Changing Values Lead to Water Management Reform in the Netherlands

Toward an Interdisciplinary and Integrated Approach to Agricultural Drainage

J. Hoevenaars
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**Acronyms and Abbreviations**

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<tr>
<td>ARD</td>
<td>Agriculture and Rural Development Department</td>
</tr>
<tr>
<td>BMF</td>
<td>Brabantse Milieu Federatie [Brabant Federation of Environment]</td>
</tr>
<tr>
<td>CBS</td>
<td>Central Bureau for Statistics</td>
</tr>
<tr>
<td>DLG</td>
<td>Dienst Landelijk Gebied [Government Service for Land and Water Management]</td>
</tr>
<tr>
<td>EEC</td>
<td>European Economic Community</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
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<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<tr>
<td>GWS</td>
<td>Groundwater step</td>
</tr>
<tr>
<td>HPA</td>
<td>Hoofd Productschap Akkerbouw [Producers Organization Arable Crops]</td>
</tr>
<tr>
<td>IAIA</td>
<td>International Association for Impact Assessment</td>
</tr>
<tr>
<td>ICID</td>
<td>International Commission for Irrigation and Drainage</td>
</tr>
<tr>
<td>ICS</td>
<td>Institute for Contemporary Studies</td>
</tr>
<tr>
<td>IKCL</td>
<td>Informatie- en Kennis Centrum Landbouw [Information and Knowledge Centre for Agriculture]</td>
</tr>
<tr>
<td>IPTRID</td>
<td>International Programme for Technology and Research in Irrigation and Drainage</td>
</tr>
<tr>
<td>ILRI</td>
<td>International Institute for Land Reclamation and Improvement</td>
</tr>
<tr>
<td>LLTO</td>
<td>Limburgse Land en Tuinbouw Organisatie [Limburg Organisation of Agriculture and Vegetable Growers]</td>
</tr>
<tr>
<td>NCCP</td>
<td>National Corporation for Crop Production</td>
</tr>
<tr>
<td>NGL</td>
<td>Netherlands Guilder (= 0.45 Euro; = 0.45 US$)</td>
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<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
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<tr>
<td>NRLO</td>
<td>Nederlandse Raad Landbouwkundig Onderzoek [Netherlands Council for Agricultural Research]</td>
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<tr>
<td>PPY</td>
<td>Practical potential yield</td>
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<tr>
<td>V&amp;W</td>
<td>Verkeer en Waterstaat [Ministry of Traffic and Water Management]</td>
</tr>
<tr>
<td>VROM</td>
<td>Volkshuisvesting, Ruimtelijke Ordening, Milieu [Ministry of Public Housing, Spatial Planning, and Environment]</td>
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<tr>
<td>ZLTO</td>
<td>Zuidelijk Land en Tuinbouw Organisatie [Southern Organization of Agriculture and Vegetable Growers]</td>
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Acknowledgments

This country study was prepared as a contribution to a series of World Bank studies during 2002 for the BNPPEW project (Bank-Netherlands Partnership Program Environmental Window Project for Water Resources Management). This project is an initiative of the World Bank, in cooperation with Wageningen Agricultural University. Parallel studies were done for Bangladesh, Egypt, Indonesia, Mexico, and Pakistan. Safwat Abdel-Dayem, task manager from the World Bank (Agriculture and Rural Development Department), and Peter Mollinga of Wageningen University provided general direction for the study and contributed valuable comments on the preliminary texts. During a special workshop in Wageningen, October 23–25 2002, many participants from all over the world discussed the provisional results and gave their observations.

Many thanks go to the individuals interviewed during the field study: Adriaan van den Boogaart, Sjaak Broekmans, A. Corporaal, Johan van Gestel, Frank Heijens, Jac. van Poppel, and Paul van Poppel.
Abstract

This study reviews agricultural drainage in the Netherlands in the context of general water management. Relations between predominant landscapes, prevailing socioeconomic developments, and the institutions for water management are interpreted from a historical perspective. The processes that have profoundly transformed the agricultural drainage sector over the past 50 years are analyzed.
Executive Summary

The project “Agricultural Drainage: Towards an Interdisciplinary and Integrated Approach“ was carried out by the World Bank through case studies in six countries. This report, a study of drainage in the Netherlands, is based on a review of the literature, interviews of actors in water management, and the author’s own analysis.

The theme of this case study, How Changing Values Result in Water Management Reforms, reflects people’s ever-changing appreciation of water. Sooner or later, changes in their values are reflected in changes in water management. To understand this process, we need some notion of current water resources in the Netherlands and the historical development of land and water use and especially the role of agricultural drainage, past and present. The process of change is analyzed with the idea that “mental” changes in a society play an important role. The study takes the local variability of natural resources and the multiple functions of water as basic principles for a planning approach to agricultural drainage.

The Water Burden of the Netherlands

A net surplus of rainfall over evaporation results in a net water output from the Netherlands territory. This amount is augmented considerably by water from the main rivers, the Rhine and the Meuse, and from many local rivers originating in neighboring countries. Ground water flow is a third source of water: fresh water from the higher surrounding countries and saltwater from the sea.

Most of the surplus water flows to the sea by gravity. However, in polders, low-lying reclaimed lands, most of the surplus water has to be pumped out. An extensive system of natural rivers, manmade canals, and pipe drains operate to maintain water quality and keep the groundwater levels within the desired minimums and maximums. Dikes have been constructed where necessary to prevent back-flow of water from the sea or from rivers. Flooding, from increasing peak discharges from rivers and streams, rising sea levels, and land subsidence is one of the main challenges confronting the water management system.

Hydroecological Regions

Geology, soils, topography, hydrology, and vegetation are the main natural factors. For the Netherlands, climatic variability is irrelevant. These natural water endowments shaped the choice of farming systems and water management methods. Based on these factors, six main hydroecological regions have been established: South Limburg Hills; Sandy Upland; Main River Plains; Coastal Polders; Dunes, and Glacial Formations. The Dunes and Glacial Formations hydroecological regions, relatively insignificant for this study, are not covered.

A hydroecological region is defined as a group of landscapes with more or less similar natural resources and typical land uses, and with a more or less coherent water management system. Based on the same parameters, a landscape is more narrowly defined.

The groundwater levels desired and other water management objectives are not uniform. They depend on the use made of the land. Land use, especially for agriculture, has historically been a function of the prevailing land and water characteristics.
Multiple Land and Water Functions: An Old Story

Many functions of natural resources are difficult to assign to water or to land. Similarly, calling a measure “land management” or “water management” is often arbitrary.

In Dutch history, land and water have always served a combination of functions. Agriculture and settlement were the most important. Building materials, fuel, shipping, flood regulation, and security are some of the others.

**Functions of the environment are the goods and services generated by the natural system. Different segments of human society appreciate or dislike these goods and services. The objective of resources management is to change these functions for the better. Integrated water management takes all functions into consideration when planning interventions in the water system.**

The hydrological situation of the Netherlands always has been a major constraining factor and an opportunity for the development of these functions. Water management has had integrated touches since the fourteenth century when water boards began to combine the evacuation of agricultural drainage water with the protection of land against flooding.

By its nature, drainage from field to sea has a serial interdependency. The weakest link determines success or failure. But there is also a parallel interdependency. Water management for one function most of the time affects other functions, and vice versa. This parallel interdependency is dominated by power relationships. The relative success of water management in the Netherlands over the centuries has been determined by the way these two principles were recognized. With steadily growing knowledge and new technologies (like windmills), serial water management functioned better and better (despite some major set-backs from time to time). The power struggle over how to manage the water, and in whose interest, has always been present. The early introduction of democracy prevented water management from evolving into a monopoly.

**Agricultural Drainage and Hydroecological Diversity**

Historically speaking, hydroecological diversity was present from the beginning. On this natural diversity, different types of land use could develop to the extent man could manage these natural resources. In the Netherlands, to expand and improve land use, drainage had to be one of the first areas for policy action. Human interventions in the natural systems gradually changed the hydroecological regions and their individual landscapes. Natural hydroecological diversity became manmade hydroecological diversity. Landscapes became manmade landscapes. Hydroecological diversity has generally diminished at the regional, and at the landscape, levels. But even today, the diversity of land use and other functions is still linked with the hydroecological regions, and within these zones, with the diversity of individual landscapes. Now, people want more natural diversity to mitigate the degradation of resources brought about by the supercontrol the Dutch thought they had over nature. The extent of control over drainage management and adaptation to the natural resources is tied to the nature of each hydroecological region and individual landscape with in it.

**Main Agents for Land Reclamation and Agricultural Drainage**

Since the expansion of agriculture in the Netherlands, organized groups have been able mobilize enough labor, capital, and knowledge for such undertakings. These groups include abbeys (1000–1200), feudal...
rulers (1200–1500), locally organized groups (1300–1500), water boards (1300–present), private or municipal land reclamation companies and peat mining companies (1500–1700), lake-draining companies (1500–1900), the State Service for the Reclamation of Lake IJssel, the Union for the Reclamation of the Heath Fields; the State Service for Land Consolidation Programs; and the State Forest Service (1900–2000). An individual’s possibilities for occupying and developing new land beyond the stage of shifting cultivation were apparently very limited. The serial interdependency of drainage systems must have been one of the main constraints. In this chain, field drainage has always been the land user’s responsibility, but drainage beyond the field has the responsibility of an institution, in most cases a water board.

**Water Boards**

The classic tasks of the Dutch water boards are flood protection, conveyance and disposal of drainage water, and maintenance of agreed minimum and maximum surfacewater levels. These tasks are being extended into water quality management, ecological management, water conservation, and flood prevention. Agriculture was once the only interest group represented on the water boards. In the last 40 years, parallel interdependency in drainage has grown considerably, and water boards have become the arena for making decisions about all water functions.

The water board is a functional government and autonomous within the policy and legislative framework of the national and provincial governments. The General Assembly and executive committee are elected bodies with full representation of different interest groups. Water board structure is adapted to deal with the assorted water management problems in their respective hydroecological regions.

**The Land Consolidation Program**

The improvement of field drainage in the Netherlands, the first link in the drainage chain, is the landowner’s responsibility. Proper drainage was long hampered by land fragmentation, scattered landownership, insufficient capacity of the conveyance network, and limited accessibility of the rural areas. A land consolidation program, covering almost all agricultural land in the Netherlands, was implemented during the past century through a series of projects. The program was designed to modernize agriculture and improve productivity as well as alleviate the backwardness of the rural population. Improving agricultural drainage was one of the main activities.

Since 1985, the objectives of land consolidation have broadened. The aim now is to find a compromise between all functions of the rural areas.

**Effects and Impacts of Improved Agricultural Drainage**

In the past, the economic impact of drainage was the main criterion for judging its feasibility. From the start, the land consolidation program also used social value as a criterion in planning and decisionmaking, for example, to alleviate rural backwardness. Later, other social values were reflected in the attention given to scenery and recreational uses. Only in the past few decades has the change in ecological values been recognized in concern about the impacts of agricultural drainage.

Agricultural drainage causes *biophysical changes* in the natural resources system, for example, by lowering the groundwater table. The effects of these changes are found in a shift of the functions of the natural resources system, for example, raising agricultural productivity. The impacts of these effects are changes of the value of these functions for mankind, for example, the economic value of an incremental yield.
The effects of drainage on functions are measurable, if proper criteria or indicators are selected. It is questionable whether the values of these effects should be added up to a single figure and used in decisionmaking, but integrated management should make all the effects of water management visible in a quantitative form. This approach helps decisionmaking because it:

- Makes the effects explicit and transparent
- Allows for fair representation of interests in decisionmaking
- Points to the nature of measures to mitigate negative side-effects
- Provides a key for cost recovery.

**The Dutch Way of Assessing the Agroeconomic Impact of Drainage**

A methodology has been developed for conditions in the Netherlands to assess the economic impact of intensified or extended drainage. It consists of the following steps:

- Classifying agricultural land into units with the same soil and groundwater (aggregation of mean low and high groundwater level)—in the Netherlands up to 110 units
- Determining for all crops an attainable reference for each soil-water unit
- Determining annually the net financial value of the reference yield
- Estimating normal yield reductions due to excess water and water shortage for each unit
- Determining the groundwater steps before and after the drainage intervention
- Calculating the change in normal yield reduction before and after the intervention
- Determining the change in actual potential benefit before and after the intervention.

**Negative Effects**

Unlike in many other countries, the performance of agricultural drainage is not an issue in the Netherlands. The main issues are the negative effects of drainage on other functions of land and water: eutrophication and pollution; desiccation of wetlands and depletion of groundwater; degradation of biodiversity; local flooding, erosion, and siltation; major flooding risks by the main rivers; land subsidence; saltwater intrusion; and degradation of scenic beauty.

In the Netherlands none of these degradation processes were foreseen or recognized as of any importance. When they surfaced on an unexpectedly large scale, mitigation or restoration measures began to fill the agendas throughout the resources management pyramid. A lesson can be learned from the Dutch experience: the way back is much more costly and painful than an uneasy but right way taken from the start.

**The Roots of Change**

Four main developments have changed water management in the Netherlands over the past 40 years, particularly agricultural drainage. First, competition for space in the Netherlands among user groups with different functions has heated up, and land and water functions are changing dramatically. Second, related to the functional changes, the relative values assigned by the public to different functions have also shifted drastically. Agriculture has lost its overarching importance in the Dutch economy, a process stimulated by urbanization and the increasing wealth of the population. Third, in the 1960s and 1970s, the
Netherlands democracy was transformed from a corporate society into an open democracy, based on citizen consultation and participation. Finally, the threat of climate change has had an important influence on the perception of water management in this vulnerable country.

**Old Institutions Get Stuck**

The old land and water management institutions served only a few environmental functions. The entire institutional complex around agricultural drainage was geared to optimizing groundwater levels and surface water discharges to maximize agricultural production. And it succeeded. The supremacy of economic values over social and, even more, over ecological values was undisputed.

Since the 1960s, as other functions have gained in importance, it soon became clear that the old institutions were not up to the new tasks. Legislation was biased, science and technology to support new management was not available, and organizations were full of people with outdated knowledge and outmoded beliefs. The fragmented system was unable to work out solutions that would serve the collective interest better than sectoral interests.

The defective system was not replaced overnight by another one in the Netherlands. It took step-by-step reforms, most of the time under duress. Once a critical momentum in reform had been reached, the rest of the paradigm shift seemed to come automatically.

**The Emergence of Change**

Water management’s old beliefs and certainties have, by now, evaporated. A paradigm shift has taken place. This was bound to happen as a function of some autonomous developments, but some other ingredients were indispensable.

- A large part of the population values a clean, biologically rich, and attractive environment.
- A democratic governmental system allows changes.
- The educational system stimulates a critical attitude among students.
- A trigger sets things in motion.

The trigger was probably the student revolt of 1968. This event marked the start of an open democracy; scientific development of new water management concepts, first by universities, later by research institutions; the birth of a series of environmental activist groups; and the coming to power of progressive political parties. As a last step, the vested executive organizations were forced to change by parliamentary decisions, laid down in new acts concerning water boards, land consolidation, water quality management, and the like. Fights characterized the process of change in the early stages and resistance by conservative powers and people, especially in the agricultural sector. Later, when new elements were institutionalized, the process unfolded more quietly and with more cooperation between the new and the old interest groups. The critical mass for self-propelling change was probably reached in 1973 when a progressive government came to power. Once the ideological fight was over, new ambitions had to be translated into plans.

