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Water Civilization: The Evolution of the Dutch Drinking Water Sector

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Dutch drinking water companies now deliver safe affordable water to the entire population, but this result was not planned. It emerged, rather, from an evolutionary process in which various pressures on the commons resulted in changes to drinking water systems that addressed old concerns but uncovered new problems. Our analytical narrative traces this problem-solution-new problem pattern through four eras in which a common-pool dilemma is addressed by a private-good solution (1850–1880), a club-good solution (1880–1910) and a public-good solution (1910–1950) before returning to a private-good solution in the last 1950–1990 era. Actions, like the dates just given, were not always exact or effective, as the process was shaped by changing social norms regarding the distribution of costs and benefits from improved water services. This Dutch history is unique, but its insights can help improve drinking water services elsewhere.

Keywords: Drinking water; common-pool goods; institutions; public health.

JEL Classification: H42, H75, I31, L33, L95, Q53, Q56

1. Introduction

This paper traces the evolution of the Dutch drinking water sector from 1850 to 1990, a period that began with barely any organized service (let alone standards of good service) and ended with affordable, efficient and good-quality services accessible to the entire population. Although improvements can be attributed to

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better technologies, rising wealth, and scientific discoveries, we argue that changing social priorities played a major role. These priorities matter because the costs and benefits of drinking water services are shared unevenly throughout the community. These mismatches can be simple (two families paying the same fixed fee for different quantities of water) or complex (a sick individual infecting everyone around them), but their existence means that water should be managed not as a private good subject to market forces of supply and demand but as a non-excludable good subject to social priorities, political decisions, and multiple interdependencies. This common-pool characteristic plays a central role in our analytical framework in terms of understanding how the Dutch drinking water sector evolved through four distinct but overlapping “eras” in which the distribution of costs and benefits from universal water services evolved.

But how did we get here, and what question are we trying to answer? We began with the goal of understanding how the Dutch introduced and used water meters as a follow-on project to Zetland (2016), which examined the implementation of water meters after 1989 in England and Wales. In that paper, meters are seen as a means of reducing water consumption (and thus environmental stress) and allocating system costs based on use rather than (outdated) property values. When we turned to the Netherlands, our goal was to understand why and how a country with “too much water” implemented universal metering. Our plan was quickly derailed when we learned, first, that The Hague introduced meters in 1888 to prevent its naturally filtered dune-water supplies from being depleted, and, second, that proponents of “water civilization” opposed metering because it would price water use and thus inhibit water consumption and quality of life — an argument also discussed in the England and Wales paper. Those facts led to our present research question, i.e., how did the Dutch bring clean water to everyone given the high cost of building drinking water systems?

1.1. Objectives and approach

To answer this question, we knew that we would need to explore the tension between water civilization (treating water as a public good) and charging users for system costs (treating water as a private good). In our experience, these tradeoffs are best explored within an analytical framework that allows one to integrate the subsidies and shared benefits of public goods with the values and externalities of private goods, i.e., a common-pooled-good framework in which benefits and costs are shared (Ostrom *et al.* 1994).

Turning to the question of time, we also knew (from the action/reaction in The Hague) that the sector’s development would reflect changing priorities rather than

following a continuous path towards a clear goal (Ostrom 1965; Ostrom *et al.* 2003; Brouwer 2013). After researching those priorities (the analysis of which makes up the bulk of this paper), we identified four eras in which one priority dominated the policies and actions affecting the commons before giving way to a new priority.

According to our (oversimplified) model, pressure for change emerges when a critical mass of citizens decides that benefits and costs from existing services are unevenly or unfairly distributed among groups. The resulting reforms of the new era address that imbalance but then reveal the next worst imbalance. This pattern fits easily into the theory of decreasing marginal returns (and increasing marginal costs) from service improvements, but it also matches the psychology of rising expectations. That said, let us note that changing priorities were predominantly about the *means* of improving water services more than the *ends* of having adequate, affordable clean water — a goal towards which the Dutch made steady advances.

We use an analytical narrative to describe how pressures and responses developed and interacted (Bates *et al.* 2000). In each era, the response to the emergent common-pooled problem involved managing water as a different type of good (club good, private good, etc.). In each era, the new management priority lasts until a new common-pooled challenge emerges and the pressure to address it results in rebalanced priorities. Although we use exact dates, these eras were not necessarily planned or even clear to people at the time. Trends and eras, like most human institutions, have blurry boundaries and long tails based on adoption, adaption, diffusion and confusion. We therefore want readers to see how multiple influences, rather than an agreed master plan, produced an emergent order.

With this structure in mind, we can give a quick overview of our eras. The first era begins in 1850 with concerns over polluted, common-pooled water supplies, which encourages companies to provide water as a private good. The second era begins in 1880 when concerns over affordability and infectious diseases leads municipalities to subsidize and regulate water services as a club good. Developments in technology and improved health outcomes during that second era result in pressure to expand services to citizens outside cities, marking the beginning of third era in 1910 in which information, finance and regulation promote water service as a public good. Although access expands during that era, heavy national spending draws criticism, which leads to the start of a fourth era around 1950 in which incentives and accounting put more responsibility for spending and use on drinking water companies (DWCs) and households respectively. This private-good treatment of costs and water brings us back to 1850 in terms of private-good

solutions but not to that era's failures in the commons. By 1990, even the poorest Dutch could afford adequate clean water. With this overview in mind, let us turn to the evolutionary model.

2. Methods: Measures, Theory and Evolutionary Dynamics

With our previous work on the tension between efficiency (avoiding over-consumption) and public health (avoiding under-consumption) in England and Wales and work on the mismatched costs and benefits from desalination plants (Zetland 2017), we quickly recognized the tradeoffs between metered water and water civilization. Our observation of diverging opinions gradually merging into consensus made it easy for us to think in terms of eras and transition phases during which controversial tradeoffs became acceptable. Our analysis through the lens of common-pooled water, public health, and/or money helped us identify eras based on the commons and identify transitions based on changing priorities regarding different dimensions of the commons (Ostrom *et al.* 2003). Our use of analytic narrative does not rely on deductive, ex-ante theory but on an inductive desire to discover reasonable explanations for various events and actions affecting Dutch drinking water services. The following sections explain how we measure the importance and impact of clean drinking water as well as explaining how we use theories of supply, demand, common-pooled goods and institutional evolution in support of our analysis.

2.1. An overview of the model and its application

A brief summary of these theoretical elements and demonstration of how they interact across our four eras will help the reader keep the big picture in mind while exploring details in the sections that follow. Our theory begins by specifying an objective, or benefit, that is valued sufficiently to justify devoting effort and expense towards its achievement. We use the reduction in infant mortality as an objective because it is an easily measured proxy for the many benefits of clean water. Although it would be better to link clean water directly to utility or other proxies (employment, nutrition, life expectancy, and so on), we lack comprehensive data for the period of study so we settled on that reduced-form proxy.

With this objective in mind, we can add basic elements of supply and demand. On the supply side, we focus on expenditure as a direct determinant of quantity supplied and technology and knowledge as indirect factors shifting the supply curve outward (thereby lowering the cost of supplying a given quantity or quality

of clean drinking water). These shift factors are important because our model evolves over decades. Demand, likewise, has elements that interact and change over time. Holding tastes and technology constant, quantity demanded depends on the price of substitute water sources. Our narrative begins with richer people paying more for imported, cleaner water while poorer people pay little or nothing for local, dirty “regular” water. That separating equilibrium changes over time as knowledge about water quality, rising wealth and changing expectations shift the demand curve out.

With supply and demand for (clean) drinking water now defined, we can discuss private and club goods (subject to supply and demand) and common-pooled and public goods such as subsidies, regulation, knowledge, open-access water sources, and so on. The under/over-provision of these non-excludable goods drives our narrative by shifting the supply and demand curves for clean drinking water and thus equilibrium outcomes affecting the objective (lower infant mortality and all its correlates). Our last element influencing outcomes (changing institutions) is sometimes overlooked, but not in our case. We have abundant evidence of changes in rules and norms leading to actions that altered the nature and impact of non-excludable goods and thus supply and demand. We will give a quick overview of how these elements interact at the end of this section.

