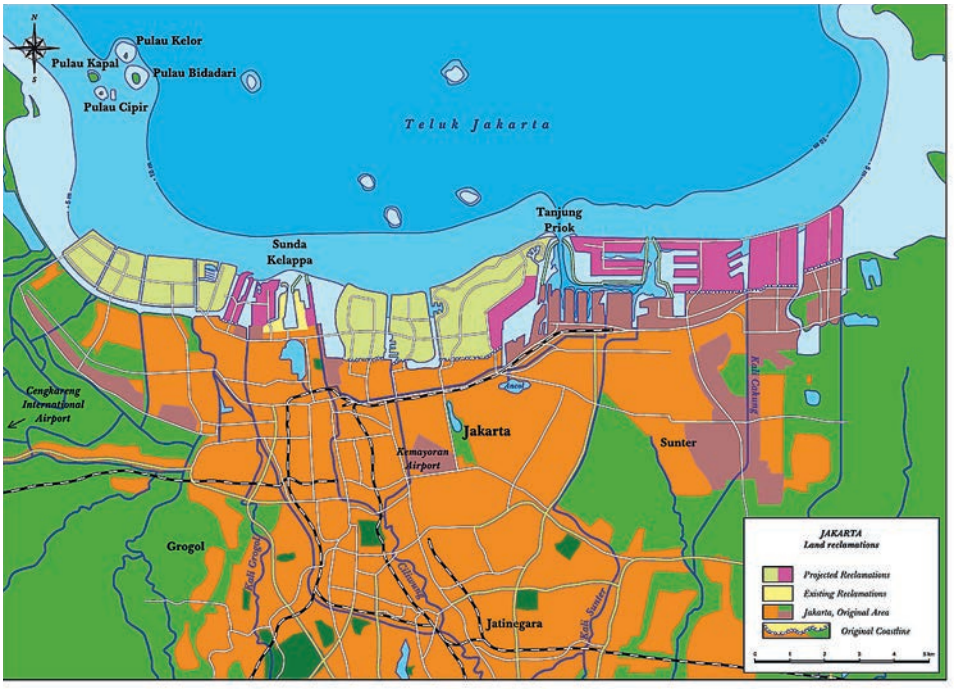


Figure 23. The original city of Jakarta and existing and proposed land reclamations in Jakarta Bay.

Figure 24. Jakarta's annual floods are a human disaster.

extension of the waterway system, the replacement of existing bridges by higher bridges and/or moveable bridges, creating accessible waterfronts, river level regulation by using weirs, pumping stations and sluices. In some cases the construction of levees/dikes along sea and rivers should also be considered. In addition, calamity storage and retention basins as well as adequate blue-green arteries should be provided. Altogether, this means a huge, but necessary operation, which can only be carried out in a step-by-step approach fitting within a flexible Master Plan. In all cases this must be combined with a social resettlement programme. That is also one of the reasons why in the case of Jakarta Aquapuncture should always be combined with land reclamations. These land reclamations should be separated by waterways and lakes with sufficient width and depth and should include the extension of the Port of Tanjung Priok, building sites for living and working, space for tourism and recreation and with an adequate infrastructure of waterways, roads, railroads, pipelines and cables. The concept of the Great Garuda, an extensive plan for flood protection and land

Figure 25. The Great Garuda is a proposed Giant Sea Wall development to protect Jakarta from flooding and create new land areas. In Indonesia the Garuda is a national symbol derived from a gigantic bird-like creature. (Courtesy of Consortium NCICD; design: KuiperCompagnons-Gijs van den Boomen).

Figure 26. Singapore's Kallang River before (left) and after (right) Aquapuncture was applied. The concrete canal was changed into a meandering river, bordered by green parks on each side.

reclamation (Figure 25) can be considered, but always in combination with Building with Nature® and Aquapuncture as well as being able to fit in a Flexible Master Plan which can be carried out in phases, segment by segment.

Making the improvement and extension of the 13 rivers and Banjir Canal system and their waterfronts a high priority is an absolute necessity in order to stop the periodic flooding of considerable areas within Jakarta.
At the same time the challenge to create opportunities for the 6 potential users of the waterways remains.