**New Strategies and Practical Problems**

In the Netherlands, these plans boiled down to a multifunctional use of the rural areas. Modern spatial planning harks back to the country’s physiographical roots. It is now national policy that, to be sustainable, the foundation for every further development should be the geomorphology of the country.
and the soil and water system with its ecological, scenic, and cultural-historical values. This applies to agricultural drainage, too. It means that many water functions will be restored to the extent possible, effective, and acceptable. In parts of the Netherlands, the optimal agricultural drainage situation will be modified or relinquished for optimal integrated water management.

Integrated land and water management takes all functions of the environment into account, involves all stakeholders in decisionmaking, and develops every part of the management system.

Problems of a more practical nature accompany these plans. Answers are yet to be found for questions like: where can the financial resources be found to compensate farmers for loss of production caused by curtailed drainage; can field management of a multifunctional environment be entrusted to farmers; how are the new goods and services valued if the system has to work on an economic basis; where are the new technologies, skills, and science needed for a multifunctional management system?

An enormous amount of work still has to be done. The new policy is directed toward restoring or reinforcing the diversity of the original hydroecological regions and their landscapes. Part of the work entails reconceptualizing agricultural drainage and developing sustainable farming systems for a multifunctional environment.
1. Introduction

The BNPPEW project is an initiative of the World Bank, in cooperation with Wageningen Agricultural University. The main concern is to make agricultural drainage more sustainable. Therefore it aims to enhance knowledge of drainage in an integrated water management context. This is one of six case studies in the project.

The main questions posed in this study reflect the project’s objectives.

- What would be a useful framework for understanding drainage in an integrated water management context?
- How can drainage be handled as part of wider sociotechnical and environmental management systems?
- How can regional and local environmental and managerial diversity be translated into viable drainage solutions?
- How can institutions be reformed from a sector oriented to an integrated management system?

Land drainage, as defined in the constitution of the International Commission on Irrigation and Drainage “is the removal of excess surface and subsurface water from the land including the removal of soluble salts, to enhance crop growth” (ICID 1979: A-156–63). This definition, repeated by Pearce and Denecke (2001), may be fine for agricultural drainage, but it is too narrow for this study. It does not recognize other objectives of drainage such as making land suitable for building, or for mechanization, or for improving public health conditions.

Knegt (2000) proposes a broader view of agricultural land drainage. He includes more objectives for drainage than improvement of yields. His typology of agricultural land drainage is based on four main objectives: flood protection; prevention of waterlogging and salinity; controlling soil moisture content; and reclamation of agricultural land (new land as well as waterlogged and salt-affected land).

This case study needs a still broader concept of “drainage” to interpret the way agricultural drainage is managed in the Netherlands (box 1).

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1 The official name reads: Bank-Netherlands Partnership Program Environmental Window Project for Water Resources Management.
Box 1 Working definition of drainage

*Drainage* encompasses all physical interventions in the natural dewatering system of soils and consequent conveyance and disposal of the effluent, water and solubles, in order to deliver more desired goods and services by the water system than natural circumstances would permit. The drainage management system includes all the institutions involved in drainage, the natural water system connected with drainage, and the consumers (stakeholders) of the goods and services generated by the drainage interventions.

Source: Author.

Land and water systems are so dynamic, that agricultural drainage always influences other land and water management activities. This inevitably makes agricultural drainage part of overall water management, which, in turn, is part of the general resources management system.

Figure 1 shows the basic structure of a resources management system. Centrally placed are the *functions* performed by the biophysical resources, which society appreciates or dislikes. The extent of appreciation is expressed in three different value systems: *economic*, *social*, and *ecological*.

Figure 1. Schematic Representation of the resources management system

Source: Adapted from J. Hoevenaars and P.P. Mollinga, (Dutye 1998).

Society has established institutions to create a balance between the supply and demand of functions.

This case study focuses on the transformations in the resources management system, in which agricultural drainage is embedded. The use people make of their resources shows important differences, even in a small country like the Netherlands. The biophysical substratum on which this variability has developed, is described in section 2. The result is a classification of the Netherlands in five broad hydroecological
regions. The evolutionary development of water management before 1960 is dealt with in section 3; the more revolutionary reforms in modern times are discussed in section 5. In between, section 4 analyses the impacts drainage has on rural livelihood in the Netherlands. Several references are made to the Appendix A Field Study, which presents experiences and opinions of a number of people involved in water management.

The theme of this case study, *How Changing Values Result in Water Management Reforms*, was chosen to emphasize that the appreciation of people in the Netherlands for what water gives them is changing all the time. This ever-changing appreciation has a major influence on water management, though with a (big) time lag and only after overcoming the in-built resistances of institutions to change.

2. Water Systems in the Netherlands

Water Balance Factors

*Climate*

The Netherlands has a temperate climate; because of its small size, the variability of climatic parameters is negligible for this study. The average annual rainfall is about 780 mm. The distribution over the year is even (figure 2), and differences between years are limited. Average evaporation amounts to 680 mm/year, without important differences between years. During the year, evapotranspiration is least in winter and greatest in summer.

During fall and winter, the surplus of rainfall over evapotranspiration first results in the replenishment of moisture in the soil, a rise in the groundwater level, and an increase in river discharges. When evapotranspiration increases in spring, the reverse process takes place. River discharges shrink and the upper reaches of natural water courses fall dry. However, most of the natural streams in the Netherlands are perennial.
External Water Inputs

Looking at the water balance of the Netherlands as a whole, some other factors should be taken into account. First, the two main rivers, the Rhine and the Meuse, carry large volumes of water through the Netherlands to the sea. A fair number of small rivers enter the Netherlands from Germany and Belgium. Second, a number of aquifers extend beyond the borders of the Netherlands into Belgium and Germany. Groundwater from these countries seeps into the Netherlands to the surface in low-lying areas. The third important factor, for two reasons, is the sea. During periods of high tides, stormy weather, and high river discharges, the “high” sea hampers quick disposal of rainfall and river water, which may cause flooding. Moreover, water quality in the low-lying western part of the country is constantly threatened by saltwater intrusion from the sea and estuaries.
Natural Hydrological Diversity in the Netherlands

Geology, soils, topography, vegetation, and climate are generally the determining environmental factors for hydrological systems. In the Netherlands, climatic variability is too small to make a substantial hydrological difference.

**Geological Substratum**

These basic hydrological characteristics (e.g. impermeable layers; texture of the parent material) and indirectly (via soil type and topography) are directly related to the characteristics of the upper geological strata. Most of the Netherlands can be grouped in five geological districts: holocene marine clays, holocene peat formations, holocene river deposits, pleistocene sand deposits, and older aeoline loam.

**Topography**

Altitude and slope are the main topographical parameters of interest for the hydrological situation. Parts of the Netherlands are below sea level, within the tidal range, and above high tide level. The landscapes can be divided in flat areas, gently sloping land, and a small area of undulating to hilly land with steeper slopes.

Two factors that have an important influence on long-range water management in the Netherlands are related to the position of land vis-à-vis the sea level. The Netherlands, and a larger part of Western Europe, is geotectonically moving downward. This isostatic process proceeds at some 10 cm per century. In the past, this sinkage was compensated by ongoing sedimentation and new peat formation.

The second phenomenon is the expected long-term sea level rise due to climatic change. Throughout history, periods of regression and transgression, spread over centuries, have appeared. Today, a worldwide sea level rise is expected over a much shorter period because of man-induced global warming.

**Soils**

In the geological formations, typical soils have developed. For this study, it is sufficient to make a distinction among the broad soil groups: clay soils, peat soils, sandy soils, and loamy soils. Locally, associations of these soils occur. Disturbances to the impervious layers in the top 2 m are of importance for local hydrological conditions.

**Natural Vegetation**

Natural vegetation develops as a function of the abiotic resources water, soil, and climate and also influences the abiotic factors. A good example in the Netherlands is the development of
fens on poor sandy soils with poor internal drainage. The thick package of peat creates its own specific hydrology by retaining the rainwater in the layers of dead plants, which is good for the living top layer. In a natural landscape, vegetation develops until reaching a balance with the abiotic resources. In the Netherlands, the most characteristic stable natural vegetation types are: peat, wet forest (alder-willow), and dry forest (birch-oak-beech). However, these original vegetation types have been reduced to now negligible areas.

*Manmade Factors*

In the course of centuries, the Dutch have reshaped almost 100 percent of their land. It is difficult to find places that are still in a “natural” state. Small peatland reserves, dune areas, mud flats in estuaries, and oak forests on very steep slopes give only a glimpse of the “roots” of the country.

Many reclamation practices in the Netherlands in the past were needed to gain agricultural land. However, these interventions—large-scale deforestation in the Middle Ages, drainage, and peat mining (for fuel) in the sixteenth and seventeenth centuries—had unintended but strong side effects on the water and land systems. Moreover, interference in the natural system triggered some long-term environmental change processes that required new interventions to head off a complete collapse of water management (section 3).

Four examples illustrate the exclusive relations between the type of agricultural drainage and the hydroecological circumstances.

- In the low-lying western part, the Dutch started to drain the extensive peat areas and mined the peat for turf. Both activities resulted in the creation of lakes and subsidence of the peatlands. Consequently, these peatlands sank below sea level, and pumped drainage had to be introduced to prevent waterlogging. Land subsidence could be avoided, however, only by maintaining a high groundwater level. And saltwater intrusion could be prevented only by maintaining a fresh water lens on top of the saline groundwater together with frequent flushing of the open water that turns brackish. Agricultural drainage under such hydroecological circumstances thus has to operate within very narrow limits.
Building dikes along the rivers was meant to protect the inhabitants from flooding and allow for more intensive agricultural use of river depressions. The consequence was that the river plains no longer received new sediment, whereas the river beds between the dikes steadily build up. Substantial seepage beneath the dikes is only one of the consequences in the river plains, with direct effects on agricultural drainage.

Sandy soils are not at risk from catastrophic floods. Even with limited agricultural drainage, the fields are still productive. Therefore, institutions to maintain a proper drainage system did not emerge as compulsory here as they did in other regions. The lack of strict internal control mechanisms resulted in a far below optimal drainage situation.

In the Middle Ages, the slopes of South Limburg were deforested for agriculture. Because loam soils are particularly sensitive to erosion, the farmers had to save strips of bush land to interrupt the surface runoff.

Identification of Hydroecological Regions

Defining a hydroecological region is not easy. The understanding in this study, box 2, is in line with the concept of landscape ecology, as discussed by Vink (1975).

Box 2 Concept of landscape ecology

“Ecosystems and landscapes are “open systems” in the sense that they are characterized by an exchange of both mass and energy with their surroundings. Ecosystems consist of plants, animals and their inanimate environment; human ecosystems represent the interlocking of social systems with ecosystems and as such are perhaps the structurally most complex systems imaginable.”

Source: Vink 1975.

This study considers a landscape a unit of land with more or less homogeneous natural resources (soil, water, climate, vegetation, and land use). Depending on the size of the regions considered, various levels of generalization can be used.
An ecological region is considered a higher level of aggregation than a landscape. It encompasses a group of landscapes. Such a group of landscapes has only one or a few common denominators. A common denominator can be selected in function of the objective of a study or a planning process. Land use often is taken as a critical parameter for ecological regions. This results in, for example, agroecological regions or zones.

For this study, water management is more significant for a relevant classification. Therefore, water management, using the prefix “hydro,” is selected as the common denominator. “Hydro” is understood as: “with a coherent water management system.”

Introducing the concept of “water management” allows analysis of the structural interlocking of hydroecological regions with social-institutional systems (box 3).

By using this definition and the resources characteristics discussed above, the Netherlands can be divided in five main hydroecological regions (figure 3): Dunes, Coastal Polders, Main River Plains, Sandy Uplands, and Hills. Had this study not focused on agricultural drainage, the scattered “built areas” (cities, towns) could have been included.

**Figure 3 Hydroecological regions in the Netherlands**

![Figure 3](image)

Source: Adapted from Ministry of Agriculture, Environment and Fisheries 2002.

The ranking used in table 1, by and large, is toposequential. Climatic parameters are not used because of the limited climatic variability in the Netherlands.
In the ensuing sections, the hydroecological region, dunes, is not included it is a relatively small area and because drainage (especially agricultural drainage) is of little significance in these areas.

Table 1 Some characteristics of the hydroecological regions in the Netherlands

<table>
<thead>
<tr>
<th>Name</th>
<th>Typifying land parameters</th>
<th>Typifying water parameters</th>
<th>Main water management objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>South Limburg Hills (1,000 km²)</td>
<td>Relief: hilly</td>
<td>Drainage pattern: natural rivers</td>
<td>Peak flow management</td>
</tr>
<tr>
<td></td>
<td>Altitude: 50–300m</td>
<td>Dewatering by gravity</td>
<td>Surface drainage</td>
</tr>
<tr>
<td></td>
<td>Soils: aeoline loam</td>
<td>Deep groundwater levels</td>
<td>Erosion and sedimentation control</td>
</tr>
<tr>
<td></td>
<td></td>
<td>High percentage of overland flow</td>
<td>Restoration of natural streams</td>
</tr>
<tr>
<td>Sandy Upland (13,500 km²)</td>
<td>Relief: flat to gently sloping Altitude: 1–50m Soils: sandy Locally disturbance by impervious layers</td>
<td>Drainage pattern: natural perennial brooks and rivers; manmade ditches Dewatering by gravity Groundwater level: 1–5 m. Annual fluctuation of 1–2 m</td>
<td>Peak flow management Groundwater and surfacewater quality management (eutrophication) Agricultural drainage (groundwater level management) Drinking water</td>
</tr>
<tr>
<td>Main River Plains (2,500 km²)</td>
<td>Relief: flat</td>
<td>Slow infiltration</td>
<td>Flood protection</td>
</tr>
<tr>
<td></td>
<td>Altitude: 0–15m</td>
<td>Groundwater level 0.5–1.2m</td>
<td>Agricultural drainage</td>
</tr>
<tr>
<td></td>
<td>Soils: heavy clays with pattern of lighter levees.</td>
<td>Lateral seepage of river water Temporary flooding of depressions Gravity drainage but hampered by river dikes and high water levels in the rivers.</td>
<td>Agricultural water supply Restoration river floodplains</td>
</tr>
<tr>
<td>Coastal Polders (13,500 km²)</td>
<td>Relief: flat</td>
<td>Groundwater table: very shallow to shallow (0.2–1.5m)</td>
<td>Pump drainage always required</td>
</tr>
<tr>
<td></td>
<td>Altitude: +2 to −5 m. Bsl.</td>
<td>Very limited fluctuations Water quality: eutrophic, overlying saline groundwater Drainage system: mostly manmade ditches and canals</td>
<td>Dikes against sea flooding</td>
</tr>
<tr>
<td></td>
<td>Soils: light marine clays and lowland organic peat soils</td>
<td></td>
<td>Saltwater intrusion</td>
</tr>
<tr>
<td>Dunes (400 km²)</td>
<td>Relief: rolling</td>
<td>Deep groundwater</td>
<td>Nature conservation</td>
</tr>
<tr>
<td></td>
<td>Altitude: 0–30m</td>
<td>No rivers, no surfacewater</td>
<td>Prevention of coastal erosion</td>
</tr>
<tr>
<td></td>
<td>Soils: sandy</td>
<td></td>
<td>Prevention of saltwater intrusion</td>
</tr>
<tr>
<td>Total area</td>
<td></td>
<td></td>
<td>Drinking water production</td>
</tr>
</tbody>
</table>

Source: Author.
Changing Values Lead to Water Management Reform in the Netherlands