2.2. Measures of progress

Figure 1 shows the decline in infant mortality (dying sometime between birth and one year of age) and decline in the overall death rate between 1840 and 2000. Those declines resulted from many factors — higher incomes, better nutrition, and improved healthcare among them — but there is no denying the importance of more, cleaner water (Cutler *et al.* 2006). The literature on 19th-century public health acknowledges that cleaner water and (later) sanitary systems reduced infectious diseases (cholera, typhoid) spread by fecal contamination of drinking water sources and/or poor hygiene (typhus) resulting from infrequent bathing (McKeown and Record 1962; Condran *et al.* 1984; Cutler and Miller 2005).

Infant mortality is a particularly good indicator of clean water because children are more vulnerable to infectious diseases and less likely to die in accidents, violence and so on, but other factors mattered (Prüss-Üstün *et al.* 2008). The Dutch worked hard to increase the rate of breast feeding and reduce conditions hospitable to malaria (mostly complete by the 1870s) before turning to more complex factors such as cultural habits and maternal health (Wintle 2000; Van Poppel *et al.* 2012). Other well-known factors affecting infant mortality, such as hospital delivery and

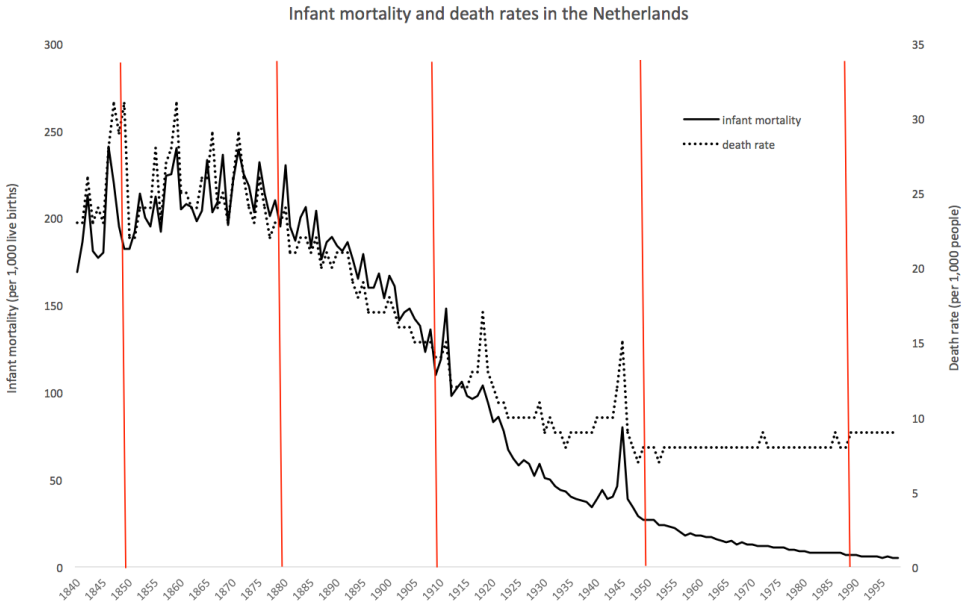


Figure 1. (Color online) Rates of infant mortality (left axis, solid line) and death (right axis, dotted line) declined from 1850 to the present. For infant mortality, the average annual decline (based on the average of 5 years of observations before and after each end-point) was 0.67 percent per year between 1850 and 1910, 2.23 percent per year between 1910 and 1939, and 1.84 percent per year between 1950 and 1990

Source: van der Bie and Smits (2001, pp. 14–16).

inoculation/vaccination, only became important after World War II (Ward 2003; van Wijhe *et al.* 2016).

It is appropriate to note that these aggregate data hide variations (some good, some bad) associated with local customs, natural environments, and differences between rural and urban life. The southern Dutch province of Zeeland, for example, was (in)famous for its poverty, soggy ground, brackish local water, and a long-standing aversion to breast feeding (Van Poppel *et al.* 2012). Those influences are worth discussing in detailed case studies, but our focus on national, long-term trends means we ignore most local factors.

2.3. Supply of drinking water

Modern drinking water services collect water from different sources, treat it to drinking quality, and distribute it through a pressurized system of large trunk pipes that feed into smaller distribution pipes that connect directly to users. Customers like these systems because they can consume clean water as easily as opening their

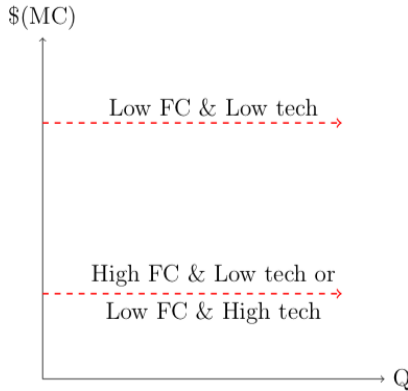


Figure 2. (Color online) Higher fixed costs or better technology results in lower marginal costs

taps, but their high ratio of fixed to variable costs (usually 4:1) means that drinking water systems require massive investments of cash and effort before users can drink, let alone pay for, a single drop of water (Hanemann 2005).

Those high fixed costs explain why earlier drinking water systems (and many systems in developing countries today) were less convenient and safe, as consumers were often too poor to guarantee or repay fixed costs. High fixed costs (and low marginal costs) also help explain how the poor (then and now) choose their water source. In the best of circumstances, they could pay a small marginal cost (in time) to collect clean water from natural sources whose existence resulted from millions of years of “natural capital” investment (Costanza *et al.* 1997). Those less lucky would incur higher costs because they would need to haul clean water further or treat regular water for drinking.

Turning to human-constructed systems, fixed cost investments were sometimes massive (e.g., Roman aqueducts) but often humble, i.e., wells, barges or pipes that would provide water at a reasonable cost of time and/or money. Those systems were common in European cities before the Industrial Revolution, and they are still common in many poorer parts of the world.

Figure 2 shows this stylized relationship, i.e., how high (low) fixed costs lead to low (high) marginal costs, holding technology constant. Improvements in technology, as we shall see in this paper, made it easier to provide cheaper water by lowering the fixed cost of supply components that previously cost much more.

2.4. Demand for drinking water

Everyone values adequate quantities of affordable clean drinking water, but not everyone agrees on the definition of clean or has the money to pay for it. Those two

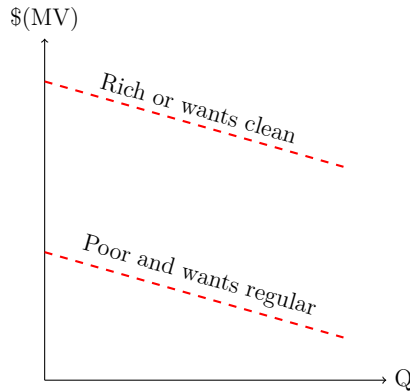


Figure 3. (Color online) Demand (value) for clean water is higher for people who know that clean water is safer and for people rich enough to buy good quality services. The uneducated and poor do not value clean water, so they consume regular water.

facts explain how the value of clean water (and thus the demand curve) is higher for people who understand the importance of clean water to health and for people who are rich enough to pay for a higher quality supply; see Fig. 3. People ignorant of the cost of dirty water and too poor to pay for quality supply will have a lower value of water, and thus a lower demand curve.

At the beginning of the 19th century, demand for water mostly depended on personal income and individual taste, but a series of discoveries (discussed in Section 4.1) linked certain diseases to germs that were spread through contaminated drinking water and inadequate hygiene. These discoveries tended to raise individual willingness to pay for clean drinking water (shifting demand up and out), but they also created a “social demand” for cleaner water. At the beginning of the 19th century, the plight of the poor was seen as their private misery occasionally shared by sympathetic outsiders. By 1880, it was clear that their misery and sickness affected not just neighbors but entire cities. This realization drove even hard-nosed misanthropes into alliance with the public health advocates and humanists who had fought for decades to bring clean water to the urban poor. Those changes in attitudes and values led to actions that occupy the bulk of this paper’s narrative. The next section will explain how those actions responded to changing definitions of the commons and community institutions.