Singapore: Active – Beautiful – Clean

Singapore is an island state, consisting of one large island and 58 smaller islands, with a population of 5.5 million on a surface of 714 km2, with 32 rivers and 17 water reservoirs. Originally these rivers were used for transport of persons and goods, but also as open sewers. The rivers and their waterfronts were consequently in bad condition. Some of the rivers became straight, concrete lined, polluted canals. From a physical, chemical and biological point of view the water quality was insufficient.

To improve the situation an initiative was developed under the motto "Active – Beautiful – Clean": a Master Plan to transform the rivers and canals step by step into blue-green arteries, to create a valuable asset in the urban fabric and the surrounding rural landscape to achieve a vibrant sustainable climate-proof liveable city. The main initiator was Mr Khoo Teng Chye, executive director of Centre for Liveable Cities (CLC). An impressive example was the transformation of a kilometres long section of the Kallang River (Figure 26).

The polluted concrete canal section was completely changed into a meandering river, bordered by green parks on each side with an upward slope towards the apartment buildings. In this way Bishan Ang Mo Kio Park came into being. In the realisation of this park Herbert Dreiseitl played an important role. The park with its river proves to be an excellent habitat for flora and fauna. In times of heavy rainfall there is room for the river to flow outward into the park on both sides. After the rainfall the river will retreat in due time in its riverbed. Furthermore the park provides for infiltration of water; introduction of green roofs give added possibilities for rain infiltration. Visual and audible warning systems are present to warn parents and children during times of heavy rainfall not to come too close to the river.

Altogether the introduction of the Bishan Ang Mo Kio Park considerably improved the liveability of this part of Singapore. Wider stretches of the Singapore and Kallang River, closer to the sea, including Marina Bay and Kallang Basin are ideally suited for the transport of persons and goods and special events like floating flower shows, dragon boat races, regatta of heritage ships, river cruises, with all the adequate facilities on the waterfronts. All the introduced physical adaptations and the necessary organisation measures form together Aquapuncture and can be further applied to the other rivers and water reservoirs with their waterfronts.

Mexico City: Back to the Future

Mexico City is one of the largest cities in the world with a population of around 9 million on a surface of 1,485 km2. The greater metropolitan area has well over 20 million inhabitants. It is situated on a plateau with an average height of 2,250 m, surrounded by volcanoes. Mexico City was once a city in the middle of a lake, connected by dams to the lakeshores where satellite towns were located.

The original lake largely dried up because of water extraction and a gradual process of town expansion, causing Mexico City gradually to sink into a basin. A remarkable remnant is Lake Xochimilco, with its canals with a total length of 170 km and its 5000 artificial rectangular agricultural plots. These so called chinampas were originally rafts, constructed of juniper branches, covered with lakebed mud and anchored with salix trees. Today, as in the past, a large number of small, non-motorised boats float on the water of the canals, almost exclusively used for tourism.

Apart from Lake Xochimilco, Mexico City had a much stronger relationship with water. It is fascinating to note that nowadays action is taken to restore this historic relationship, be it to a limited extent. As far as possible dilapidated industrial sites are being converted into lakes and waterways with parks, recreational and other facilities, complete with cultural-historical elements.

Tenochtitlan as predecessor of Mexico City used to be the capital of the Aztecs. The city found its origin on an island in a large lake, connected to the lakeshores by a series of