Toward an Interdisciplinary and Integrated Approach to Agricultural Drainage

Section 3

J. Hoevenaars
### Acronyms and Abbreviations

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>ARD</td>
<td>Agriculture and Rural Development Department</td>
</tr>
<tr>
<td>BMF</td>
<td>Brabantse Milieu Federatie [Brabant Federation of Environment]</td>
</tr>
<tr>
<td>CBS</td>
<td>Central Bureau for Statistics</td>
</tr>
<tr>
<td>DLG</td>
<td>Dienst Landelijk Gebied [Government Service for Land and Water Management]</td>
</tr>
<tr>
<td>EEC</td>
<td>European Economic Community</td>
</tr>
<tr>
<td>EU</td>
<td>European Union</td>
</tr>
<tr>
<td>FAO</td>
<td>Food and Agricultural Organization</td>
</tr>
<tr>
<td>GPS</td>
<td>Global Positioning System</td>
</tr>
<tr>
<td>GWS</td>
<td>Groundwater step</td>
</tr>
<tr>
<td>HPA</td>
<td>Hoofd Productschap Akkerbouw [Producers Organization Arable Crops]</td>
</tr>
<tr>
<td>IAIA</td>
<td>International Association for Impact Assessment</td>
</tr>
<tr>
<td>ICID</td>
<td>International Commission for Irrigation and Drainage</td>
</tr>
<tr>
<td>ICS</td>
<td>Institute for Contemporary Studies</td>
</tr>
<tr>
<td>IKCL</td>
<td>Informatie- en Kennis Centrum Landbouw [Information and Knowledge Centre for Agriculture]</td>
</tr>
<tr>
<td>IPTRID</td>
<td>International Programme for Technology and Research in Irrigation and Drainage</td>
</tr>
<tr>
<td>ILRI</td>
<td>International Institute for Land Reclamation and Improvement</td>
</tr>
<tr>
<td>LLTO</td>
<td>Limburgse Land en Tuinbouw Organisatie [Limburg Organisation of Agriculture and Vegetable Growers]</td>
</tr>
<tr>
<td>NCCP</td>
<td>National Corporation for Crop Production</td>
</tr>
<tr>
<td>NGL</td>
<td>Netherlands Guilder (= 0.45 Euro; = 0.45 US$)</td>
</tr>
<tr>
<td>NGO</td>
<td>Non Governmental Organization</td>
</tr>
<tr>
<td>NRLO</td>
<td>Nederlandse Raad Landbouwkundig Onderzoek [Netherlands Council for Agricultural Research]</td>
</tr>
<tr>
<td>PPY</td>
<td>Practical potential yield</td>
</tr>
<tr>
<td>V&amp;W</td>
<td>Verkeer en Waterstaat [Ministry of Traffic and Water Management]</td>
</tr>
<tr>
<td>VROM</td>
<td>Volkshuisvesting, Ruimtelijke Ordening, Milieu [Ministry of Public Housing, Spatial Planning, and Environment]</td>
</tr>
<tr>
<td>ZLTO</td>
<td>Zuidelijk Land en Tuinbouw Organisatie [Southern Organization of Agriculture and Vegetable Growers]</td>
</tr>
</tbody>
</table>
Acknowledgments

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Many thanks go to the individuals interviewed during the field study: Adriaan van den Boogaart, Sjaak Broekmans, A. Corporaal, Johan van Gestel, Frank Heijens, Jac. van Poppel, and Paul van Poppel.
Abstract

This study reviews agricultural drainage in the Netherlands in the context of general water management. Relations between predominant landscapes, prevailing socioeconomic developments, and the institutions for water management are interpreted from a historical perspective. The processes that have profoundly transformed the agricultural drainage sector over the past 50 years are analyzed.

3. Agricultural Drainage in Historical Perspective

Development of Water Functions

Before 1000 A.D., the Netherlands was sparsely populated, had little part in the economy of Western Europe, and lagged behind in development. Only few areas were suited for settlement-cum-agriculture or settlement-cum-fishing. The main constraint was the hydrological situation. The indigenous population of those days had very limited skill and organization to overcome this constraint. Most of the Netherlands was too wet, susceptible to flooding, and overgrown with peat moors and heavy forests. Small settlements were found only on the higher elevations, mainly in the Sandy Upland and on the levees in the Major River Plains. In the Northern Polder Region, people had developed a system of dwelling mounds (terpen) where they could escape the devastating floods. The oldest of these mounds stem from the sixth century B.C. and are probably the first organized water management measures in the Netherlands. The only region with a much older history of habitation and agriculture is the hilly area of South Limburg, where relatively “dry” land, combined with fertile soils, were abundant.

In the second half of the Middle Ages food, clothing, housing and fuel, safety, and health constituted the primary needs of the people. The Netherlands, like the rest of Western Europe, was the scene of many local armed conflicts between warlords (later called “the nobility”), and every now and then pestilence ravaged the population. The warlords started to erect strongholds and castles. These attracted people who offered their services to the lords, saw opportunities for trade, and eventually sought some protection. Walled cities emerged with a population no longer self-sufficient in food and other primary needs. Thus, a market for agricultural products could emerge. The development of market-oriented farming had already begun. More and more virgin land had to be turned into agricultural land for which drainage and flood protection were prerequisites.

Next to food, the satisfaction of other basic needs was also strongly influenced by the water factor (table 2). Development of these functions was the basis for the development of Dutch society. And, since water in the Netherlands has so many functions, managing it required almost immediately a number of institutions. The Netherlands has never known purely sectoral water management. Agricultural drainage, flood protection, water management for defense, and transport have been interwoven since early times. The development of water functions had adverse side effects, however, which forced the early water managers to look over the top of their own dikes. Table 2 summarizes early functions of water in the Netherlands, with the main management practices and associated long-term degradation of the resources.

The functions were not uniformly distributed over what is the Netherlands today. Diversity in functions was closely linked to the hydroecological regions of the Netherlands and, within these regions, to the
diversity of individual landscapes. Therefore, development of these functions through water management and mitigation of resource degradation is specific for hydroecological regions and even more specific for individual landscapes within them.

Agricultural drainage, often associated with the development of flood protection, thus developed differently in the four hydroecological regions as a result of specific problems and opportunities for development.

Table 2 Early functions of water in the Netherlands

<table>
<thead>
<tr>
<th>Functions</th>
<th>Related practices</th>
<th>Degradation processes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suitability for settlement</td>
<td>- Moats for defense and navigation</td>
<td>- Pollution of water bodies</td>
</tr>
<tr>
<td></td>
<td>- Disposal of sewerage</td>
<td>- Creation of waterlogged areas</td>
</tr>
<tr>
<td>Regulation of flooding</td>
<td>- Construction of sea and river dikes</td>
<td>- Cut off of natural sedimentation</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Land subsidence</td>
</tr>
<tr>
<td>Agricultural productivity</td>
<td>- Agricultural drainage</td>
<td>- Land subsidence</td>
</tr>
<tr>
<td></td>
<td>- Deforestation</td>
<td>- Erosion</td>
</tr>
<tr>
<td></td>
<td>- Land conversion</td>
<td>- Loss of biodiversity</td>
</tr>
<tr>
<td>Fishing productivity</td>
<td>- Gathering from nature</td>
<td>- Overfishing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disappearance of species</td>
</tr>
<tr>
<td>Delivery of drinking water</td>
<td>- Groundwater development</td>
<td>- Saltwater intrusion by overpumping</td>
</tr>
<tr>
<td>Delivery of fuel (peat)</td>
<td>- Mining of stocks</td>
<td>- Erosion of lowland fens</td>
</tr>
<tr>
<td>Delivery of hydroenergy</td>
<td>- Use of water mills</td>
<td>- Flooding</td>
</tr>
<tr>
<td>Navigation</td>
<td>- Construction of canals and sluices;</td>
<td>- Upstream waterlogging</td>
</tr>
<tr>
<td></td>
<td>harbors</td>
<td>- Flooding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Disturbance of fish migration</td>
</tr>
<tr>
<td>Road transport</td>
<td>- Construction of roads; bridges; ferry-</td>
<td>- Desiccation and waterlogging</td>
</tr>
<tr>
<td></td>
<td>dams; fords</td>
<td>- Saltwater intrusion</td>
</tr>
<tr>
<td>Production of building</td>
<td>- Construction of clay pits</td>
<td>- Waterlogging</td>
</tr>
<tr>
<td>materials</td>
<td>- Reeds fields</td>
<td>- Flooding</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Malaria</td>
</tr>
</tbody>
</table>

Source: Author.

South Limburg Hills

At the outskirts of the Ardennes lies South Limburg, administratively a part of the Netherlands, physiographically part of the rolling areas in bordering Belgium and Germany. Three different landscapes are distinguished: plateaus; sloping land; and valley bottoms. The soils consist of rich loams. The area is drained by natural streams that run into the Meuse river. The loamy soils have a good soil moisture capacity but a low infiltration capacity. Except at the narrow valley bottoms, there is no significant excess water constraint for agriculture. Excess water is quickly discharged as overland flow. Soil erosion is pronounced, as a consequence of deforestation, poor agricultural practices, and inadequate surface drainage.

This section is based on Arets (1986).
This is the oldest agricultural region in the Netherlands. Remnants of Roman civilization prove that agriculture was already widespread two millennia ago. Historically, agricultural land use has become specialized according to the agrohydrological limitations of the landscapes. Grassland was found on the wet valley bottoms; orchards with permanent ground cover, and permanent grassland on the slopes; arable cropping on the plateaus. The steepest slopes were left with natural forest.

Since groundwater levels in the hills are mainly deep, trying to control them made no sense. The only landscapes for groundwater drainage were the narrow valley bottoms. Agricultural drainage in this region was confined mainly to surface drainage.

By far the most important drainage practice was to conserve narrow contour strips with natural vegetation during deforestation and land reclamation. These vegetated strips caught the eroded material and developed into seminatural terraces (*graften* in Dutch).

The only function that may have interfered with agricultural drainage was the presence of water mills. To run them, weirs had to be built on streams, causing waterlogged areas upstream of the weir.

**Sandy Uplands**

The typical physiographical pattern of the Sandy Uplands shows low ridges that form the basin divides of the local streams. From here the land slopes gently to the natural streams. At the lower ends of the cross slopes are the streams with their adjacent wet lowlands or brooklands. The lower side of a whole basin normally borders the Main River Plains or the Coastal Polders.

Land use by and large developed according to this pattern. The higher and drier land on the ridges were suitable for early settlements and arable cropping. Here, the need for drainage was limited. The gently
downward sloping parts gradually became too wet for arable cropping but could still serve as grazing areas for cattle and sheep. Where grazing was too intensive, these poor lands degraded into heathland. Over time, a network of open drain ditches was constructed there, to channel excess water into the natural streams or just in local depressions. For many centuries, the brookland remained too wet for use most of the year. Only one cut of hay could be harvested each year, in late summer. Since the individual dry and wet landscapes were all close to the settlements, a mixed farming system developed with arable cropping and animal production on the same farm. One of the most important functions of animal husbandry was to maintain the fertility of the arable land. Sheep and cows grazed on the grassland and heath by day. At night and all winter-long, they were kept in stables. The dung (with its valuable nutrients) was supplied only to the arable land. This process of concentrating nutrients on the arable fields was strengthened by gathering hay in the low-lying brookfields (which were relatively fertile) and sod from heathlands (which were relatively infertile). No wonder that wind erosion became one of the region’s main land degradation processes.

Agricultural drainage was important for the expansion of agricultural land in the Sandy Upland. Field drainage was practiced in two ways.

- Ditches were normally constructed around the fields (except for the highest parts). They offered some control over the groundwater level and discharged surface runoff, but their main advantage was a lower moisture content of the soil during the growing season. The advancement of the growing season in spring time, allowed by improved soil workability of the soil and higher soil temperatures, was also important.

- Where the water table in the streams and ditches remained too high for a reasonable lowering of the groundwater table, or where shallow impervious layers obstructed internal drainage of the soil, the surface was reshaped into beds and furrows. In this way, at least part of the land became drier.

Surplus water from the Sandy Uplands had to be discharged by field ditches. Sometimes they were directly connected with a natural stream, but most of the time collector canals had to be built.

Maintenance of the drainage network was one of the main problems in the Sandy Upland region. Water boards were established in this region around 1850, much later than in the Polders. The boards were responsible for the natural streams and the main collector system. Maintenance of the field ditches was (in contrast to the situation in the Polders and the Main River Plains) an individual responsibility, without any water board inspection or enforcement. Many of the field ditches formed a property boundary
between different landowners. Ditches often ran through the property of downstream landowners. Field ditches were properly maintained only as long as mutual understanding between these landowners was good, which certainly was not always the case. While this situation existed, most of the time the drainage situation in the Sandy Upland was worse than in the low-lying but better organized Polders. Land consolidation improved this situation.

The Main River Plains

The Main River Plains region consists of three important landscapes: the somewhat higher levees along the river course with light sandy-clay soils, the depressions or back swamps at some distance from the river, with very heavy clay soils, and the flood plains outside the winter dikes.³

The levees have been inhabited since prehistoric times. During Roman times, the navigable rivers, together with the dry levees, formed an important transport axis through the wilderness. The drier and lighter soils of the levees were suitable for arable cropping and orchards as well as settlements. The depressions remained empty until 50 years ago. The lowest parts of the depressions were true wetlands, where only some minor natural products were gathered (e.g., water fowl, willow-groves, reeds, fish). Somewhat higher land in the depressions could produce a single hay harvest in late summer. The depressions played an important role in regulating flow and sedimentation. Peak flows of the rivers were flattened by flooding of the depressions. This water slowly returned to the river through downstream creeks, leaving sediment behind.

The flood plains, at some distance from the river, came into being only after the construction of dikes. River dike construction had started around 1300 A.D. After every major flood, with breaches and overtopping, the dikes were built higher and stronger. The last river dike reinforcement program, now almost complete, was started in 1995 after a nearly disastrous flood.

³ This section is based on de Bruin (1988).
The flood plains remain dry most of the summer, which makes the land suitable for grassland. Grassland can survive prolonged periods of flooding when temperatures are low. Arable cropping of the flood plains was also possible but at the risk of crop failure in case of inundation during summer.

Farming systems in the Main River Plains were mixed but with dairy production more important, due to the scarcity of land suitable for arable cropping.

The construction of dikes had and still has some important consequences:

- The river system (the river bed and flood plain) started to rise slowly but steadily because of sedimentation. The flood plain is now about 2 m. higher than the protected land.
- Free discharge of drainage water from the embanked land was no longer possible. Outlet sluices had to be built and, since the water level in the rivers was rising, pumping stations had to be installed more often than not, to pump out excess water.
- The higher water levels in the rivers increased seepage from the river into the lower embanked land. This aggravated the waterlogging process.

Field drainage in the main river plains was determined by soil characteristics and relative land elevation. The flood plain consists of light soils. During summer, the groundwater level, governed by low river water levels, is relatively deep. An extensive network of ditches took care of excess rainfall in summer. On the levee land, a dense network of ditches controlled the groundwater level.

This was different for the depressions. Although the sticky clay can hold a high percentage of water, its hydraulic conductivity is too low for quick infiltration of rainwater and lateral groundwater flow. To
relieve waterlogged conditions, surface drainage was the only solution. The flat land was gradually reshaped into beds, which could be built fairly high. Nevertheless, river plain depressions remained an awkward place for agriculture. Most of the time the land was too wet, but after a dry spell of some weeks, the land could not deliver water fast enough, and the plants and became parched (Groeneveld 1985).

**Coastal Polders**

The Coastal Polders are a manmade hydroecological region, which in the Netherlands came into being in the Middle Ages. The youngest polders (box 4) were formed between 1927 and 1968 by reclamation of parts of Lake IJssel, once part of the sea.

The Polder region consists of two main landscape types, based on soil and hydrology: *marine clay* polders and *peat* polders. Within these two landscapes, there is little diversity. In peat polders, there is so much open water that they could also be called a separate water landscape.