2.5. Drinking water and the commons

Although it is possible to provide clean drinking water as a private good (e.g., bottled water), it is difficult to ignore the positive externalities from reliable drinking water services or the negative externalities resulting from their absence.

	Excludable	Non-excludable
Rival	Private good	Common-pool good
Non-rival	Club good	Public good

Figure 4. Goods are defined by their properties of (non-)rivalry and (non-)excludability. Derived from [Cornes and Sandler \(1986\)](#)

Those spillover effects into the commons often justify community or government involvement in the provision of drinking water. Figure 4 will help us think about these dynamics, as it sets out the four basic types of goods based on their exclusivity and rivalry.

The key idea in this paper is that drinking water services can be defined as any of these four goods, depending on circumstances. Water can be a private good (as discussed just above), a common-pool good (if scarcity is increasing rivalry and shortage), a club good (if distributed in a network with adequate demand and cost controls), or a public good (subsidized to the point where everyone can consume without fear or limit). The financing of the water system can, likewise, be defined using this scheme, as water is private when metered customers pay tariffs, a club good when funded by local taxes, or a public good when national transfers cover costs ([Winpenny 2003](#)). The right mix of financing sources depends on individual capabilities (tariffs), local prosperity (taxes), and national priorities (transfers).

Capabilities, prosperities and priorities changed throughout the period discussed in this paper, but we can rely on a few trends. The first is that cumulative experience and investment ease further expansion of drinking water supplies. We can thus see how initial investments by DWCs selling water as a private good might make it easier for other DWCs to think about providing water as a club good and perhaps even a public good. This progress will not be automatic, as the steps to non-rivalry and then non-exclusion bring, respectively, greater subsidies and political complexities ([Hanemann 2005](#)). Financial worries can be reduced by replacing transfers with tariffs, but that shift is only feasible when customers have adequate income. Figure 5 shows how only the rich can afford water supplied with

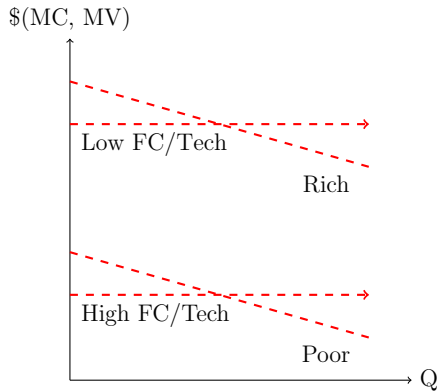


Figure 5. (Color online) The poor can only afford water when networks have high fixed costs investment or better technology

low technology or low fixed costs as well as how improved technology or higher fixed cost investments can lower prices to the point where the poor can also afford to pay. Our story will start and end with this figure, as the situation in 1850 looked like the equilibrium for the rich, while the situation in 1990 — due to cumulative investments and technological progress — allowed the poor (and everyone else) to consume adequate quantities of clean water.

2.6. Changing institutions

Institutions generically refer to formal rules and informal norms. In the water sector, they can refer to technological capabilities, professional practices, customer habits, and so on. In the Netherlands, institutions aid cooperation in the management of the commons. The Dutch “polder” model of collaboration is named after the polders formed when communities cooperated to build dikes that would allow land to be reclaimed from open water and/or protected from flooding. Nowadays, the Dutch say they are “poldering” when they are engaged in multi-faceted, multi-party negotiations on how to share private costs in the course of creating social gains (Randerad and Wolfram 2001; Geels 2006; Brouwer 2013). It is therefore easy to see the value of the polder model to water management, whose challenges are well-known:

The omnipresence of fixed costs and surface water supply creates a classic economic problem of cost allocation which has no satisfactory technical solution. The extraordinary capital intensity and longevity of surface water supply infrastructure, and a

predominance of economies of scale, create a need for collective action in the provision and financing of water supply that simply does not arise with most other commodities

— (Hanemann 2005, p. 87).

Hanemann cites Olson (1965) in explaining the difficulty of agreeing on voluntary collective action to overcome selfish individual choices. The Dutch were aware of those challenges, but it still took them decades to agree on who would pay for improvements in drinking water supply, aided or stymied, respectively, by the presence or lack of social norms, collective identity, and acknowledged interdependence.

How did change occur? Stachowiak (2009) describes “six theories about how policy change happens” in an attempt to impose frameworks on processes that are — by their nature — oversimplified yet complex, directed yet diverted, planned yet interrupted by external forces (Hayek 1945; Scott 1998). With that caveat in mind, we can use her brief to pick a few relevant theories of change, i.e., “policy window theory” and “prospect theory.”

Policy window theory identifies three streams in the policy process, i.e., problems with social conditions, policies aimed at those problems, and the national mood that collects attention in support of those policies. In this paper, these three streams often converge on the role and importance of drinking water services.

Turning to prospect theory (originating in Kahneman *et al.* (1990) and subsequent work), framing of an issue, options for addressing it, and inconsistent decisions all interact in a process that seems chaotic but eventually moves towards an objectionably worthy goal. In this paper, prospect theory explains how growing scientific knowledge and technical skills could deliver a water quality solution based on the framed need to protect or support the commons associated with public health and poorer citizens, respectively.

Stachowiak (2009) sought to explain how change happens, but change is not automatic. Cockerill and Armstrong (2015) explore the “wicked” aspect to water management problems that result from complex causes, require collective action to address, and depend on cooperation among groups with different needs, opinions and capabilities. These factors explain the lack of clear direction at the beginning of our narrative, when variations in laws and technologies and differing opinions on the need for action and role of different actors meant that disagreement dominated consensus. Luckily for the Dutch, those counter-productive elements receded as prosperity reduced policy-window-theory-related constraints and experience reduced the prospect-theory-related uncertainty over the costs and benefits of various actions (Brouwer 2013).

The Dutch built environment also plays an important role in our narrative. The Netherlands was one of the world's most urbanized countries in the 17th century. In 1675, over 40% of the population lived in settlements of 2,500 or more (a share that persisted until 1850), but the division between larger and smaller urbanizations changed as the population share of cities of 20,000 or more declined from about 21% in 1750 to as low as 17% in 1815 before rising back to 21% in 1840 and growing steadily thereafter (de Vries 1985). The growth of larger cities was driven by the Industrial Revolution, expanding railway networks, and regional integration that pulled economic power from smaller towns (2,500 or so) and eventually rural areas (de Vries 1985; Kooij 1988). This urbanization trend strengthened in the twentieth century. Between 1889 and 1971, larger cities grew by an average of 2.4% per year while national population grew by 0.8% (de Groot *et al.* 2011). Rising urban populations increased demand for improved drinking water systems, but their economic output provided the means to pay for them. By similar logic, falling relative population in smaller towns and rural areas meant their inhabitants (who were also poorer) would find it more difficult to pay for their own drinking water systems (de Groot *et al.* 2011). These trends matter for two reasons. First, the reality and perception of a water quality gap can further exacerbate the separation between wealthier areas (often cities) and poorer areas. Second, the presence of a gap creates social and political pressure to help under-provisioned regions. The strength of this pressure — and effectiveness of any response it triggers — depends on how the clean water deficit is perceived. The next section will explain how those perceptions changed over the four eras of our analysis.

2.7. A brief summary of how the model evolves

In the sections above, we explained how supply and demand for clean water as a private good could be influenced by perceptions and impacts of clean water on the commons of public health, government finances, and so on. In this section, we will use this model framework to build a foundation on which the details of the four main eras can be imposed, organized and understood.

Our workhorse structure for describing a situation and its (in)stability is Fig. 4, which shows how rivalry and excludability (or their absence) interact to define four types of goods. We use this structure throughout the paper to investigate how clean water's nature as a good changes under various pressures and how those changes, in turn, make it easier to predict what response or problem might come next. Figure 6 summarizes the moves that define our eras, which we will briefly describe here.