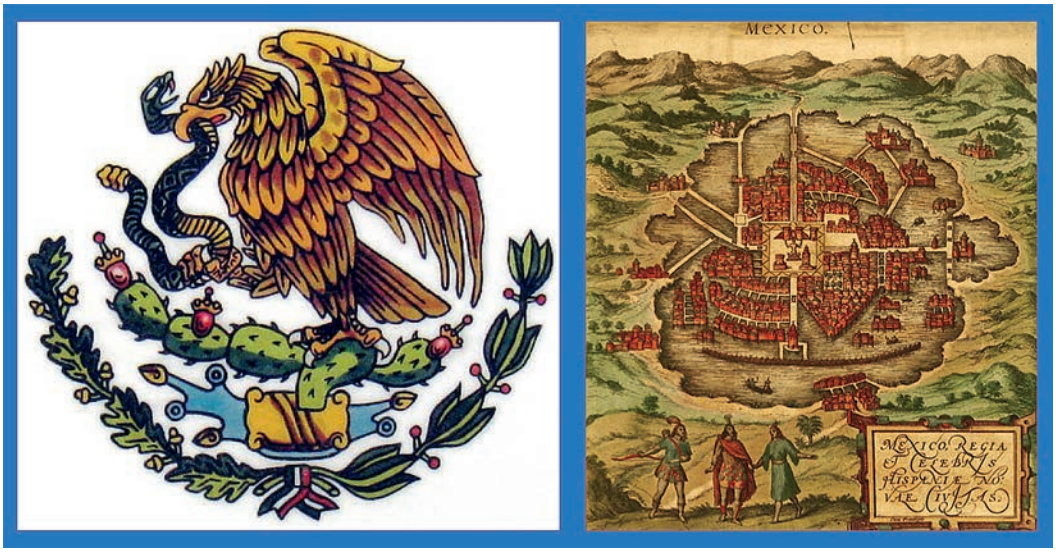


Figure 27. From Tenochtitlan to Mexico City on the Mexican coat of arms: Tenochtitlan, the predecessor of Mexico City, was founded on an island situated in a large lake, most of which has disappeared and is now being restored. This coat of arms is found in the centre of the Mexican flag.

dams with satellite settlements along the shores. The myth tells us that Tenochtitlan was founded on this island after siting of an eagle perched on a cactus with a snake in its beak. As coat of arms, this symbol can be found on the central white band of the Mexican green-white-red flag (Figure 27). The historical map of Mexico City shows its original location in that lake which for 80% has disappeared. Aquapuncture is being used to protect and upgrade Lake Xochimilco as a World Heritage Site and to create more lakes with attractive waterfronts for the benefit of Mexico City.

Colombia: Revitalisation Rio Medellín

Worldwide 80% of the largest cities are situated in a coast or delta position. Therefore, 20% has an inland situation, of which the majority has a relation with water (river and/or canal). A remarkable example within the last category is Colombia, since the three largest cities Bogotà, Medellín and Cali are all situated inland with a river flowing through the city: Rio Bogotà, Rio Medellín and Rio Cauca with their tributaries.

Take for example Medellín with its river. Medellín is the capital of the province Antioquia and the second-largest urban agglomeration in Colombia in terms of population and economy, with more than 3.5 million people. Its river was once used for transport of persons, materials and manufactured goods. In due time its transport function was taken over by the faster road and railroad system. The river became an open sewer and became heavily polluted. The relation between the city and the river was neglected and the necessity arose to clean up the river. Aquapuncture has become an ideal instrument to revitalise the relation between the river, the waterfronts and the city. This means adaptation of the river for the earlier defined six potential user groups in order to achieve a liveable city.

ORIGIN AND DEVELOPMENT OF THE AQUAPUNCTURE CONCEPT

The concept of Aquapuncture was initiated by Jaap Brouwer and further developed in close cooperation with Ronald E. Waterman. It found its first expression in the city of Delft within the Dutch Association Region Water (Vereniging Regio Water) of which Waterman was one of the founders.

Many cities, linked by the waterway system, became members of the association for the promotion of the usage, adaption and management of their mutual waterway system. They became members, because each of them realised that they all would benefit from this association.

In a later stage a coalition was formed with the Dutch Stichting Recreatietoervaart Nederland (SRN, nowadays Waterrecreatie Nederland) in order to take part in the European Programme Waterways Forward. Organisations from 13 countries came together for the promotion of their waterway systems.

CONCLUSION

AQUAPUNCTURE© for the optimal use, adaptation and management of inland waterways and their waterfronts, has been proven to be a successful instrument for stimulating the Blue Green Economy for regional, socio-economic and spatial development, whilst safeguarding navigability, environmental values and nature as well as safety. Adaptation of the inland waterways through Aquapuncture will continue to play a significant role in the total concept for achieving a smaller global footprint. Master classes Aquapuncture have been given in Dublin, Paris and Brussels and other presentations have been made worldwide. A post academic course in cooperation with the Delft University of Technology in the Netherlands is planned as well.

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