The land use that developed in these polders is strongly related to soil and hydrology. Peat polders were used exclusively for dairy farming, because only grass can stand such high groundwater levels. Clay polders were used exclusively for arable cropping.

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**Box 4 Definition of Polders**

A *polder* is defined as a complex of fields, surrounded by an embankment, with water level control independent of water level control in the surrounding land.

Source: Segeren 1983.

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Bird's eye view on peat polder and old peat mining pits. Photo: Courtesy Roel Slootweg.

Peat fens developed in the fresh backwaters behind the dunes. Packages up to 6 m thick existed before their conversion to agricultural use. Two user practices determined the destiny of peatland in the Netherlands: drainage and peat mining. Farmers started to construct shallow surface drainage systems to dry the top layer and make it suitable for grazing land. At first, tidal drainage removed the water; a simple
wooden culvert with movable flapgate at the downstream end was sufficient. However, this intervention triggered a downward spiraling process of land subsidence (Janssen, 1987), caused by shrinkage as a result of desiccation of the top layer, oxidation of the organic matter, and compaction by the extrusion of water from the saturated zone of the peat soil. The process of land subsidence has proceeded for many centuries, and in most peat polders between 1.5 m and –3 m of the peat package has disappeared.

Agricultural drainage practices in peat polders were and still are very special. They had two objectives: to slow down the process of land subsidence by maintaining a high water level in the polder ditches and canals and to improve agricultural productivity by timely removal of excess rainwater. At the polder level, flood protection and pumping out of excess water are two related activities. Because of the flat topography and the communal dike, individual drainage requirements could not be met. Everybody was subject to changes in water management. The strong mutual interdependence as regards water management was probably the most important key for the establishment of water boards (Dolfing 2000), but it has also given rise to numerous conflicts.

Peat mining was widespread over the lowland fens. The pits, which were filled with water, were prone to wave erosion and could grow into complete lakes. Large tracts of peatland were lost, and larger parts, including cities, were threatened. To stop this process, plans have been developed and implemented since the seventeenth century to reclaim these lakes by building ring dikes and pumping them dry (Schultz 1992). This was made possible by a new technology: pumping with windmills.

The oldest clay polders are on mud flats bordering the estuaries and the northern coast. Later, drained lakes and reclaimed Lake IJssel polders greatly augmented the total area of this landscape type. Clay polders keep water levels lower than do peat polders, and their naturally more fertile marine clay soils are better suited to arable cropping. The hydrological properties of clay allowed control of the groundwater level by a system of open ditches. Flood protection and pumping of the discharge are basically the same as in peat polders.
The Dawn of Water Management Institutions

Most of the earliest land reclamation in the Netherlands started as planned and organized activities of larger groups of people. Around 1000 A.D., religious orders, the first agents, managed to mobilize enough people, capital, and knowledge, to overcome the most immediate technical barriers. Later, (1200–1500) the role of the abbeys and monasteries was taken over by the landlords, who could also, under a feudal system, undertake projects of some size to develop new land and force people to maintain the drainage infrastructure.

The landlords long remained the rulers in the rural areas. However, by the end of the Middle Ages, cities had their own, more or less democratic, local governments. Agriculture in the Netherlands became more market oriented, and the economy became a monetary economy. Rich city people started land-reclamation and peat-mining companies. Many of the polders—drained lakes, reclaimed heath fields, and peat fens—date to this era (Schultz 1992). After the French revolution, the power of the landlords, also in the Netherlands, was reduced. Both their role and their lands were taken over by the United Government (at municipality level or at central level) that emerged after the war of independence against the Spanish king (1648).

At the local level, local institutions organized villagers to maintain the main water courses and roads. These tasks were taken over by a democratic water management institution, the water board.

Water Boards: Institutionalization of Water Management in the Netherlands

Water boards emerged about 800 years ago in the low-lying part of the Netherlands, (Dolfing 2000). Before that time, individuals and small groups of people did the necessary, building dwelling mounds or simply abandoning land that had become too wet for occupation. Between 1100 and 1200 A.D., people began to take structural measures on a larger scale to protect their land from flooding and, more important, organized themselves, often at the instigation of the ruling landlords, to maintain these dikes. As a consequence, drainage, too, had to be managed, since free discharge of polder water was blocked by the flood protection works. The community, therefore, was the first water management organization. Gradually, water management tasks were separated from general local governance, probably to prevent mixed interests.

As more infrastructure was built, and measures taken by one water board began to interfere with others, the water boards developed into functional organizations based on hydraulic boundaries. The classic model of the Dutch water board, developed over a period of some 400 years, changed little until 1992, when the new Water Boards Act (box 5) rewrote the rules on the composition of the Water Board’s Council (Huisman, Cramer, and van Ee 1998). The classic water board was tasked with flood protection, drainage water disposal, and maintenance of minimum and maximum surface water levels.

What started as a spontaneous self-organization of people with a common interest, on a small, local scale, became a functional government for water management. This government was elected periodically, had its own tasks, was self-financing and had a set of rules and regulations, its own policing apparatus and enforcement mechanisms. Disputes between the water government and the users remained under the jurisdiction of the civil courts. Dolfing and Snellen (1999) analyzed the relative success of water boards in the Netherlands. They tested the design principles of Ostrom (1992) for sustainability of self-governing irrigation management systems and added four more (table 3, shaded rows) that seem relevant for Dutch water boards.
Box 5 Water boards in the Netherlands

In 1946, practical water management in the Netherlands was handled by 2,500 small water boards, as compared with 66 boards today. These 66 are organized according to the Water Boards Act of 1992. The organization consists of:

- the General Assembly, elected by three categories: owners of land, owners of buildings, and residents.
- the Executive Council, nominated by the assembly.
- the chief executive (chairman), nominated by the Crown (national government), presides over both the General Assembly and the Executive Council.

A professional staff (administrative and technical) implements the decisions made by the assembly. Water boards are a functional government. Every resident and property owner in the management area is subject to the water board government and has to pay for its services proportionally to his interest, but also has the right to participate in electing a representative board (the interest-payment-say principle).

The distribution of seats in a water board’s assembly is based on this rule, and therefore varies from board to board. In urban regions, the majority of votes normally goes to building owners and residents. In rural regions, landowners are still the majority. The provincial government specifies the national policy for the province and oversees the water boards. The province, every four years, determines the number of seats for each main interest group in each Board Assembly.

The annual budget is shared by the three categories in proportion to the number of seats each holds. Under landownership, subinterests are defined according to the volume of water that needs to be conveyed and the extent of protection needed against flooding.


Table 3 Design characteristics of a self-governing water management organization

<table>
<thead>
<tr>
<th>Principle</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>The service area and the individuals or households with users’ rights are clearly defined.</td>
</tr>
<tr>
<td>2</td>
<td>There is proportional equivalence between benefits and costs.</td>
</tr>
<tr>
<td>3</td>
<td>A financial formula, accepted as equitable, is set forth to secure the organization’s financial viability.</td>
</tr>
<tr>
<td>4</td>
<td>The majority of the users can participate in modifying the rules for use and maintenance</td>
</tr>
<tr>
<td>5</td>
<td>Decisions and rules with regard to use and maintenance are consistent and coherent.</td>
</tr>
<tr>
<td>6</td>
<td>Monitors are accountable to the users or are the users themselves.</td>
</tr>
<tr>
<td>7</td>
<td>Users who violate the rules receive graduated sanctions.</td>
</tr>
<tr>
<td>8</td>
<td>Users and their officials have rapid access to low-cost local arenas for resolving conflicts between users or between users and officials.</td>
</tr>
<tr>
<td>9</td>
<td>Decisions and rules guiding and directing rules on use and maintenance have to be present, consistent, coherent, and transparent.</td>
</tr>
<tr>
<td>10</td>
<td>The enterprises are nested.</td>
</tr>
<tr>
<td>11</td>
<td>Rights to organize are recognized.</td>
</tr>
<tr>
<td>12</td>
<td>In addition to recognition of rights to organize, external (governmental) authorities provide support for management activities and conflict resolution between self-governing organizations that manage natural resources.</td>
</tr>
</tbody>
</table>

Source: Dolfing and Snellen 1999.
One important factor in the success of the water boards was that they were not forced to develop in a uniform way; they were self-designed according to the needs of the management area. For the hydroecological regions, tasks were of varying importance. The South Limburg Hills and the Sandy Upland regions did not need flood protection dikes or precise water level controls; the River Plains needed river dikes and river training. The Coastal Polders needed sea dikes (quite different from river dikes), exact regulation of water levels, pump drainage, control of saltwater intrusion and erosion, and scouring of peat pits and lakes.

From the standpoint of integrated water management, classic water boards are not equipped to manage water in the interest of all users recognized today, although they did serve more than one interest group right from the beginning. Protecting land from flooding favors settlements; conveying and disposing of surplus water allows agricultural drainage necessary for food production; maintaining water levels in canals and rivers not only serves agriculture but also allows shipping. (For further reading on water boards, see Appendix A, van Gestel, Heijens, and Broekmans.)

The Land Consolidation Program

Knowledge of the land consolidation program is needed to understand the agricultural drainage situation in the Netherlands. Improving agricultural drainage was one of the main activities in this program. This program covers 1,500,000 ha—almost 45 percent of the total land area and 65 percent of the present agricultural area (Groeneveld 1985). The Government Service for Land and Water Management is responsible for general coordination and implementation of the program.

Due to cheap imports of agricultural products from America and Australia at the end of the nineteenth century, Dutch agriculture could no longer compete on the world market, and the rural population was becoming impoverished. Fragmentation of land holdings was considered the biggest constraint to agricultural modernization. Some small land reallocation projects were implemented on a voluntary basis after 1905, but a few landowners who did not want to participate often blocked such projects. By 1924, the call for land reform had become so strong, that the Parliament passed the first Act on Land Consolidation. The act, meant only for agriculture, provided for three main interventions: reallocation of parcels, improvement of the drainage situation, and improvement of the road system. As regards drainage, it was also decided that users would be responsible for the construction and maintenance of surface and subsurface field drains. The surface drain maintenance was enforced through annual inspections, with financial penalties for noncompliance.

The decision to have a land consolidation project was entrusted to the landowners in the project area. Initially, a double majority of votes was required: on majority based on individuals (heads), the other based on land area owned. This double requirement proved too limiting, and the act was amended in 1938. A land consolidation project would be approved if only one of the two criteria showed a majority, an arrangement that favored the bigger landowners. Already in 1924 it had been decided to put commissions, consisting of local stakeholders, in charge of the executive work, and a professional staff of surveyors and engineers was assigned to each commission. Government and stakeholders shared the costs of the project, respectively, in an 80-to-20 ratio. The projects were thus heavily subsidized. Each stakeholder had to pay in proportion to the (estimated) net profit to be gained from the project, and the contribution had to be paid in fixed annual installments over a 30-year period.

The land consolidation projects had both positive and negative consequences. From the point of view of agriculture, there were mainly benefits (table 4). Production costs dropped, and yields rose dramatically
(undoubtedly also due to intensified drainage). More opportunities emerged for specialized agricultural production and, as new roads made rural areas more accessible, rural standards of living improved.

The negative consequences also became evident, but not for some time and only after more and more land consolidation projects had sprung up across the Netherlands. The erstwhile small-scale and location-specific land and water development had generated a rich variety of landscapes and joint biodiversity.

Table 4 Some economic effects of land consolidation

<table>
<thead>
<tr>
<th>Cost-reducing factors</th>
<th>Yield-improving factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanization instead of labor</td>
<td>Direct increases in yield through improved drainage</td>
</tr>
<tr>
<td>More time-efficient farming (defragmentation)</td>
<td>Wider choice of varieties</td>
</tr>
<tr>
<td>Lower transport costs from and to the farms</td>
<td>Improved opportunities for specialization</td>
</tr>
<tr>
<td>Lower storage losses</td>
<td>Less animal disease</td>
</tr>
<tr>
<td>Up-scaling of farm enterprises</td>
<td>Higher product quality</td>
</tr>
</tbody>
</table>

Source: Author.

Large parts of the Netherlands lost much of scenic charm and biodiversity due to the large-scale land consolidation programs and the sharp increase in fertilizer use. The landscapes left by the projects were uniform, geometric, stripped of hedges and trees, and full of canal-shaped rivers and brooks—not very enticing to city people looking to the countryside for recreation. Then, people started to realize they had paid for most of it through their taxes.

The other target of criticism was the nature side. The loss of biodiversity and the deterioration of many wetlands (because of desiccation through intensified drainage) triggered the organization and mobilization of nature protection groups, mainly nongovernmental organizations (NGOs).

The growing dissatisfaction of large groups with the land consolidation practices gained political weight. Many rural area functions were eroding, and the many users of these functions were not represented in the decisionmaking process. When, after World War II, food security became the main issue, the overriding argument to promote and subsidize agriculture focused the land consolidation projects. But when prosperity returned to the Netherlands the food security argument lost power in the face of demand for recreational opportunities and an ecologically rich environment. In 1954, an amendment to the Land Consolidation Act obliged for the local executive commissions to allocate 5 percent of the project area to recreation and nature. A major revision in the Land Consolidation Act in 1985 provided for representation of other interest groups (e.g., environmentalists, water boards, and municipalities) in decisionmaking and in the Executive Commissions.

4. Socioeconomic Impacts of Agricultural Drainage

Agricultural drainage has always been part of package programs like land reclamation and land consolidation. It is therefore difficult to separate the socioeconomic impact of agricultural drainage as a single intervention from the overall impact of these programs.
Economic Benefits of Field Drainage

The direct farm economic benefits of field drainage can be gauged by comparing “with” and “without” cases. For instance, simple tile drainage installations at the farm level can be compared, assuming that downstream collection and disposal of the effluent does not pose a constraint. A methodology for estimating the economic effects is presented below.

If only pipe drains are installed and all other production factors remain the same, the production level of a crop will change and eventually the quality of the produce as well. The direct effect is caused by changes in the in-situ agroecological system such as:

- Improved air-moisture ratio in the soil
- Higher in soil temperature in the spring
- Increased availability of nutrients for the crop
- Decreased plant or animal diseases
- Increased bearing capacity of the land (less crop damage by machinery or grazing animals).

Subsequent economic effects of agricultural field drainage on yields are accrued by:

- Expanded opportunities for mechanization
- Expanded opportunities for high-yielding varieties
- Decreased need for herbicides
- More efficient fertilizer application

Use of subsurface pipe drainage means:

- Less land is lost for drains.
- The groundwater level can be controlled more closely.
- There are more opportunities for large land parcels and mechanization.

Surface drainage measures for erosion control (in the hills) often lead to higher immediate production costs, mainly because they present more obstructions to mechanization. The benefit of erosion control becomes visible only after a number of years, as land that is not controlled loses its productive top-soil and develops rills and gullies. Because of this time lag between costs and benefits, erosion control measures are never very popular. The same mechanism shows up in the mitigation of land subsidence. Deep drainage of peat soils gives short-term benefits for agriculture and long-term costs for pumping, strengthening of dikes, and damage to buildings and infrastructure.

In the Netherlands, much research has been done to find the relation between production levels and controlled groundwater levels (figure5). These relative production curves are specific for the following parameters: soil type, crop type and rooting depth, and rainfall distribution during the growing season.

Crops planted in coarse soils and clay soils respond differently to groundwater depth because soil moisture storage and capillary rise are different in the two types of soil, smaller for coarse sand than for heavy clay soils.
The Effects of Decommissioning Agricultural Drainage

Today agricultural drainage in the Netherlands has reached its optimal state, a compromise between technical possibilities and economic effects (Huinink, Verstraten, and Janssen 1998). However, taking into account other functions of water, the agricultural drainage optimum exceeds the overall optimum, which is the maximum net sum of all drainage costs and benefits. This general maximum is hard to determine, because benefits are valued differently in different value systems. The economic benefits of agricultural drainage have to be weighed, for example, against social well-being. Such choices belong to the realm of politics, not economics. In the Netherlands, the present policy is to back off from the agricultural drainage optimum in areas where regained benefits (e.g., in terms of nature and recreation) are high and agricultural losses minimal.