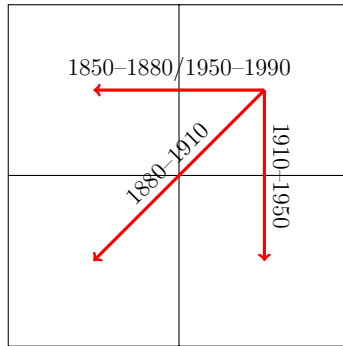


Figure 6. (Color online) Our four eras can also be defined in terms of how the responses to pressures on the commons turned clean drinking water into other types of good

Our story begins before 1850, when surface and shallow groundwaters were clean enough for most Dutch to collect their drinking water from local sources. Our first era begins as that situation is threatened by pollution that changed the nature of local waters from public good (adequate clean water) to common-pooled good (scarce clean water) in congested cities. Residents faced with dirty water could continue drinking it (suffering the consequences), but others secured “private” water through their own means (e.g., rainwater cisterns) or by purchasing water from enterprises founded to supply quality. Figure 6 indicates this move in the 1850–1880 era with the arrow going from common-pooled good (top right) to private good (top left).

Most regions in the world have experienced this transition from clean to polluted communal water sources. Pollution can come from industrial, agricultural or residential sources, but the resulting choice is always the same: drink polluted water or find a protected (private-good) source. Private-good sources can be provided via bottles, personal filters, or private companies delivering cleaner water to paying customers. The mix of solutions depends on willingness to pay, technology and business models, but they are also small scale and ineffective in protecting public health.

Concerns over the commons of public health led to the next era (1880–1910) in which clean water services were offered to urban citizens at subsidized prices as a means of protecting cities from cholera and other water-borne diseases. In this era, urban water services are offered as a club good to all residents (i.e., without rivalry regarding supply or payment) as a means of promoting public health, water civilization and general prosperity. This era had many debates over subsidies and effectiveness, but the technology made it cheaper to provide water and research supported the value of clean drinking water to the community.

That value led to a further push to provide clean water to citizens outside wealthier cities and a willingness to spend heavily on subsidized services. The 1910–1950 era brought clean water to smaller and smaller towns. This move ignored the common-pooled (rival) aspect of budgetary limits in favor of providing water as a public good, as shown by the arrow in Fig. 6. (That choice led to a push for accountability after 1950, as explained below.)

These two eras (or steps in the provision of water services) have also occurred elsewhere. Most higher income countries have clean urban water supplies, but this club good is not provided to urban slums in many poorer countries. The second step (to nationwide clean water provision) is less common, for good and bad reasons. In some countries, remote or rural water supplies are clean enough for small-scale or self provision. In other countries, the step is necessary (water is polluted) but not taken because rural people are too poor, politically irrelevant or ignorant of their danger (e.g., Bangladesh before arsenic poisoning was uncovered). In the Dutch case, the move to provide clean urban water was driven by a fear of widespread cholera while the move to provide water across the nation was driven by falling costs on the supply side and rising expectations from citizens newly allowed to vote.

The final stage — moving from common-pool to private good in the 1950–1990 era — is relatively easy to understand as the result of a drive to align incentives for consumers and water utilities (“privatizing the commons”) in a time when the government was still spending a lot of money (especially in the post-war rebuilding period), but citizens were better able to pay for good water services. This private-good treatment was less controversial than it was in 1850–1880 because improvements in the sector’s institutions, cost-structure and governance improved the benefit-cost ratio for spending at the national, utility and household level (Brouwer 2013). These same factors mean that it is often possible to have good quality water service in most countries in the 21st century. Why does reality fall short of possibility? In some countries, it is difficult to convince voters and users that they should pay the full cost of services (Zetland and Gasson 2012). In others, politicians and managers pursue short-term goals by under-pricing water or under-investing in reliability, respectively (Zetland 2017).

These examples should clarify the basic model we are using to explain the evolution of the Dutch drinking water sector.

The next five sections will test, dispute and support this model by testing theories of supply and demand, goods and institutions against historic facts, perspectives and decisions. The narrative begins with emerging concerns regarding the impact of dirty water on the public health commons and moves through four eras of conflicting priorities over different commons of water, health, money,

voting and land value. History moves in a straight line, but institutions evolve in response to the (sometimes conflicting) influences of changing technology, morality information, and community identity. Our analytical narrative might clarify how the Dutch struggled (and succeeded) in providing adequate, affordable clean drinking water to all, but it will not answer every question nor fit every event.

3. Increasing Pressure on the Commons (Pre-1850)

Most Dutch settlements were founded near dunes or rivers to gain access to cleaner water via small-scale methods that worked well for at least a thousand years. Amsterdam's fresh water access was much worse, but the city grew with the success of its port and trading activities. The first known instance of selling water in the Netherlands dates from 1480 when Amsterdam's beer brewers stopped using water from local canals and began importing cleaner water from the nearby Haarlemmermeer (Haarlem lake), which they sold alongside beer. In 1786, the Fresh Water Society began importing water to Amsterdam on ships to sell for profit. Its fleet grew to 44 large and 246 smaller ships within a decade (Groen Jr. 1978).

Those who could not afford to buy imported water made do with dirtier local supplies, but increasing urban population and rising discharges of pollution reduced the quality of those common-pool waters, leading to conditions that "would remind the hygienist of today [1949] of the Middle Ages" (van Marle 1949, p. 6). In rural areas, groundwater also became saline as irrigation imported salts from rivers and/or increased salt-water intrusion.

These problems (turning clean public-good water into common-pooled dirty water) invited small-scale private-good solutions. In low-lying cities, people collected rain water in cisterns because groundwater was often dirty. In cities at higher elevations, people drew groundwater from private or shared wells following rules that rationed water and maintained the well. Access to a well in Arnhem, for example, was limited to those who paid a subscription (Wijmer 1992).

The wealthy could afford to pay for cisterns, wells or water deliveries, but other citizens could not. The gradual and then accelerating decline of water quality in congested areas converted public-good, clean water into common-pool, polluted water. This situation attracted entrepreneurs hoping to sell water as a private good. It also caught the attention of public health advocates who pushed for government interventions to provide clean water as a public good.

Amsterdam's troubles previewed the future of other Dutch cities, but its challenges were familiar in other European cities. According to Goldsmith and Carter (2016), London's private companies started competing to deliver water in

1582. Many companies went bankrupt because they could not recover their fixed costs, but their assets helped other firms succeed. Others survived with additional cash from investors, protection from aristocratic supporters, the financial security of 500-year leases on water sources and infrastructure, and the eager participation of investors flush with profits from privateering or colonial exploitation. Surviving firms often took decades to repay debts but paid generous dividends thereafter.

London's private companies provided water of varying quality and reliability, but they charged one-third less than porters bringing water from the Thames. Their competitive advantage grew over time as the Thames got dirtier and their real price of service fell (the nominal service price of one pound per year did not change between 1582 and 1852). Steady revenue on the supply side and increasing affordability on the demand side led to an increase in quantities delivered over time, even if the quality of service did not improve by much. In 1810, a "water war" broke out as newcomers fought for market share. They introduced filtering and settling systems to improve water quality and delivered continuous pressurized supply through cast-iron pipes. The wars were good for customers accustomed to receiving river water through wooden pipes a few times per week, but expensive for companies. The end of the wars in 1817 resulted in price increases, but higher profits did not last.

We will return to this story in a few pages, as it parallels events in the Netherlands, but first we need to catch up with Amsterdam, where deteriorating water quality was creating a market opportunity to sell water as a private good.

4. Avoiding Pollution via Private Goods (1850–1880)

After nearly 200 years of ebb and flow, Amsterdam's population started to increase around 1830. In 1860, it set an historic high that kept rising, from 220,000 in 1850 to 520,000 in 1900. Unprecedented urbanization increased population density and the problems associated with crowding across the country. In 1848 and 1849, 22,460 urban Dutch died from cholera outbreaks. Not everyone agreed on the cause of cholera outbreaks — some blamed "miasmas" (polluted air), others filthy living conditions — but wealthier people gave more attention to their hygiene and water quality (Houwaart 1991). Their demand for clean water attracted entrepreneurs who thought they could beat the Fresh Water Society's water-by-boat model with pipes that could deliver continuous supply. The lawyer Jacob van Lennep and engineer C.D. Vaillant founded the first Drinking Water Company (DWC) in the Netherlands. The Dune Water Company (*De Duinwater Maatschappij*) relied on British investors and engineers to build a 23 km pipe to

bring dune-filtered water from Bloemendaal to Amsterdam (Groen Jr. 1978; Wijmer 1992).