![Figure 5 Yield-groundwater depth relations](image)

Source: Adapted from van der Molen 1968.

Table 5 Main soil groups used for yield reduction calculations

<table>
<thead>
<tr>
<th>Group</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>V</td>
<td>All peat soils</td>
</tr>
<tr>
<td>W</td>
<td>Peaty-sandy and peaty-clayey soils</td>
</tr>
<tr>
<td>K1</td>
<td>Clay and silty-clay soil with peat subsoil</td>
</tr>
<tr>
<td>K2</td>
<td>Clay and silty-clay soil with sandy subsoil</td>
</tr>
<tr>
<td>K34</td>
<td>Clay and silty-clay soil with heavy clay layers or subsoil</td>
</tr>
<tr>
<td>K5</td>
<td>Homogeneous clay and sandy-clay soils</td>
</tr>
<tr>
<td>H1</td>
<td>Podsolos with less than 30 cm organic A-horizon</td>
</tr>
</tbody>
</table>
Agricultural drainage cannot be decommissioned, however, without compensating the farmers. Therefore, the agricultural costs of decommissioning (decline in productivity) have to be estimated in order to serve as a reference point for compensation. The costs are calculated as follows:

**Step 1.** A number of soil-representative areas were selected, where the Dutch Central Bureau of Statistics (CBS) monitors yields regularly. Soils were aggregated in 11 soil groups (table 5).

**Step 2.** Central to the procedure is the classification of the groundwater situation before and after an intervention. The single parameter used for this is the “groundwater step” (GWS). It indicates the mean high groundwater level in winter, and the mean low groundwater level in summer (table 6).

**Step 3.** For most crops in the Netherlands the practical potential yields (PPYs, in kg/ha) and financial farm economic result (in dollars/ha) have been determined for different zones (similar to hydroecological regions). PPYs are updated from time to time.

**Step 4.** For the 110 combinations of soil groups and GWSs, tables have been developed, presenting yield reductions (compared to the PPY) due to excess water and due to drought for the most important crops (the “HELP-tables”). Yield reductions are based on average yields obtained from the CBS monitoring.

**Step 5.** Comparing the yield reductions of a crop-soil group combination for the old and the new groundwater step results in the actual yield reduction (in kg and dollars/ha). The key is: total yield reduction as compared to the practical potential yield (100) is the yield reduction due to excess water minus the yield reduction due to excess water times the yield reduction due to drought, or in mathematical terms:

\[
\text{Total yield} = (100 - YR_{e.w.}) - (100 - YR_{e.w.}) * (Y.R_{d.r.}/100).
\]

Example: Potato yield reductions (percent) for excess water and drought for a clay soil (K5) and a sandy soil (H1).
The overall yield reduction caused by closing drainage outlets on this land would be 6 percent of the practical potential yield if the groundwater step goes from VI to III. A farmer growing potatoes in clay soil would be compensated more than a potato farmer with sandy soil, although they end up with the same yield after the drainage decommissioning.

The tables can be used the other way around as well (Huinink, personal communication). They are a tool for estimating the effect of intensified field drainage of agricultural land.

**Drainage: Part of a Package Program**

Most agricultural drainage was developed as part of a package. In land reclamation, drainage has always been part of total activity, after, for example, deforestation and dike construction. In land consolidation projects, drainage is also a complementary activity after re-allotment of land parcels and road construction. For such integrated activities, trying to attribute costs and benefits to drainage alone is pointless. It is “all or nothing,” and cost-benefit calculations should be related to the entire intervention (figure 6). Table 7 shows some effects of a land consolidation project.

**Table 7 Effects of land consolidation projects in the Netherlands**

<table>
<thead>
<tr>
<th>Parcel characteristic</th>
<th>Without project</th>
<th>Arable land</th>
<th>Arable land</th>
<th>Arable land</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grassland</td>
<td>Arable</td>
<td>Grassland</td>
<td>Arable</td>
</tr>
<tr>
<td>Average plot area (ha)</td>
<td>2.0</td>
<td>4.0</td>
<td>3.0</td>
<td>9.4</td>
</tr>
<tr>
<td>Distance of farm building to land (km)</td>
<td>1.4</td>
<td>1.1</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>Number of parcels per farm</td>
<td>4.9</td>
<td>6.2</td>
<td>2.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Percentage of parcels contiguous with farm buildings</td>
<td>40.0</td>
<td>28.3</td>
<td>75.5</td>
<td>50.7</td>
</tr>
</tbody>
</table>


Figure 6 shows the compound economic impact of a number of land consolidation projects in the Netherlands (Vonk 1995).

**Social Impacts of Agricultural Drainage on Farm Families**

The social impact of agricultural drainage is even more difficult to isolate from overall rural development projects like land consolidation projects. In the first place, economic benefits have a strong social multiplier effect. And social impact and financial impact are expressed on different value scales. Quantification of social benefits is impossible, unless certain quantifiable proxies are adopted. In the Netherlands, the correlation has always been strong between poor drainage of agricultural land and the land users’ social backwardness. De Bruin (1988) describes this phenomenon for the Main River Plains. Agricultural drainage had positive effects on crop security, healthy living conditions, and accessibility of settlements.
**Crop security**

The direct effect of agricultural drainage in general is to lower the groundwater level, which greatly increases the soil’s water storage capacity. For example, for sandy soil with a 50 cm. lower drainage basis, the extra storage capacity amounts to between 100 mm and 200 mm. This means that the frequency and duration of saturation of that land, especially during the growing season, drops considerably. With drainage, crop failures from prolonged waterlogging disappeared almost completely. (Other constraints, like soil fertility and drought sensitivity were not alleviated by agricultural drainage.)

![Figure 6 Compound benefit-cost ratios for land consolidation projects in the Netherlands](image)

Note: US $1 = DFL 2.2. Source: Vonk 1995.

**Living environment**

Farm houses in the Netherlands were frequently built (and still are) right on the farmland. When the groundwater level of the land was high, the houses were damp, and people suffered from rheumatism and the like. Lowering the drainage basis has improved living conditions in most such places.

**Accessibility**

Roads in badly drained areas were often little more than mud tracks, difficult to travel. Transport to remote farms was difficult and expensive. Doctors could not reach the houses, children had to make a long trip to school, market places were difficult to reach. Deeper drainage of all land was the first step to improving the road systems. Later, land consolidation projects provided for all-weather roads, even in the most remote places.

Thus, to improve rural living conditions, drainage had to be improved, but that was not sufficient. The whole scale of infrastructure had to be reconstructed in complementary programs as well. Once the
waterlogging problem had been solved, drought sensitivity became the next constraint. By and large, farmers individually could solve this constraint, using surfacewater in the improved drainage systems in the Polder and River Plains regions, and the abundant, but not unlimited, supply of groundwater in the Sandy Upland and the Hills regions.

5. Present Trends and Issues in Dutch Water Management

Before 1960, water management in the Netherlands was organized by user sectors, and for some sectors it was not organized at all. Each sector tried to optimize water management for its own sectoral (or subsectoral) objectives. Agricultural drainage institutions focused merely on optimizing groundwater levels and surfacewater discharges to maximize agricultural production. Municipalities and industries disposed of wastewater as cheaply as possible, which meant dumping it untreated into the water system. Pumping groundwater for sprinkler irrigation started as recently as the 1960s without any regulation or licensing because groundwater was still considered an inexhaustible resource. To protect low-lying land from flooding, higher dikes were built, and there was more river training. Economic values took undisputed precedence over social and ecological values.

Now, nearly a half century later, agricultural drainage is being criticized for its negative effects on the scenery, on wetlands, and on water quality. Licenses are needed to extract groundwater; all wastewater has to be treated; water conservation in water-rich Netherlands has become a prominent issue; and the justification for building higher dikes is being seriously questioned. The old water management beliefs and certainties have completely evaporated. Now the classic institutional arrangements for water management, including agricultural drainage, have to be transformed as well, a process that has just begun. It is impossible to pinpoint the moment or identify the precise event that triggered this turnaround in thinking on water management, but it was an inevitable result of other developments. This section tries to unravel the main contributing factors to this paradigm shift in water management in the Netherlands and discusses the institutional response to it.

Main Autonomous Developments

Three main developments have completely changed water management in the Netherlands in the past 50 years. First, competition for space among different user groups has intensified tremendously, and one use is expanded at the expense of another. In other words, the functions of land and water are changing dramatically. Second, related to these functional changes, the relative values assigned by the public to different functions have also shifted. Third, the threat of climate change, combined with a series of floods and near floods, has an important psychological influence on the long-term water management planning processes.

Competition for space

The Netherlands has developed into a densely populated, heavily industrialized and prosperous country. This trend, moderate until the early 1960s, then took off. Table 8 shows demographic developments and changes in land use in the past century.

Not only has the agricultural land area decreased, (a process hidden for a while by the reclamation of the 1,650 km² Lake IJssel), but pressure is also building to convert agricultural land into land for
multifunctional use—such as water conservation, recreation, and ecological functions. Multifunctional use always puts pressure on current agricultural practices, including drainage.

**Shift in functional values of land and water**

During World War II and its aftermath, the Netherlands suffered from famine and severe unemployment. Many homes and much of its industrial infrastructure had been destroyed. Disastrous sea flooding in the South Western Polders in 1953 was the major event of the postwar period. In this environment, policy goals were clear: food security; rebuilding and quick replenishment of the housing stock; free expansion of industries; safe dikes. All attention went to producing enough goods and services—volume rather than quality—more food, more houses, more jobs, and zero flooding risks.

<table>
<thead>
<tr>
<th>Year</th>
<th>Population (million)</th>
<th>Total water(^a) (x 1,000 km(^2))</th>
<th>Total land (x 1,000 km(^2))</th>
<th>Agriculture(^b) percent of land</th>
<th>Nature(^c)</th>
<th>Urban</th>
</tr>
</thead>
<tbody>
<tr>
<td>1890</td>
<td>5.9</td>
<td>10.1</td>
<td>31.5</td>
<td>68.6</td>
<td>26.5</td>
<td>4.9</td>
</tr>
<tr>
<td>1930</td>
<td>7.8</td>
<td>9.5</td>
<td>32.1</td>
<td>73.0</td>
<td>21.2</td>
<td>5.8</td>
</tr>
<tr>
<td>1950</td>
<td>10.0</td>
<td>8.5</td>
<td>33.0</td>
<td>76.1</td>
<td>15.3</td>
<td>8.5</td>
</tr>
<tr>
<td>1970</td>
<td>13.0</td>
<td>7.8</td>
<td>33.8</td>
<td>74.6</td>
<td>14.7</td>
<td>10.7</td>
</tr>
<tr>
<td>1985</td>
<td>14.7</td>
<td>7.6</td>
<td>33.9</td>
<td>70.6</td>
<td>13.3</td>
<td>16.1</td>
</tr>
<tr>
<td>1996</td>
<td>15.8</td>
<td>7.7</td>
<td>33.9</td>
<td>69.4</td>
<td>13.6</td>
<td>17.0</td>
</tr>
<tr>
<td>2030 low</td>
<td>18</td>
<td>7.8</td>
<td>33.7</td>
<td>64</td>
<td>16</td>
<td>20</td>
</tr>
<tr>
<td>2030 high</td>
<td>20</td>
<td>7.8</td>
<td>33.7</td>
<td>55</td>
<td>22</td>
<td>23</td>
</tr>
</tbody>
</table>

Notes: Changes relate to: \(a\). Conversion into drained lakes. \(b\). Conversion from/to water, nature, urban uses. \(c\). Conversion to/from agriculture. Source: VROM 2001.

After two decades of restoration, the immediate needs of the population (for food, jobs, and housing) had been satisfied, and wages started to rise. A plan for protecting the coastal polders against floods had been prepared and construction had begun. The Netherlands had become part of the European Economic Community (EEC), for which agriculture was the main sector for common policies and regulations. Dutch society was changing. People had more wealth and wanted a better quality of life to go with it: better and more diversified food; more luxury in and around the house; more time for recreation. The stress on food self-sufficiency waned, since supplies were guaranteed by the large EEC economic entity. Fast and disorderly growth, however, had marred the quality of the environment, polluting water, air, and later also the land.

In agriculture, the EEC strongly stimulated scaling-up and specialization to provide farmers with decent incomes and consumers with reasonably priced food. The industrial and services sectors could easily absorb displaced farmers, and land consolidation programs created optimum conditions for large-scale farming. The result was a highly productive but uniform, geometric landscape. Just as people were beginning to have leisure time for recreational activities in the countryside, their rural surroundings were less and less inviting.

In the Netherlands plans are under way for the “reconstruction” of rural areas to respond to demand for environmental quality. This effort can be seen as a follow-up to the land consolidation program of the 1950s through the 1990s. To understand the current role and future of agricultural drainage in the Netherlands, it has to be viewed in this national and regional planning context.
A typical case in the reconstruction program is presented in a policy note from Noord Brabant province (van Dortmont and Prins 2001). This note revolves around the various functions of the rural area (land and water): agriculture (in different manifestations), recreation, flood regulation, nature (including forests), drinking water, water conservation, cultural-historical significance, archaeological significance and settlement.

**Threat of climate change**

In the 1980s, people became aware that the Earth had slowly been warming-up. Most experts agree that global warming will bring changes in sea level and in rainfall characteristics. Since climate change is a slow process, it is particularly important consideration for long-term planning (box 6).

Comparable to erosion and land subsidence, climate change demands investments now to prevent future damage. Normally, such measures are postponed for short-term financial reasons until something goes drastically awry. In the low-lying parts of the Netherlands, however, in the Coastal Polders and the Main River Plains, living near water entails risks, and people are ready to accept financial sacrifices now for safety in the future. Two climatic events have also helped the government make some far-reaching decisions. The flood disaster in 1953, when the sea covered most of the southwest part of the country and 1,850 people died, triggered the decision to plan and implement the Delta Works. And the near-flood of the Rhine river in 1995 gave decisive impetus to start discussions for a completely new policy of river-flood prevention within the context of debate on climate change.

**Main Environmental Issues**

Next to external developments, land and water management practices of the past have had their own impact on the present situation. While their positive contribution to the Netherlands development and very existence have been overwhelming, these interventions in the natural system had negative repercussions on the environment. Combined with demand for a better quality of life, these negative effects have strongly influenced the perceived values of certain uses. They are now the main issues in water management in the Netherlands.

**Eutrophication and pollution of the water system**

The main sources of water pollution and eutrophication are: domestic and industrial sewage dumped directly in surfacewaters, organic and inorganic residues of agrochemicals and organic manure, reuse of already polluted river water for irrigation and maintaining minimum water levels in polders, and emissions (acid rain) by agriculture, industry, transport, and households.

Pollution of water courses by domestic and industrial sewage destroyed water ecosystems. It killed fish and other aquatic life, caused sometimes unbearable odors, resulted in loss of water for recreational swimming and other water sports, created problems for drinking water companies that rely on surfacewater.
The Rhine river is the most important external water source for the Netherlands. Its water replenishes surfacewater in the Polder region. The smaller Meuse river, less important for this purpose, is less contaminated. Its water is used for domestic purposes for some densely populated areas. Until the 1980s, the Rhine was so heavily polluted its water was unfit for drinking water and so high in salts it could not be used to water vegetables. The sediment carried by the Rhine was treated as chemical waste. Nevertheless, this water has always been used to replenish polder water in the Main River Plains and the Coastal Polders. The main purpose was to keep peat from sinking and groundwater levels high enough for agricultural production. This surfacewater is also widely used in sprinkling irrigation.