On Friday, 9 December 1853, the mayor and aldermen of Amsterdam granted the Dune Water Company a permit to start operating on the condition that they would charge half the price of the Fresh Water Society, or one cent per bucket (probably 10 l) — the equivalent of €10/m³ in 2017 (Wijmer 1992). They sold 4,450 buckets on Monday, 12 December. By Friday, their sales had increased to 10,575 buckets per day (Groen Jr. 1978). By 1856, Amsterdammers could buy water from 56 Dune Water Company taps. By 1860 it became clear that ships could not compete with pipes, and the last water-ship sailed in 1870 (Wijmer 1992; Geels 2005). In 1856, a second private DWC started in Den Helder, where ships departing to the Dutch Indies (Indonesia) took on food and water before departing on their long voyages (Bijl 1924; Geels 2005).

These early ventures took advantage of the sand dunes as natural filters for removing solids and killing bacteria and viruses. Figure 7 shows the importance of “dune water” over the past 150 years. Dutch DWCs currently get roughly 70% and

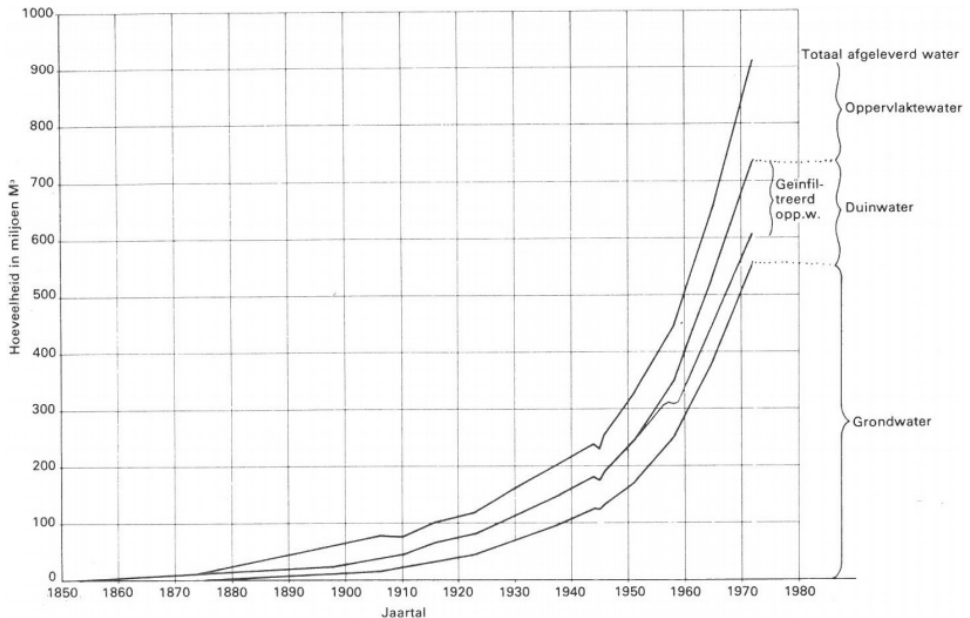


Figure 7. Water sources were primarily from groundwater, with the remaining supply coming equally from dune water (later supplemented by “infiltrated” surface water) and surface water
Source: Leeflang (1974).

30% of their supply from dune/ground- and surface sources, respectively (VEWIN 2015).

4.1. Demands to protect public health

The piped water business was successful at solving the problem of dirty water in the commons for those who could afford to buy private water, but those who were excluded still got sick. The lack of clear knowledge (or understanding) on the germ theory of disease made it difficult for people to agree on the role or value of clean water. The upper classes distanced themselves from the dirtier, poorer classes by embracing water civilisation, and their pursuit of personal hygiene created markets for clean water and private baths (Geels 2005). The working classes, for their part, saw purchased water as an extravagance in comparison to the free, but dirty, water they took from canals (Schuursma 1949; Wijmer 1992). The upper classes supported public interventions to help the poor, reasoning that “water civilization” would make up for their “deficiencies in character and behavior” (Geels 2005, p. 384). The middle classes mimicked upper class attitudes, supporting interventions and attending “housewife schools” where personal hygiene was synonymous with modern living (Geels 2005). Similar beliefs were held in London, where the upper classes assumed that high rates of sickness among the poor reflected filthy habits. In fact, much of the problem could be traced to the lack of water supply on the upper floors of buildings where the poor lived — a deficiency resulting from weak water pressure rather than an aversion to cleanliness (Cockerill and Armstrong 2015).

The cholera outbreaks of 1848–1849 in both Britain and the Netherlands led some people to seek cleaner water, but John Snow’s publications on the connection between fecal-contaminated water and cholera in 1849 and 1855 greatly increased public interest in public health and clean, communal water supplies (Klostermann 2003). Citizens supporting public health and clean drinking water for all — the so-called “hygienists” — published pamphlets on hygienic standards during epidemics and gave advice on lifestyles to the aristocratic and working classes (’t Hart 1990; Houwaart 1991; Wijmer 1992). Besides appealing to man’s better nature, they also argued that the public and private benefits of better drinking water systems would exceed the costs of subsidies. These ideas are only slowly entering global consciousness (see, e.g., Ciriacy-Wantrup (1961); UNICEF (2009)), so it is no surprise that many saw subsidies as wasteful (Geels 2006). In the meantime, advances in the scientific understanding of the germ theory of disease lent additional support to the hygienists’ claims. Pasteur proposed bacteria in 1862. Cohn and Koch made them visible in

1880, and Koch identified the bacteria linked to tuberculosis and cholera in 1883 (Houwaart 1991).

In 1866, 19,691 Dutch died in another cholera outbreak, and the Dutch government ordered an investigation into the relationship between drinking water and cholera ('t Hart 1990). In 1868, the Commission for Research on Drinking Water (*Commissie tot Onderzoek van Drinkwater*) published its *Report to the King*, which concluded that the hygienists were right, i.e., that cholera was spread by polluted drinking water (*Commissie tot Onderzoek van Drinkwater 1868*). Their report convinced politicians of the need for clean drinking water, but there was still no consensus on whether government should subsidize waterworks. Members of Parliament asked if the government planned to act on the findings (*Tweede Kamer 1869a*). The government replied that Article 135 of the 1851 Municipality Law delegated responsibility for public health to cities (*Tweede Kamer 1869b*). Some cities ignored this call to action while others embraced the conclusion that water's impact on public health meant that supply could not just be left to the market and the treatment of water as a private good. It was necessary to provide water as a club good to all urban residents.

5. Supporting Public Health via Club-Goods (1880–1910)

The push to distribute cleaner water to urban citizens was immediately slowed by concerns over the high fixed costs of building systems that would be able to deliver large volumes at low prices (recall the discussion in Section 2.3). Larger cities had two advantages in this regard, as they were able to build larger systems with greater economies of scale and then spread the costs of those systems among a larger population. Figure 8 shows the “strong correlation between the size of cities and the year that piped water was implemented” (Bijl 1924; Geels 2005, p. 380). This correlation was neither causal nor automatic, as most municipalities wanted to avoid going into debt to finance the construction of water supply systems. They avoided debt by granting concessions to private investors who would build and operate waterworks under government regulation (Putto 1949). With that temporal question out of the way, most cities sought a supply large enough to meet basic needs, i.e., networks providing water as a club good that would be paid for by a combination of tariffs on users (often paid by landlords) and local taxes on property owners.