Agriculture is another main source of pollution and eutrophication of the Netherlands water bodies. Due to the emergence of the bioindustry, the supply of organic manure on agricultural land has increased tremendously since the 1960s. Many soils became saturated with phosphates. Nitrates were formed so abundantly that crops could not absorb all of it. Overfertilization of land means that part of the nutrients are leached out with the drainage water. These substances pollute the shallow and, in the long run also the deeper, groundwater, and the surfacewater receiving the drainage water eutrophies. Algae proliferate and, when they die and rot, water becomes deoxygenated. Destruction of aquatic ecosystems and smelly waters are the consequence. The problem is compounded by the bioindustry’s concentration in the Sandy Upland, where the soils are least able to bind the nutrients, so they are quickly released into the drainage system.

Other dangerous substances transported with drainage water are agrochemical residues of inorganic fertilizers, pesticides, and herbicides. This phenomenon is not specific to any hydroecological region, although sandy soils leach them out easily, and surface runoff from the hills also transports them quickly to the surfacewaters.

Many measures have been taken to stop this pollution or mitigate its effects.

- An extensive program to treat almost all sewerage water before disposal has almost been completed.
  - To decrease the amount and severity of pollutants, the polluter-pays principle was introduced into legislative provisions and awareness campaigns.
- To improve water quality in the Rhine, the Meuse, and the smaller rivers, bilateral and multilateral negotiations with the upstream countries have slowly achieved some success (table 9).

**Table 9 Water quality of the Rhine river at the German-Dutch border**

<table>
<thead>
<tr>
<th>Chemical</th>
<th>1972</th>
<th>1985</th>
<th>1993</th>
<th>Reduction 1993/72 (%)</th>
<th>Natural load</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury (t/yr)</td>
<td>99</td>
<td>5</td>
<td>2.5</td>
<td>97</td>
<td>0.7</td>
</tr>
<tr>
<td>Cadmium (t/yr)</td>
<td>167</td>
<td>9</td>
<td>2.8</td>
<td>98</td>
<td>1</td>
</tr>
<tr>
<td>Chromium (t/yr)</td>
<td>3,627</td>
<td>378</td>
<td>251</td>
<td>93</td>
<td>240</td>
</tr>
<tr>
<td>Lead (t/yr)</td>
<td>2,000</td>
<td>441</td>
<td>346</td>
<td>83</td>
<td>75</td>
</tr>
<tr>
<td>Copper (t/yr)</td>
<td>2,018</td>
<td>473</td>
<td>314</td>
<td>85</td>
<td>70</td>
</tr>
<tr>
<td>Nickel (t/yr)</td>
<td>—</td>
<td>356</td>
<td>219</td>
<td>—</td>
<td>—</td>
</tr>
<tr>
<td>Zinc (t/yr)</td>
<td>13,800</td>
<td>2,995</td>
<td>1,724</td>
<td>88</td>
<td>250</td>
</tr>
<tr>
<td>TOC (kg/s)</td>
<td>29</td>
<td>13</td>
<td>8</td>
<td>72</td>
<td>—</td>
</tr>
<tr>
<td>Oxygen (mg/l)</td>
<td>4.4</td>
<td>8.0</td>
<td>10.0</td>
<td>56</td>
<td>10</td>
</tr>
<tr>
<td>Phosphate (kg/s)</td>
<td>1.3</td>
<td>1.0</td>
<td>0.5</td>
<td>63</td>
<td>0.2</td>
</tr>
<tr>
<td>NH₄ (kg/s)</td>
<td>1.0</td>
<td>1.4</td>
<td>0.5</td>
<td>47</td>
<td>0.3</td>
</tr>
</tbody>
</table>

The manure problem has been attacked in several ways. The objective was to reach and maintain a balance at farm level between nutrient supply and absorption by crops, allowing for an unavoidable small net leaching component. Each farmer must keep records of all the nutrient inputs and outputs on his farm, all fertilizers, manure, and agricultural products entering or leaving the farm. The norms for nutrient application are differentiated by soil types and crop groups. A farmer exceeding the norms is fined proportionally to the overapplication, but a farmer with a nutrient surplus can sell it to a farmer with a deficit at a price set by the free market. An inspection team supervises the regulation with the help of annual satellite imagery and detailed soil and topographical monitoring at parcel level. In another approach to the problem, the government is allowed to buy out bioindustrial farmers’ production rights. As a result of these measures, the pig population, for example, fell by 1 million heads over four years. A third measure to mitigate nutrient leaching is a regulation forbidding farmers in the Sandy Upland region to apply organic manure between October 1 and February 1, the winter, when crops do not absorb any nutrients. A fourth measure, particularly close to the hearts of the bioindustrial farmers, would diminish the nutrient content of dung by using more efficient animal feeding methods.

The restrictions on nutrient application, started in 1987 under the Soils Protection Act, are still evolving. Results, in terms of amelioration of surface and groundwater quality, are promising. However, groundwater systems react slowly, and it will take several decades to attain the quality norms set for groundwater.

**Desiccation**

The Netherlands has a net annual surplus of water, but temporary shortages occur locally for a number of reasons. First, some water is not suitable for every use. Water quality is most problematic in the River Plains and Coastal Polder regions. Second, during summer, there is a net deficit between rainfall and evaporation-cum-drainage, which means that buffers have to make up for the difference to allow optimal crop growth. Buffers are formed by the storage of natural soil moisture in winter and replenished by capillary rise from shallow groundwater in summer. Buffering capacity is lowest in the Sandy Upland region, due to the soil’s poor moisture retaining properties and the depth of groundwater. In most land consolidation projects, priority was given to lowering the groundwater table instead of to conserving water for drought periods. Thus, the winter’s water surplus is quickly drained-off. The problem worsened after sprinkling irrigation, using groundwater, became popular in this region in the 1970s. Many drinking water companies also extract raw water in the Sandy Upland because of its good quality.
All together, the groundwater table dropped between 0.5m and 1 m in the lower parts of the Sandy Upland and sometimes more than 5 m in the higher parts. It took some years for the effects to become noticeable, as wetlands and forests began to dry up. Occasionally, agricultural land in the higher parts was more productive then optimally drained land in the lower parts, and farmers who did not receive the benefits were paying the costs.

Several measures have been introduced to conserve water and prevent desiccation. Most of these measures relate to the Sandy Upland and make use of the drainage system. (Cases are presented in Appendix A, van de Boogaart and Jac. van Poppel). These measures are:

- Controlled compartmentalization of surface and groundwater to create protective zones around the most valuable wetlands
- Augmentation of the number of regulating structures in drainage channels to fine tune the groundwater level to the locally required optimum.
- Complete closure of drains in forests to retain and infiltrate rainwater. Water conservation is also one function of the new wetlands.
- Restrictive regulations to improve the efficiency of sprinkling irrigation. Farmers are allowed to sprinkle only in June, July, and August and never during the day. All water pumping installations with a capacity of more than 10 m$^3$/hr are subject to licensing. Soon, extraction of groundwater is expected to be metered and priced.
- Quality improvements in surface water so that it can be used for irrigation. This is confined mainly to the River Plains and Coastal Polders

*Loss of biodiversity*

The biotic environment is another natural resource, delivering goods and services to society, which individuals appreciate or dislike. Biodiversity is a quality of biotic resources, as fresh or salt is a property of water. Biodiversity is usually subdivided into genetic diversity, species diversity, and diversity of ecosystems (Slootweg and Kolthoff 2001).
Loss of biodiversity is usually an indirect effect of changes in the abiotic environment. Desiccation, eutrophication, and acidification all lead to imbalances in the prevailing ecosystems that cause some species to (almost) disappear and other populations to explode. Most of the time the nasty species—both flora and fauna—survive. Nitrogen-responsive plants, fast growers by definition, invade the fields. Caterpillars appear by the millions, no longer eaten by cuckoos, small birds that disappeared after losing their niche when hedges were removed during land consolidation projects . . . And so on, up and down the chain. As a response to plagues, man’s first reaction is to grab the sprayer and destroy the invader. But this leads from bad to worse, because the whole ecosystem becomes thinner. Moreover, the accumulation of poison also directly threatens society’s other resources.

Agriculture and agricultural drainage are not responsible for all biodegradation, but they deserve blame for a large part of it. Several mitigating measures have been taken to stop further dismantling of ecosystems:

- Regulations governing choice and application of agrochemicals have been tightened.
- More and more areas are being acquired by government for use exclusively for conservation and ecosystem survival purposes.
- More and more areas are being dedicated to combined agricultural and natural uses.

Landowners are being offered a choice of subsidies (under a number of conditions), for instance, for cultivating some small natural landscape elements (e.g., hedgerows, small ponds), or maintaining an ecologically rich piece of land in its pristine state (Laser 2000). Subsidies to maintain the most valuable ecological features can be as high as US$2,500/ha/yr. This should be compared with a “normal” annual benefit of a fodder crop like silage corn of about US$700 /ha/yr.

Local flooding, erosion, and siltation

Sometimes small rivers cannot discharge their peak flows without spilling over their embankments and submerging tracts of low-lying land. Flooding has always occurred, but it is becoming increasingly problematic for three reasons:

- These local floods are becoming higher and more frequent.
- Cities and villages have expanded into the lower, flood-prone land.
- For the inhabitants of built-up areas prone to floods, flooding is less acceptable than in the past. The cost of damage is higher because infrastructure and houses have a higher economic value today.

The observed trend toward higher and more frequent floods has several explanations. First, canalization of drainage canals allows quick discharge of water, with higher peak flows in tributaries. This effect is partly neutralized, because most agricultural land has a deep drainage basis, which allows storage of water in the soil. Second, the percentage of land that has no storage capacity at all has expanded and is still expanding fast. Structures with hard surfaces like greenhouses, paved roads, and houses slough off rainwater, and compaction of arable land by heavy machinery decreases its threshold values of infiltration. Finally, rainfall characteristics are changing as a result of climate changes.

Local flooding occurs along local rivers in the Hilly region and the Sandy Upland. In Coastal Polders, the pumping capacity needed to handle intense discharges is apparently not available. The problem is most significant in polders with greenhouses and newly expanded cities.
Flooding in the Hilly region is aggravated by erosion of steep slopes and siltation of the slush in the lower parts of the river basin. The silt adds considerably to flood damage as it settles in the river beds, decreasing their discharge capacity. Erosion and siltation also occur in the Sandy Upland but the problem is less severe than in the Hilly region. Much of the problem is generated in the upper catchments of local rivers in neighboring countries.

Flood-management measures are specific to the different hydroecological regions. In the Hilly region, a program of surface runoff and erosion control is being implemented (Appendix A, Heijens). This program consists of several components. Farmers are encouraged to use contour cultivation to slow down surface runoff. For the steepest and most erodible slopes, land use restrictions have been imposed on farmers, limiting plantings to grassland, forests, and other permanent vegetation. The surface drainage system is being protected against erosion and undercutting. Small flood retention tanks are being constructed to store runoff peaks. Prohibitions on the construction of new housing or industrial areas in flood-prone places are being discussed.

To lower the risk of flooding in the Sandy Uplands, programs are being developed and some aspects have been implemented. The strategy consists of four elements:

1. Slowing down drainage and runoff from the higher parts of the basin. This can be achieved by constructing retention basins (larger than those possible in the Hilly region), by restoring (decanalizing) meandering rivers and brooks, and by creating (semi-) natural wetlands at strategic locations, which also can store water for some time.

2. Installing sand traps to concentrate sedimentation and prevent loss of discharge capacity by dredging.

3. Allowing controlled flooding in areas with the lowest potential for damage, usually agricultural land in the low parts of river valleys.

4. Constructing flood protection devices (embankments, bypass canals) in areas with the highest potential for damage.

In the Polders, the only thing that can be done is to expand storage capacity (open water surfaces) and pumping capacity. Storage capacity in the Peat Polders is limited, because the water level has to be kept high to prevent land subsidence.

Flooding risks in the main rivers

In 1993 and 1995, the Rhine and the Meuse rivers breached the dikes and hundreds of thousands of people had to be evacuated. Since then, everybody in the Netherlands has felt that safety provided by dikes is relative. The regions at risk are the Main River Plains and part of the Coastal Polders, like the densely populated industrial areas around Rotterdam. Discharges from surrounding countries into the main rivers are almost entirely responsible for this flooding, which is increasing in both frequency and intensity. Changing land use as well as climate change in the river basins are responsible for the hydrological changes of both rivers. Both phenomena are expected to persist.

Three long-term processes work against efforts to reduce flooding. First, the entire country has been sinking since the last Ice Age, as the northern parts of Europe have been rising. Second, climate change is also expected to result in a higher sea level, which will interfere with discharges from the main rivers into the sea. Third, the natural rise in the river plains and coastal zone by sedimentation has been cut off ever since the first dikes were built to protect the area from flooding. Most sediment is carried to the sea, where it further obstructs the free outflow of river water. Some sediment settles on the flood plain,
causing the river system to build up above the surrounding plains. Today the flood plain is between 2 m and 3 m. higher than the plains.

Right after the near disasters of 1993 and 1995, the public, and therefore also the Parliament, were ready to make some far-reaching decisions. These were twofold. First, it was decided to reinforce the river dikes and make them higher as fast as possible to provide more safety in the short run. This construction program is almost finished. Second, a new departure was made in thinking about long-term river management: people finally realized they could not continue building higher and higher dikes. Other ways have to be found to coexist with the main rivers. A new policy now emerging will make space for the rivers and more natural hydrological behavior. Large, sparsely populated areas without major industries will be designated as potential retention basins. To save other areas, these basins will receive the highest discharge peaks. In the flood plains, new gullies will be constructed and old ones excavated, thus increasing rivers’ discharge capacity. At strategic points, “green rivers” will be created, embanked strips of land to convey river water during peak flows and release it back into the river some 40 km downstream. They will function as extra flow channels. Under normal circumstances, the adjacent land can be used for agriculture, nature parks, or in any combination of agriculture and nature.

**Land subsidence***

As described above, land subsidence is problematic in the peat areas. Current policy note on rural area planning says water management in the peat areas poses a dilemma—referring to the conflicting interests of modern agriculture in a deep groundwater level and of environmentalists and other groups in a high groundwater level (Ministry of Agriculture 2002). A high groundwater level would increase farmers’ pumping costs to dispose of drainage water and aggravated saltwater intrusion.

The measures taken or contemplated are:

- The government contemplates a strategy for lowering groundwater levels in areas with limited scenic value that have a relatively thick peat layer. The strategy will be extended with restrictive regulations to switch grassland to other agricultural uses and prohibit individual farmers from creating their own deep-drained polders.
- Parts of the peat region will be set aside for new wetlands where new peat growth will be stimulated. These areas will be withdrawn from agriculture.
- Parts of the peat landscape with a unique scenic value will be managed for high groundwater levels. Since this is a serious handicap for agriculture, farmers will be compensated.

**Saltwater Intrusion**

Salt and brackish groundwater is the main problem in most of the Coastal Polder region. The system is connected with the sea via saline aquifers. Because many polders are below sea level, a hydraulic gradient causes upward seepage of saltwater, which can amount to 0.5 mm to 2 mm a day (van Dam 1987), depending on the hydraulic conductivity of the upper clay and peat layers. The closer a polder is to the sea or a saline estuary and the farther below, the more severe is the upward seepage. Without drainage, a fresh water lens would cover the salt groundwater and push it downward. But without drainage the polders would also turn back into lakes. Thus, in winter, excess water has to be drained off, leaving a shortage and a salinity problem during the summer. In summer, saline water creeps up and reaches the root zone.
The Dunes along the central coastal Netherlands contain a bulb of fresh water that pushes the saline groundwater downward, helping to slow down saltwater intrusion. However, large-scale withdrawal for drinking water has undermined this regulating capacity of the dunes.