Not every city could offer attractive terms. After failing to attract private investors, Rotterdam and The Hague decided to finance their systems with taxes, and their DWCs began operating in 1874 (Bijl 1924; Nordlohne 1963; van den Noort and Blauw 2000). In the case of Rotterdam, the decision to move ahead was

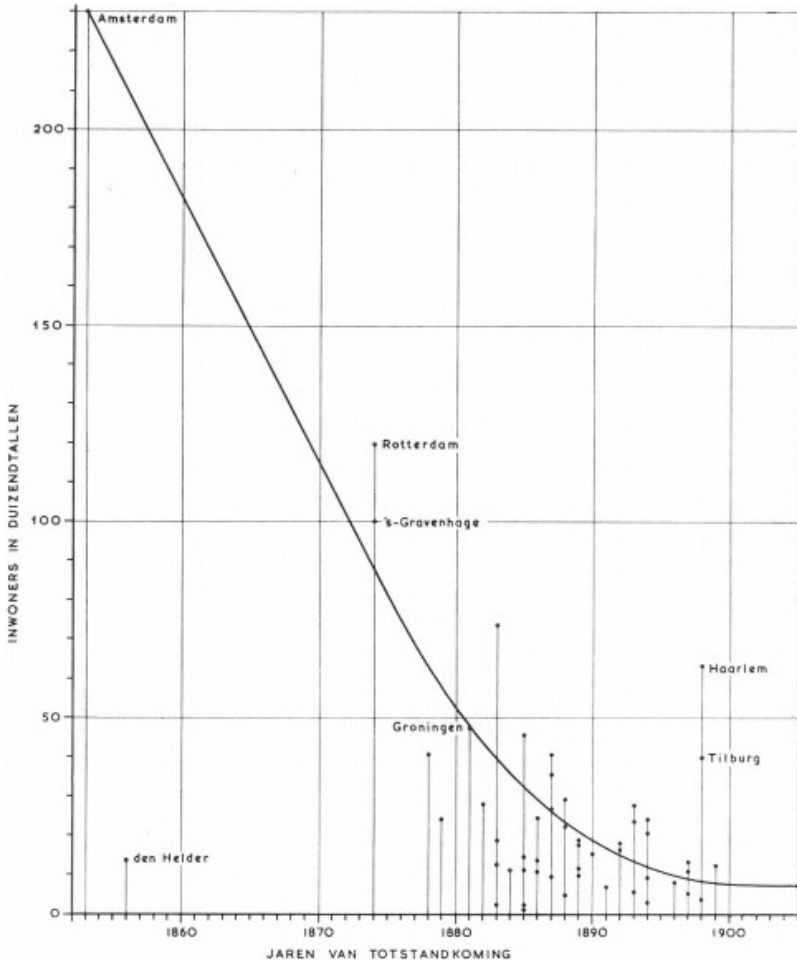


Figure 8. The negative correlation between population (vertical axis, in thousands) and establishment of a DWC

Source: Jäger (1963).

motivated more by the need to flush its trash- and excrement-clogged canals than a desire for clean drinking water — although the two were related (van den Noort and Blauw 2000). The Hague had “solved” its canal problem by filling and covering some of its canals, but an 1867 report advised the municipality that it should start importing clean drinking water from the dunes at Scheveningen (Bijl 1924). The resulting increase in water use and discharge forced the city to build more canals for flushing and drainage, but that system was operationally inadequate and politically unpopular with downstream neighbors, so the city opened the first Dutch sewerage system in 1893 (Geels 2006).

Private DWCs began operations in Leiden in 1878, Nijmegen in 1879, Groningen in 1881, Dordrecht in 1882, and Utrecht in 1883 (Günther 1934; Geels 2005). Municipalities helped stimulate demand for services to reduce the spread of contagious diseases and keep their cities attractive to the growing middle class (Wijmer 1992). Maastricht minimized the maintenance of public water pumps to increase demand for DWC water, while Breda spread oil in its canals to reduce consumption of canal water and reduce the risk of a cholera outbreak (Cillekens *et al.* 1988; Groeneveld 1994). By 1900, the Netherlands had 60 DWCs, most of which were private (Klostermann 2003; Blokland 1999). These efforts matched the trend in other industrialized cities (e.g., Paris, New York, London, Berlin) that were issuing regulations, subsidizing costs, and sometimes buying out private operators in an effort to expand services and improve quality (Geels 2005; Prasad 2007).

Increased municipal attention brings us back to London (via Goldsmith and Carter (2016)), which we last saw emerging from the water wars of 1810–1817. Its eight private DWCs quickly raised their prices to recover the cost of heavy investments made during the wars, but those moves ran into increasing opposition as politicians and scientists connected the dots between overcrowded, unsanitary slums and disease outbreaks. The cholera outbreak of 1848 and John Snow’s discovery of the connection between cholera and polluted water from the Broad Street pump in one of London’s poorer neighborhoods led to regulations on water quality and pricing (1852), oversight of services and finances (1871), and water supply as a condition of dwelling’s “habitability” (1891). These regulations lowered prices and improved services to a certain degree, but the industry’s high profits (many paid the maximum-allowed dividend of 10% for decades) and close connections to Members of Parliament (MPs) protected the companies from stronger regulation. It was not until 1880 that MPs were prohibited from overseeing DWCs in which they held shares. That change showed both the difficulty in overcoming vested interests (lobbying against such conflicts of interest had begun in 1821) as well as how momentum for change had grown. In 1902 all eight private water companies were purchased and merged into the Metropolitan Water Board for London. The city’s takeover was not a financial success — private owners were overpaid and charges were set too low to pay for service improvements — but it eventually resulted in better service at lower prices.¹

London’s experience overlaps with the Dutch experience in a few interesting ways. London had piped water (1582) long before Amsterdam (1853) but both cities implemented regulations in the latter half of the nineteenth century and took

¹The privatizations of 1989 seem to indicate that this trend reversed sometime in the next 87 years, but that debate is beyond the scope of this paper.

over their water suppliers around 1900. Amsterdam's lag on the supply side can be explained by its lower population, local water sources, and differing institutions, but their overlap on regulation and ownership can probably be traced to the growing realization that water supply played a crucial role in the commons, i.e., protecting public health and promoting quality of life. Turning to technology and financing, it is also helpful to remember that much of the early investment into Dutch drinking water networks came from Britain, where systems and operators were more sophisticated but also where investors enjoying fat profits were looking abroad for new opportunities. They eventually learned that they would not make the same profits in the Netherlands (the government set prices lower and demanded better service), but they had already transferred much knowledge and wealth by then. The bottom line is that London and Amsterdam pursued policies appropriate for their differing conditions but then converged after 1850 as it became obvious that clean drinking water was beneficial to the community as a whole.

We can also draw on [Reghizzi \(2016\)](#) to examine how Paris dealt with similar issues. The city had private DWCs delivering water around 1800, but their underinvestment, the city's stinginess with subsidies, and weak regulation led to health outcomes and life expectancy that was worse than in the countryside. The impetus for public investment and regulation came from Haussmann's desire to replace the city's dirty Seine water supply with clean imported water that would complement his grand plans. Haussmann's push helped the city's wealthier residents, but the poor continued to use cheaper Seine water (distribution systems carried water from different sources). The result — mortality in poorer districts was two-to-three times the average — can perhaps best be explained by the city's reluctance to invest tax revenues into the water system and preference for private operators that could operate without subsidies. Local leaders appeared to think that regulations requiring water and wastewater services in poorer neighborhoods were intervention enough ([Kesztenbaum and Rosenthal 2012](#)).

These comparisons support the conclusion that the Dutch, for all their faults and hesitancy, were moving reasonably quickly to extend adequate, affordable water to all urban residents, i.e., members of the club. In 1901, the national government passed a Health Care Law requiring municipalities to consult a Health Care Commission regarding large-scale housing developments (the dominant source of new urban housing at the time) and a Housing Law requiring municipalities to ensure the provision of drinking water to new and existing homes ([Günther 1934](#); [Leeflang 1974](#); [Geels 2005](#)). Regulations requiring waterworks connections for new homes resulted in new distribution networks for entire neighborhoods and lower connection charges for homeowners ([Klostermann 2003](#)).

5.1. Demands to serve all citizens

These developments reflected a gradual consensus on the importance of shared benefits from water systems, but private DWCs focussed more on the private-good aspects of their service (clean water to paying customers) and less on providing public goods (e.g., technology standards or information) or protecting common-pool goods (e.g., public health or water sources). Those practices were acceptable in most Dutch cities in the 19th century, as they followed a “small government” model at the behest of the minority of citizens whose wealth or income gave them the right to vote. This model was gradually overturned as the voting franchise expanded from 29% of the male population in 1887 to all adult men and women by 1919. New voters demanded greater financial and technical resources for the improvement and expansion of water and wastewater networks that would serve everyone (Geels 2006).

Popular support for the provision of public goods was complemented by scientific discoveries that highlighted the value of clean water and engineering improvements that lowered the cost of provision. The Second Dutch Congress on Public Health Regulation, held in 1897, suggested that drinking water should be delivered through pipes, treated for clarity and hardness, and carry “non-harmful” concentrations of lead and other contaminants (Leeflang 1974). Participants at the Congress also pushed for government subsidies to municipalities unable to afford their own waterworks (Leeflang 1974). A mix of private and public DWCs founded the Association for Dutch Waterworks Interests (*Vereniging voor Waterleidingbelangen in Nederland*, or VWN) in 1899 (Klostermann 2003). VWN (later VEWIN) collected, created and distributed knowledge on geology, hydrology, materials, technologies, water quality and so forth (van Marle 1949).²

The sector’s lack of knowledge and experience sometimes led to mistakes. The Second Congress’s emphasis on clear rather than safe water meant that “best practices” would allow for cheaper but dangerous lead pipes rather than safer copper pipes (Leeflang 1974). VWN developed its own voluntary water quality norms in 1909. The government did not issue mandatory quality standards until the first Drinking Water law was passed in 1957, at which point local authorities could be sued by government health inspectors for failing to meet standards (Geels 2005). The national government set up bodies to conduct research and provide

²VWN was renamed *Koninklijke VWN* (Royal VWN) and then *Koninklijk Nederlands Waternetwerk*, or Royal Dutch Water Network (KNW). In 1953 KNW became *Vereniging van Exploitanten van Waterleidingbedrijven in Nederland* (VEWIN), or Association of Water Company Operators in the Netherlands), which later changed its name — but not its acronym — to the *Vereniging van Drinkwaterbedrijven in Nederland*, or Dutch Association of Water Companies.

advice to government, provinces, municipalities and water companies: the State Commission for Drinking Water Systems in 1910 and Netherlands Institute of Drinking Water Supply (*Rijksinstituut voor de Drinkwatervoorziening* (RID)) in 1913 (Leeflang 1974). RID played a major role over the coming decades in providing free technical advice and subsidizing system improvements. These changes and interventions signaled the beginning of the next era in which water services would be treated as a public good.

6. Serving Citizens via Public Goods (1910–1950)

Expanding popular suffrage led governments on all levels to spend more on those who had little economic power but now possessed political power.³ Only 15,000 guilders were dedicated to constructing waterworks in 1910, but 420,000 guilders were spent in 1949 — an increase from €166,000 to €1,815,000 in constant 2016 values (De Glee 1949; Putto 1949). In 1910, the national budget included “costs of preparing for the anticipated need for drinking water” for the first time (Tweede Kamer 1909). From 1910 and into the 1930s, the national government provided interest-free loans (*rentelooze voorschotten*) and revenue risk guarantees (*verleende risico-garanties*) to DWCs that were expanding into underserved areas (Jannink 1938; Geels 2006). In 1913, Amsterdam became the second Dutch city (after The Hague in 1893) to install sewerage, and all cities with more than 50,000 inhabitants had sewer systems by 1938 (Geels 2006). The cost of these new and expanded systems was high but bearable: GDP per capita grew by 2.16% annually between 1913 and 1929 (van Ark and de Jong 1996). Figure 9 shows how these combined influences spread drinking water services across the Netherlands.

The share of DWCs under public control grew as stronger service regulations increased costs faster than revenues, straining finances at private DWCs that were unwilling — or perhaps unable — to expand to achieve the scale economies consistent with regulations and aspirations that water be provided as a public good. Blokland (1999) tells the typical story of the Leeuwarder Waterleiding Maatschappij (LWM), which did well in the first few years after its founding in 1889 but started losing money on heavy demand, leading to the cancellation of its concession in 1921 and merger of its operations into a provincial DWC co-founded

³Members of the popular chamber of the Dutch Parliament (De Tweede Kamer) are elected by proportional representation, with the country as a single district. This system means that even the hundredth most popular candidate will get a seat in parliament.



Figure 9. DWC service areas spread to less densely populated areas in these maps from 1899, 1924, 1939 and 1949

Source: [Leeflang \(1974\)](#).

with eight other municipalities. Other examples of municipal takeovers are Amsterdam in 1896, Maastricht and Groningen in 1918 and Arnhem in 1939 ([Schaap and Seebach 1985](#); [Cillekens et al. 1988](#); [Klostermann 2003](#)).

The LWM example typifies how provinces used scale to bring services to less-populated areas but also how they used regulation and subsidies to achieve their goals. In 1919, the provincial government of North Holland used its veto over DWC operations to encourage consolidation, and other provinces followed its lead ([Leeflang 1974](#)). These interventions often resulted in public take overs of private DWCs, as the provinces did not mind merging loss-making with profitable DWCs. The resulting larger entities had market power, but they were regulated

(and subsidized) in order to provide cheaper services to more people. The number of private DWCs dropped below 50% of the total by 1910 and fell throughout the twentieth century as municipal and provincial governments established new DWCs and took over private DWCs (Blokland 1999).

Figure 10 shows how the number of drinking water companies rose by 250% between 1900 and 1940, peaking at over 200 DWCs. Assuming that each DWC had fixed costs, it is clear that the drive to bring water to more customers may have encouraged municipalities to support their own residents and workers rather than cooperate to build at scale. The resulting cost inefficiencies resulted in national and provincial pressures to save money and achieve scale via mergers (Klostermann 2003). Figure 10 shows how the number of DWCs rose while service expansion was emphasized and then fell as the priority switched to rationalization and efficiency.

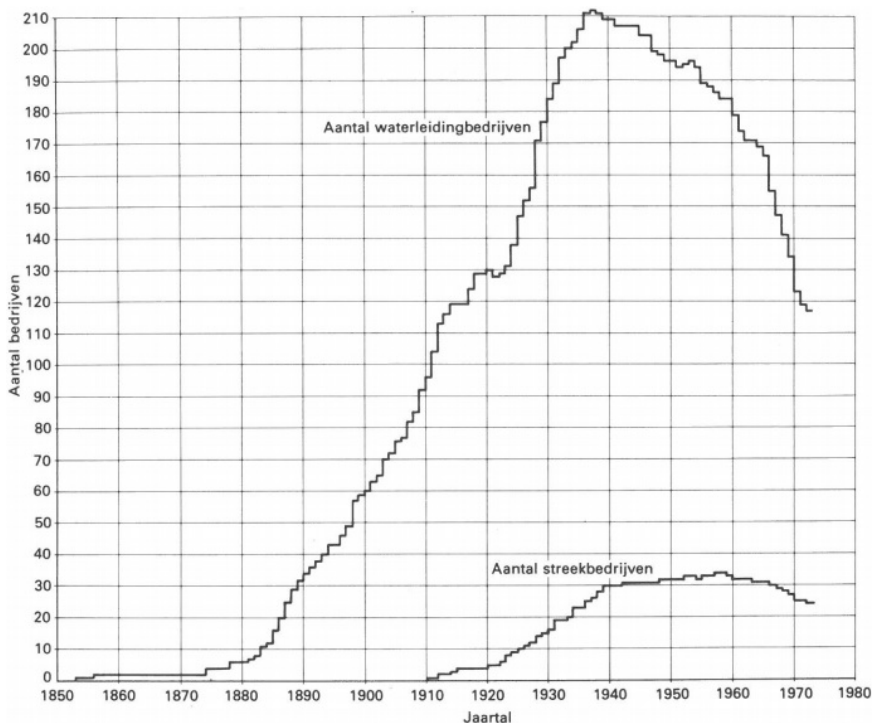


Figure 10. The number of DWCs rose steadily before peaking at 231 in 1938. the lower trace shows the total count of provincial water companies, which rose as they absorbed smaller DWCs

Sources: Leeflang (1974); Klostermann (2003).

6.1. Demands to waste less money and water

The beginning of the end of this era is not visible in outcomes (Fig. 1 shows that infant mortality continued to drop) but in concerns over excessive spending in a Depression economy in which GDP per capita was shrinking by 0.89% per year between 1930 and 1938 — and throughout WWII (van Ark and de Jong 1996).