Rotterdam harbor, in fact the mouth of the Rhine and Meuse rivers, has an open connection with the sea. Discharge from these rivers would normally be high enough to keep saltwater out, but this waterway has been widened and deepened to allow the largest supertankers to enter. Now a saltwater wedge penetrates some 50 km inward, affecting upstream polders.

Some measures taken in the past mitigated the saltwater intrusion problem, but they did not constitute a “coherent strategy.” They included:

- Some large estuaries have been closed as a flood protection measure in the southwest part of the coastal Netherlands. Barriers in these “Delta Works” turned the backwaters into fresh water lakes, which has stopped saltwater intrusion almost completely. One estuary, the Easter Scheldt, was designed with movable gates that are closed only in case of a serious flooding risk (box 7).

- The Zuiderzee, a large, shallow, semi-inland sea, offered the Dutch an opportunity to expand their land by impoldering large compartments. First this sea was closed off with a long barrier, so that saline water would be replaced, and dikes could be kept more modest than sea dikes. Once the water of what is now called Lake IJssel was fresh, saltwater intrusion in the surrounding polders, and in the newly reclaimed land started to diminish. However, it will take many years before all the residual salts are removed (box 8).

**Box 7 Closure of the Easter Scheldt barrier**
The open Easter Scheldt barrier was constructed at a cost of more than US$1.4 million, after bitter discussions between different interest groups in 1972–75, were finally settled in Parliament in 1975. The fishermen and the environmentalists had won a major battle against the agricultural sector and some residents. Opponents were afraid the open barrier system would lessen safety and jeopardize their fresh water supply.
Box 8 Plans shelved for Markerwaard

The first motivation for reclamation of Lake IJssel (Zuiderzee) was to expand agricultural production in line with earlier lake-draining projects. Later, when agriculture became less important, the creation of land for new cities was another acceptable objective. However, the last planned polder, the 45,000 ha Markerwaard, did not materialize. It was strongly opposed by environmental interest groups and the recreation sector. After the struggle for an open Easter Sceldt, this was the second main victory by the new interest groups over the established powers.

In Polders of the World, the chairman of the Landbouwschap, the national tier of farmers representation, makes a strong plea for impoldering the last part of Lake IJssel:

“The Markerwaard will pay for itself so to speak. I am convinced that this investment will bear full fruit. The new Government will have to make a choice. The new polder, new jobs, new space, new economic potential, or it can display the unenterprising spirit which is so often the characteristic of politicians. … In the East Scheldt we are spending 6 billion guilders in order to construct an open storm surge barrier instead of a closed dam, merely for environmental reasons. The Markerwaard will cost less than 20 percent of that amount, spread over a period of 15-20 years. We have the knowledge and the experience. The project cannot fail to have major positive effects on employment, space for urban construction, agriculture and recreation.” (van der Veen 1983: 140).

The ecological value of an open body of water had overridden the economic value of new land. In 1990 Parliament decided to postpone the Markerwaard plans indefinitely.

Drinking water companies have constructed large fresh water infiltration schemes in the dunes, after realizing that the supply of their resource was finite. This measure has restored part of the fresh water bulb below the formation, alleviating the saltwater problem.

Despite these measures, many polders in the coastal part of the Netherlands are still at risk of upward seepage of saline water. Precise regulations are needed for fresh water supply from the main rivers, surfacewater flushing, and discharge into the sea.

Institutional Issues

Over the centuries, the water management system of the Netherlands has grown increasingly complex. Responsibilities for and jurisdiction over different parts of the water system have been entrusted to many, organizationally separate parts of government as well as to private parties (table 10). This division has evolved historically and, by and large, follows hydraulic boundaries.

Present management structure

An important part of the water management system is the body of legal arrangements and regulations governing new water management legislation, policymaking, research and planning, decisionmaking, practical execution (construction, operation and maintenance), inspection, and financial arrangements.

In the Netherlands, there are four tiers of water management: the national government, the province, the third tier—consisting of the functional governments water board or the Hoogheemraadschap, or both, and the municipality—and finally, the landowner. The European Union is gradually becoming the supreme authority over the national governments in certain legal arrangements, some of them related to water management. Each lower authority is empowered to act without encumbrance within the legal limitations set by the higher authorities.
In addition to these authorities, many other parties play a role in water management. Drinking water companies, consultants, and contractors play a business-oriented role in exploitation, planning, and execution. Pressure groups and NGOs influence the policy- and decisionmaking process. Universities and research institutes are instrumental in sustaining (education) and expanding (research) knowledge of water management.

**Table 10 Authorities in water management in the Netherlands**

<table>
<thead>
<tr>
<th>Hydrological subsystem</th>
<th>Water quantity management</th>
<th>Water quality management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Territorial sea and seashore</td>
<td>Rijkswaterstaat&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Rijkswaterstaat</td>
</tr>
<tr>
<td>Main rivers</td>
<td>Rijkswaterstaat</td>
<td>Rijkswaterstaat</td>
</tr>
<tr>
<td>Local rivers and main drainage system</td>
<td>Water boards</td>
<td>Hoogheemraadschap&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td>Main shipping canals</td>
<td>Rijkswaterstaat</td>
<td>Rijkswaterstaat</td>
</tr>
<tr>
<td>Minor shipping canals</td>
<td>Hoogheemraadschap or water boards</td>
<td>Hoogheemraadschap</td>
</tr>
<tr>
<td>Lakes and ponds</td>
<td>Water boards and private owners</td>
<td>Hoogheemraadschap</td>
</tr>
<tr>
<td>Sewage collection systems</td>
<td>Municipalities</td>
<td>not applicable</td>
</tr>
<tr>
<td>Sewage treatment and disposal</td>
<td>Hoogheemraadschap</td>
<td>Hoogheemraadschap</td>
</tr>
<tr>
<td>Field ditches, tile drains, surface drainage systems</td>
<td>Landowner</td>
<td>Hoogheemraadschap</td>
</tr>
<tr>
<td>Road ditches</td>
<td>Road owner</td>
<td>Hoogheemraadschap</td>
</tr>
<tr>
<td>Groundwater</td>
<td>Provincial government</td>
<td>Provincial government</td>
</tr>
</tbody>
</table>

<sup>a</sup> Rijkswaterstaat is the Dutch name of the government service (under the Ministry of Traffic and Water Affairs) responsible for management of the main water bodies.

<sup>b</sup> Hoogheemraadschap is the name of an organization responsible for water quality management in a certain area. It is analogous to water boards for water quantity management.

Source: Author.

**Fragmentation of roles and responsibilities**

Table 11 shows the division of roles and responsibilities among the water management partners.

This table can be applied to each hydrological subsystems in table 10. A three dimensional picture (if it could have been reproduced) would show further fragmentation of roles and responsibilities for the 11 different hydrological subsystems. Box 9 illustrates an actual situation.

Nor is a farmer entirely free to do what he wants in planning, construction, and operation and maintenance of a field drainage system. To design an agriculturally optimal field drainage system, the farmer may trust his own knowledge of agricultural drainage, gained from education and extension based on research, or he may call in a consultant. Whether this optimal design is technically feasible depends on the characteristics of the main drainage system, which is in the hands of the water board. Whether the design is legally permissible depends on policies and legislation in his locality. The European Union Groundwater Directive of 1980 is binding upon national governments. At the national level, a groundwater policy (developed in negotiations among political parties and lobby groups) provides guidelines to protect

**Box 9 Complex planning in action: 1 basin with 38 plans**

For the Kromme Rijn and Vecht basin, there are two water policy plans (two provinces); two water management plans (two water boards); one separate management plan for Amsterdam-Rijn shipping main canal (Rijkswaterstaat); two business plans (two drinking water companies); 29 municipal water plans and 29 sewerage plans (29 municipalities).

groundwater, which are translated at the provincial level into Provincial Government Orders, setting area-specific norms. The water boards are the executive authority, to which the farmer has to apply for a license for his design. A contractor usually handles construction, and the farmer pays. Gravity systems run on their own, but in the case of a pump scheme the farmer has to operate the engine. Maintenance is often a mixed activity, shared by contractors and the farmer.

Table 11 Water management roles and responsibilities in the Netherlands

<table>
<thead>
<tr>
<th>Overall water management system</th>
<th>Policymaking</th>
<th>Legislation</th>
<th>Research</th>
<th>Planning</th>
<th>Decisionmaking</th>
<th>Construction</th>
<th>Operation</th>
<th>Maintenance</th>
<th>Inspection</th>
<th>Financial management</th>
</tr>
</thead>
<tbody>
<tr>
<td>European Union</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>National government</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Provincial government</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Water board</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hoogheemraadschap</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Municipality</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Private landowners</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Water-right holders</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drinking water companies</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Contractors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>x</td>
<td></td>
</tr>
<tr>
<td>Consultants</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Universities</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Research institutes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nongovernmental organizations and pressure groups</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Political parties</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Author.

Cost allocation and recovery is entrusted to authorities at different levels in the water management hierarchy (table 12).

Table 12 Cost allocation and financing of water management in the Netherlands (in millions of 1994 NLG)

<table>
<thead>
<tr>
<th>Institution</th>
<th>Flood protection</th>
<th>Water quantity</th>
<th>Water quality</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>State</td>
<td>726</td>
<td>290</td>
<td>548</td>
<td>1,564</td>
</tr>
<tr>
<td>General tax (national budget)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>1,407</td>
</tr>
<tr>
<td>Province</td>
<td>100</td>
<td>42</td>
<td>283</td>
<td>425</td>
</tr>
<tr>
<td>General tax (national budget)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>168</td>
</tr>
<tr>
<td>Interest-payment principle</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>74</td>
</tr>
<tr>
<td>Water board/Hoogheemraadschap</td>
<td>120</td>
<td>690</td>
<td>1,660</td>
<td>2,470</td>
</tr>
<tr>
<td>Interest-payment principle</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>810</td>
</tr>
<tr>
<td>Polluter-pays principle</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>1,660</td>
</tr>
<tr>
<td>Municipality</td>
<td>14</td>
<td>81</td>
<td>1,389</td>
<td>1,484</td>
</tr>
<tr>
<td>General tax (national budget)</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>421</td>
</tr>
</tbody>
</table>
The total cost per capita in 1994 amounted to NGL 386 (US$175), about 1 percent of the national income. Drinking water is supplied by 25 companies (1998), at an average cost of US$57 per capita per year.

**Friction and inertia in the system**

This fragmented and compartmentalized water management structure is considered more and more out-dated, inefficient, and ineffective in solving the ever-changing imbalances between what the water system can offer and what society demands of it. The following list of institutional defects is illustrative, not exhaustive.

- Each hydrological subunit under the jurisdiction of one organization is connected with other subsystems (serial interdependency). At each transition point, problems can occur, and specific arrangements for handling them have to be made and adjusted from time to time (box 10).

- Quality and volume management of the same water is often done by different organizations (box 11).

<table>
<thead>
<tr>
<th>Sewerage tax</th>
<th>?</th>
<th>?</th>
<th>?</th>
<th>964</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>960</td>
<td>1,103</td>
<td>3,880</td>
<td>5,943</td>
</tr>
</tbody>
</table>


Even where strong horizontal linkages exist in planning and in the policy- and decisionmaking processes, the realization of changes in water management is cumbersome and time consuming.

Last but not least, an important factor that may hold up decisionmaking in water management is the individual right of each citizen or corporate body to contest any intended decision in court and through an appeal process. This is a healthy practice that tests the consistency of complex legislation. But it sometimes takes a disaster to accelerate decisionmaking.
Box 12: Institutional defects

In the Netherlands, about 260,000 households and enterprises incur damage from high groundwater levels, about 100,000 have problems with low levels, but this number could reach 2 million to 3 million. Damage from low groundwater levels occurs in peat polders, where houses are built on pilings, but streets, sewerage systems, and public water pipes are not. Uneven land subsidence causes, for example, rising doorsteps and breaks in pipelines. This is the result of the drainage depth maintained and inadequacies in design and construction of the buildings. Regionally, surfacewater level management and changes in groundwater withdrawal and influx are widening the problem. The cost of mitigating problems associated with the high groundwater depth, already between US$500 million and US$1 billion, is growing by US$14 million to US$20 million a year. Mitigating problems associated with low groundwater levels costs more than US$2 billion in total.

The lines of authority for urban groundwater management are also tangled. National, provincial, municipal governments, and water boards each have some power, but no party has explicitly been given overall responsibility. Thus, there is no legal base for holding any of these parties responsible for taking proper corrective measures or for enforcing compensatory damages. Discussions are ongoing, but, in the absence of a common vision, only formal juridical and organizational arguments, all partially valid, are being exchanged. The result is a deadlock.


The Emergence of Institutional Changes in Water Management

This case study is about agricultural drainage in the Netherlands and how it has changed over the past 50 years. One observation is simple. To put it bluntly, a half century ago, large-scale pipe drainage was introduced in agriculture. Today tractors with subsoilers are demolishing those drains. That is what has changed. Why and how this change took place is more difficult to explain. First of all, the position of agricultural drainage has to be recognized at the far end of a complex resources management system. What eventually happens to pipe drains depends on the weighing of interests of a higher order. What will happen to agriculture in the Netherlands? How much do the Dutch citizens want to pay for a more varied environment? How seriously does the public take the threats of climate change?

Second, institutional changes in water management are not independent phenomena. They are part of a broad change in the decisionmaking culture in the Netherlands—more democracy, more transparency. Different objectives can be found in many other management systems. To explain why, at the moment, destroying pipe drains is popular in the Netherlands, the broad context must be understood. This section attempts to provide a basic understanding of this context.

The ingredients of change

The ingredients that enabled a paradigm shift in water management in the Netherlands have been introduced:

- Space (and the functions attached to it) is a scarce commodity; combinations of functions of the environment have to be found.
- The population is prosperous and largely urban. Some of their needs can be satisfied only in the countryside.
A large part of the population is aware of the importance of a clean, biologically rich, and attractive environment.

The population wants a say in decisionmaking and a transparent decisionmaking process.

A democratic governmental system allows for changes.

An educational system stimulates a critical attitude among its students.

A trigger sets things in motion.

Since these ingredients were present, a radical change in water management (but not in water management alone), was probably bound to happen, and most likely in the direction of integrated water management.

Some important metamorphoses

Land and water management institutions, except for the main water bodies, were dominated by the agricultural lobby. An old-boy network of politicians, professors, researchers, agribusiness people, agribankers, executive officials in government land and water management services, and the minister of agriculture himself, ruled the sector in great harmony. Most of these personalities of what was then called the “Green Front” had studied at the same university, Wageningen (Appendix A, Corporaal).

As a starting point for change, one can take the demand of ordinary but well educated people for a more participatory and transparent democracy, culminating in the students’ revolt in 1968. If this is not the whole truth, at least it coincides with the start of important changes in the land and water management system.

After the unrest at universities, including Wageningen, progressive lecturers and students started to develop new ideas and explore new subjects. For a long time, conservatives in top positions in the “agrinetwork” tried to resist or obstruct the new ideas. As new generations replace older ones, however, more open-minded people have gradually taken over the top positions. This change in leadership was a prerequisite for reform, if not one of the engines.

Another product of the new wind sweeping through the Netherlands democracy was the emergence of environmental activist groups (Appendix A, van Poppel). Such a phenomenon was previously unheard of. Citizens, mainly left-wingers, chained themselves to trees, fought with the police, closed sewerage outlets, threw paint on fur coats, and the like. Gradually, these activists, transformed into orderly NGOs, organized themselves in tiers, and became a recognized interest group and discussion partner for government.