Some observers focussed on water waste as a sign of moral decay. According to van Nievelt (1949, p. 113), “beneficial usage of water is a blessing for the community and the individual. Wasting, on the other hand, is a symptom of a disease that needs to be fought.” Such thoughts reflected a tension between treating water as a public good contributing to water civilization and worrying about over-exploitation of commons of money and water under lax management.

The criticism of excessive water consumption arose from the lack of water meters for domestic use. (Industrial customers were usually metered but it is not clear if they paid to subsidize household users — or vice versa.) Water meters were not widely used due to their high cost (as high as 15–30% of a DWC’s total expenses) and tendency to reduce quantity demanded (and thus water civilization) by introducing a marginal price on water consumption (RvD 1919). Proponents of water civilisation preferred tariffs based on wealth (imputed from the number of bedrooms) and spending to increase supply rather than spending on meters that would suppress demand (van Royen 1938; Groen Jr. 1978). The Hague was the exception to this rule — recall that it installed watermeters in 1888 — because it needed to reduce demand for its limited supply of dune water, but few cities followed its lead (Bijl 1924; van Royen 1938). These norms fed worries about wasteful water consumption and excessive public spending — concerns that led to a post-war era in which water is treated as a private good to be managed by corporate DWCs and consumed by metered customers.

7. Internalizing Costs via Private Goods (1950–1990)

The post-war reconstruction of the Netherlands (*De Wederopbouw*) brought annual GDP-per-capita growth of 3.7% between 1947 and 1973 (van Ark and de Jong 1996). Increasing wages and tax revenues made it easier for the government to push more responsibility onto utilities and users (treating drinking water as a private good) but also made it easier for the welfare state to provide financing and regulation (as public goods). Thus, we see a simultaneous increase in government spending with a push for local responsibility. DWCs were forced to consolidate and improve their services while balancing their budgets. Customers had to pay for their metered water use. These policies — by converting common-pooled into

private goods — changed incentives and perceptions around waste. The next paragraphs will explain the policies' results.

Many public DWCs had acted as independent corporate entities with their own balance sheets and profit & loss statements since the 1920s. This structure allowed them to invest revenues and depreciate costs more freely than if they had shared accounts with the city governments that owned them. This system limited loss-making behavior, but DWCs had weak incentives to improve their services and no incentive (and probably no legal ability) to grow to a more efficient scale. The resulting excess of DWCs offering costly service explains why national and provincial governments pressured DWCs to merge. The 1957 Waterworks Law encouraged DWCs to serve more customers as well as merge their operations (Leeflang 1974). The government offered a subsidy of 80 million guilders towards bringing drinking water connections to 93% of the population (Tweede Kamer 1955). That spending (0.66% of 1960's GDP of 12 billion guilders) represented a much larger share of GDP than today's monetary equivalent would imply (€230 million is only 0.04% of 2016's GDP of €653 billion), but it was effective: 99% of the Dutch had drinking water connections by 1968 (Klostermann 2003).

In terms of mergers, the trends of the previous era were further encouraged by a 1971 amendment to the Drinking Water Law that restricted operating licenses to DWCs with more than 100,000 customer-households (Klostermann 2003). At the provincial level, Chapter III (1975) of the Drinking Water Law allowed provincial governments to force local DWCs to merge, improving economies of scale and service quality. The mergers also shifted the locus for subsidies from the national level (via RID) to the provincial level. Uniform provincial tariffs meant that lower-cost urban customers subsidized higher-cost rural customers. Figure 10 indicates that over 100 DWCs were operating in the early 70s. By 1990, there were only 20 DWCs in the country, with eight of 12 provinces having only one DWC. Figure 11 shows the service areas for today's total of 10 DWCs.

The campaign against water waste was pursued by installing more meters. Amsterdam, Rotterdam, and Groningen wrote regulations requiring meters in the 1980s and 1990s (Blokland 1999). Metering penetration rose from roughly 50% in 1952 to around 96% in 2007 — a rate defined as “universal” because the remaining 4% of residences were deemed “uneconomic” to connect (VEWIN 2012).⁴ Meters were unpopular for their installation cost and occasional heavy-handed installation deadlines, but they did not attract the same “anti-poor” criticisms as was seen in

⁴These statistics are based on the 1915–2007 editions of Vewin's annual *Waterleidingstatistiek* (Water supply statistics).



Figure 11. (Color online) The Netherlands now has 10 DWCs

Source: VEWIN (2015).

England and Wales — probably because the Netherlands had public DWCs, an adequate social safety net, and a culture that accepted meters as a fair means of allocating costs (Klostermann 2003; Zetland 2016).

Dutch drinking water and sanitation systems were pervasive, effective and efficient by 1990. Most of the population paid for clean safe water as a private good and used as much as they wanted from well-funded and maintained systems; see Fig. 12. The death rate had dropped to a “natural bottom,” and the infant mortality rate was lower than ever (see Fig. 1). From this perspective, the industry only needed to hold steady, but success raised expectations that DWCs should do — and could do — more. At this point, we could discuss environmental policies,

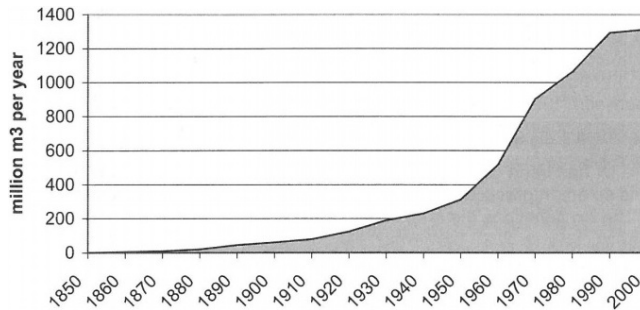


Figure 12. Water sales for both domestic and industrial users rose quickly after WWII

Source: [Klostermann \(2003\)](#).

new social targets, and EU-level cooperation, but we won't. The Dutch had achieved water civilization.

8. Lessons Learned

This paper has explored the evolution of the Dutch drinking water sector, beginning in the 1850s when a small share of the population could afford to buy water by the bucket and ending in 1990 when everyone received clean, affordable water in their homes. The sector's evolution was neither chaotic nor predictable, but linear in the sense that each change improved on current services, while adding cost and complexity.

Our analytical narrative explained how changes in knowledge, culture, and technology led to policies that altered the scale, scope and quality of water services. To understand the pressure for change and impact of policies, we used a framework that classified drinking water service as one of four types of good (private, public, club or common-pool) and used this framework to explain the evolution of the sector throughout eras in which emerging threats to the commons are addressed by converting water services into another type of good (private, club or public) that reduced that threat for the time being.

To recap our narrative, our first era begins around 1850 with a desire to avoid polluted common-pooled water. The solution to that desire — treating water service as a private good — was successful until it was superseded by a desire around 1880 to extend service to all citizens in cities (to improve the commons of public health), which meant treating water as a club good. That solution ignored citizens in smaller communities who were also suffering from poor water services (thereby undermining their common-pooled rights as citizens), so a push began around 1910 to provide water service as a public good for all. That solution resulted in

concerns about excess spending (depleting the budgetary commons), which led to changes around 1950 in which water was treated as a private good. That move did not mean returning to 1850s-style sales of water in a bucket. Advances in technology, finance, and regulatory skill meant that “corporate” utilities could internalize the costs of providing good services. Greater wealth and public understanding of the importance of clean water meant that customers could be charged for their metered water use. Our narrative ends in 1990 because everyone had access to adequate safe water from companies with reliable operations and finances.

Can other countries learn from this unique Dutch experience? Yes, if they see how drinking water can have different characteristics as a private, club, common-pooled or public good, as these characteristics make it easier to choose a mix of subsidies, regulation and information that will bring as much water to as many people as possible. Yes, if they take a gradual, step-by-step approach to moving from current conditions to viable goals. Yes, if they appreciate how discussions and decisions must include all stakeholders — water managers, customers, taxpayers, regulators, public health professionals, *et al.* It may take a village to raise a child, but it takes a nation to deliver water civilization.

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