Third, a fundamental idea broke into the public consciousness: that the natural environment has many functions and, more important, that one cannot be treated independently of the others. Vink (1975) already points in that direction. The new land evaluation concepts developed in the 1970s were a precursor of the idea. When the finiteness of natural resources became poignantly clear, the idea broke through. Naturally, such a point is reached earliest in a densely populated country like the Netherlands. R.S. Groot (1992), among others, framed the idea in a theoretical concept. The concept of integrated (water) management is the logical next step.

Finally an important metamorphosis for decisionmaking in water management took place in the representation of interests on water boards and in land consolidation projects. In both instances, this was regulated by revisions of, respectively, the Land Consolidation Act in 1986, and the Water Board Act in
1992. The basic, almost holy, principle for participation in water boards is the triad: interest-payment-say. It means that people who want their interests looked after must pay proportionally to get a proportional say in decisionmaking (table 12). In the past under this dogma, only landowners, chiefly farmers, were represented in these institutions. Now building owners and residents are also recognized as interest groups and pay for water board services, so they, too, get a say in policy. Whether representation has changed because of the democratization movement of the 1960s and 1970s, or for other reasons, remains unclear. The result is the same. A variety of interest groups have entered the water management arena. The strategy of the agricultural lobby to keep its majority in seats by nominating its own people failed, because environmentalists and municipalities did the same.

Today, the trend is toward further scaling up of water boards and merging water volume and quality management. Debate has just started over whether maintaining a separate functional water government is still worthwhile or whether transferring water management to the provincial and municipality governments would be better. The main plea for this change is that water management has become so tightly interwoven with other rural and urban management systems that integrating all these management systems into one platform would be more effective. The main fear is that the gap between “water government” and the “field” might become too wide and “water governance,” too bureaucratic.

Agricultural drainage used to be controlled by the agricultural sector. The only purpose was to optimize agricultural production, and that is what it was designed to do. The form in which agricultural drainage will continue will now be decided in negotiations between different interest groups. The outcome of these negotiations will be largely determined by discussions elsewhere concerning the designation of landscapes for various functions and will sometimes result in a decision to demolish perfectly working pipe drains.

Some Practical Problems of Change

It is evident that the classic models for water management and for agriculture in the Netherlands have been exchanged for a new paradigm: multifunctional use of space and integrated water management. It has taken about 30 years to shift from the old to the new belief. The discussions are not about principles anymore but about the practical implementation of the new paradigm and its problems.

Financing the new policies

Farmers were heavily subsidized for drainage and land consolidation to allow them to modernize and optimize their enterprises 25 years ago. Yet, there is little debate about compensating them for loss of agricultural production when they have to accept expropriation or tolerate multifunctional use of their land, for example, for water retention or ecological development. The application scale of the new policy (on tens if not hundreds of thousands of hectares) and the current market price for agricultural land and the production rights attached to it (about US$40,000/ha) immediately raise the question of who is to pay the bill (perhaps as high as US$5 billion). The national government’s current budget provides about US$100 million a year, which would condemn the policy to a time span of 50 years to be fully effective. Additional financing is being sought in the green-for-red compensation. This means that municipalities are obliged to finance part of the nature development program (green) when they want to develop town extensions (red). In the end, this would lay the bill on the doorsteps of new house owners. Another proposal would oblige water boards to take care of the costs of new “water-related” measures, but they could recover these costs through their normal water tax system. Farmers affected by the new measures would thus pay part of the bill.
Management of a multifunctional environment

A third financing option is to offer farmers an opportunity to deliver “green services” under contract (Appendix A, Corporaal), since farmers are best placed to do so. However, the environmentalists doubt that farmers, of all people, should be entrusted with responsibilities of this kind, and the farmers mistrust the long-term reliability of government promises. A main hurdle probably will be to convince the European Union that paying for green services is not a hidden subsidy to agriculture. Developing an accepted methodology to measure the new goods and services and translate them into a single financial value is an important challenge for research institutes. Once a simple and financially interesting procedure matures, much of the current discussions will probably seem redundant.

New tools for integrated water management at farm level

Farmers’ skills and the available technology for on-farm water management have long been concentrated on obtaining optimal agricultural drainage (Appendix A, van Poppel). To this end, farm equipment and activities are unilaterally fine tuned—from pipe drainage systems and equipment to clean them, to open field ditches and mowers to maintain them, to timing of maintenance, and to farmers’ choice of varieties to plant, fertilizers to use, and timing all these activities. Under a new water regime, a completely new type of farming system and new farming skills have to be developed to make a new optimum possible. A simple example is the first step in this process, integrating field drainage with field irrigation and groundwater conservation. A farmer who wants to do this has no reliable scientific trials or economic evaluations for guidance. Nor are there any tools on the market for automated closing of pipe drains or for mowing ditches full of water. Different location-specific farming systems will have to be developed for each hydroecological region and landscape within these regions, not least because restoring the diversity of the original Dutch landscape is an objective of the new policy.

Thus, the transition to such a new farming model entails a big leap—for the education and research community to develop the new knowledge system required and for farmers to learn new methods and skills. The excerpts in box 13 from a policy advisory note illustrate some of the practical problems to be surmounted for this switchover.
“To accomplish this change (in water management), efforts are needed on a magnitude comparable with the Delta Works and even exceeding them in administrative and societal complexity. Can the knowledge system adequately initiate and accommodate this paradigm shift?” (NRLO 2000: 6).

“The paradigm shift . . . offers many new tasks for knowledge development and innovation. New knowledge and understanding are required, especially on the interface of water management and the social environment. Not surprisingly, all the primary knowledge themes mentioned in this advice relate to the interaction between water management and society. These themes—meeting water; the value of water; participatory planning in water management; and interadministrative management of space and water—are still underexplored in research. Moreover, this advice shows a fragmented, compartmentalized and technocratic knowledge structure regarding water, with a chasm between research, on one hand, and policy and practice on the other” (NRLO 2000: 7)

Modern Strategic Planning of Integrated Drainage Based on Local Diversity

In the Netherlands, modern spatial planning harks back to the country’s physiographical roots. It is national policy today that the geomorphology of the country and the soil and water systems with their ecological, scenic, and cultural/historical values, to be sustainable, should be the foundation for every further spatial development. Water in all its manifestations is taken as the main ordering principle. This means that the natural behavior of water, and its accompanying functions, will be restored to the extent possible, effective, and acceptable. In the Sandy Upland, agriculture will have to withdraw from the lowest parts, drainage management on the slopes will change to integrated water management—which encompasses agricultural drainage and irrigation and flood control and water conservation. Groundwater quality management will be further developed. The Main River Plains will no longer be 100 percent flood free. In preparation are measures to permit controlled flooding in emergencies. In the South Limburg Hills, restrictions on land use for erosion control are being implemented. For the Polders, plans are being made to return some polders to the sea. Saltwater-cum-flood protection barriers are being reopened to restore brackish tidal ecosystems. To stop land subsidence, water management in the peat polders is directed at allowing the water table to rise very high. Thus, water management measures in this policy reversal are specific to the main hydroecological regions and still more specific to the individual landscapes.

To accomplish this, a new type of water management is required—one that aims to be effective and efficient, with stakeholder participation and representation, full financial compensation for disadvantaged stakeholders, and a pro-active stance regarding mitigating measures. In its executive methodology, this new water management institution should follow some basic principles.

- A first main principle for a successful implementation of this policy is to have proper spatial information about the landscapes, sufficient knowledge of the dynamics of the water system within and between landscapes, and thorough knowledge of the current and planned functions of the landscapes, their values, and their stakeholders.

- Second, a quantitative assessment is needed of the effects projected interventions might have on the existing resources, so that informed and transparent decisions can be made.
Third, for fair compensation and for feasibility assessment, an analysis is needed of the financial impact an intervention or a nonintervention would have.

Finally, the institutional system has to be evaluated in relation to the new policy, and the necessary changes should be made. An institutional plan should be an intrinsic part of the total plan.

6. Conclusions and Lessons

Agricultural drainage falls apart in two different management areas: field drainage and conveyance of the effluent through a network of open water courses to the sea.

**Agricultural Drainage, Water Management, and Land Management**

Field drainage in the Netherlands is groundwater management in the flat part of the country, about 97 percent of the area. In the remaining hilly part, field drainage is a kind of erosion control. In both cases field drainage can be considered *land management*, because drainage is a measure intended to improve land. Since groundwater does not stop at the edge of the field, field drainage lowers groundwater levels in a wide area, with consequences for owners of land far beyond a single field. Because of this *parallel interdependency* in field drainage between different landowners and users, arrangements are needed to resolve conflicts of interests.

Conveyance of drainage water is part of a true *water management system*. Drainage water flows by gravity or by pumping through a communal, and partly natural, open water system to the sea. In a flat country like the Netherlands, the conveyance system allows for downstream, but also for upstream water level control. The discharge at any point in the conveyance system depends not only on how much water is released upstream, but also on what is allowed to pass downstream. This *serial interdependency*, for both water volume and quality, was the main reason for the emergence of water management institutions in the Netherlands. They were created not only to oversee agricultural drainage but also to consider the requirements of other users of the main, communal drainage system.

**About Drainage Typology**

The Dutch case generally shows a strong correlation between an area’s natural resources, functions provided by the area for human society, and the water management institutions in place. Agricultural productivity is one important function of natural resources. At the agricultural level, the same correlation exists between the natural resources, the farming systems in use, and the agricultural drainage institutions.

Natural resources are clustered, according to certain characteristics, in hydroecological regions and landscapes that often have hard boundaries. Hydroecological regions share some prominent resource characteristics, including exposure to flooding, deep groundwater tables, very poor soils, and pumped drainage. Landscapes are subunits of hydroecological units, but their resources, and therefore their functions are more uniform. In agriculture, this results in typical landscape-bound farming systems and, as a consequence, landscape-specific agricultural drainage. This relates not only to the technical infrastructure, but also to legislation and financial arrangements, organizational characteristics, and scientific knowledge. At the hydroecological regional level, there are bigger differences, but on fewer water management issues.
Adverse effects of agricultural drainage are basically the change of other functions of the same landscape, or of connected landscapes, for the worse. Mitigating measures therefore have to be specific to different landscapes.

Thus, in the Netherlands, the important denominators for agricultural drainage typology are threefold: the hydroecological regions and landscapes, the prevailing farming systems, and the institutional drainage arrangements. Spatially, the typology is delineated by the hydroecological regions and landscapes. Larger contiguous areas with the same farming system can be taken as sublandscapes. Since this typology is based on the biophysical environment, the functions this environment has for its users, and the institutions in place to optimize these functions, it is instrumental in drainage planning.

**Institutional Development for Integrated Water Management**

An analysis of the historical development of water management in the Netherlands shows the dynamic nature of the water management triangle. Institutions were set up to improve the functions of landscapes by physical interventions. This process has changed the landscapes, and many of their functions, to the point where the Netherlands consists entirely of manmade landscapes. The demands of human society (the priorities assigned by society to different functions) have been the engine for constant evolution of the water management system. These demands include mitigation of negative functions of the biophysical environment, like land subsidence. To understand the direction water management took in certain times and places, one has to know both the priorities of different users and their relative decisionmaking power (political or military). This principle seems to apply always and everywhere.

In the first half of the twentieth century, agricultural production received high priority in the Netherlands over most of its land area, and the agricultural sector was well represented in political and other decisionmaking institutions. The resulting institutional system optimized water management for agriculture to the benefit of farmers. Every segment of this system evolved in this monofunctional direction, while other, nonagricultural functions of the environment were neglected or sacrificed.

A reverse development emerged in the second half of the past century. The value once awarded to agriculture decreased, as the fear of food scarcity decreased. And the value placed on other functions of the Netherlands landscapes and water systems increased because of their relative scarcity. Once these other functions gained representation in the power structures, they were politically translated into priorities, and the water management system was bound to be affected. The Netherlands is now in the midst of transition from a sectoral water management system to an integrated, multifunctional system.

**Policy Recommendations**

Comprehension of the intrinsic relations between landscapes, their different functions and stakeholders, and the water management institutions should have consequences for water policy development in general and agricultural drainage in particular. Some recommendations flow from that understanding:

- The key condition for integrated water management is fair representation of water stakeholders in decisionmaking. Today, planning of water management in the Netherlands, including agricultural drainage, is making greater and greater use of landscape-function evaluation. However, more room for representation should be given to organizations representing a variety of user interests. And, for informed decisionmaking, quantification of the effects of interventions in the water system on its functions is a prerequisite. This quantification should comprise economic, social, and environmental effects.
The agricultural sector used to dominate the water management model in the Netherlands, but now there is a risk that this sectoral management model will be exchanged for another sectoral model—the environmental sector. Fair representation of a variety of stakeholders in decisionmaking is required to head off another one-sided situation.

Integrated water management appears to be difficult to practice, partly because compromise, inherent in the approach, is difficult. Another main hindrance stems from the institutional system, which is not adjusted to integrated water management. These institutions include legislation, organizations, knowledge systems, financial arrangements, and physical infrastructure. If integrated water management is advocated as the panacea for solving all water-related problems, changes are required in every part of the institutional system. A promising approach may be to entrust responsibility for the negotiating process to the parties whose interests conflict, without any government intervention—and then to honor the results.

In the Netherlands, a trend is apparent toward merging water management organizations into large structures with broad mandates, and local bodies are disappearing. This trend goes against the principle of devolving management to the lowest suitable level. Strong institutions may have to be built at whatever level integrated water management is needed, where different functions of water may come into conflict. Nonetheless, organizations that take care of only one or two functions at lower levels will still be needed to allow flexible and quick responses to local problems.
Appendix: Field Study

This appendix reports on interviews and discussions with some actors in water management in the Netherlands. The reports are not a literal representation of what was said but a summary of the interaction. The contents have been enriched with some written information made available by the people interviewed—annual reports, visions, project documentation, and the like. Some of the information from these interviews has been incorporated in the main part of the report.

Johan van Gestel

Johan van Gestel, a farmer, was chairman of the successive water boards Boven Mark and Mark and Weerijs between 1972 and 2002. The second board resulted from a merger between Boven Mark and Aa of Weerijs. The water board’s working area is the Sandy Upland Region. Van Gestel is a member of the governing body of the West Brabant Hoogheemraadschap, charged with water quality management and flood protection.

On agricultural drainage

Johan van Gestel remembers his first confrontation with subsurface drainage some 45 years ago—when brickwork pipes were still used and lines were still excavated manually with spades. Before the local land consolidation project (implemented between 1972 and 1982), agricultural drainage in the region was underdeveloped. Although landowners were officially obliged to clean the ditches and drainage canals if water from upstream landowners had to pass by, cleaning was rarely monitored and more rarely enforced. Most ditches were too shallow to even think of constructing subsurface drainage. Only land adjoining the main drainage canals was provided with subsurface drainage.

As part of the land consolidation program, van Gestel had pipelines laid on his land at a cost of US$270/ha in 1972. In 2002, the same work would have cost between $900 and $1,150/ha. The most important benefits for arable land were time gained to prepare land in spring and protection for the soil structure. For grassland, the benefits mentioned included warmer soil and an earlier start to the growing season, earlier response of the grass to fertilizers, and less trampling damage from cattle. The effectiveness of drainage depends heavily on soil type and the presence of impervious layers.

On the Mark en Weerijs Water Board

The water board owns the main drainage system, which consists of a local river with its natural tributaries and a network of main drainage canals connected to the system. Most parts of the main drainage system are provided with inspection and maintenance roads. The board is responsible for maintaining systemic design discharge capacity at a specified design water level, with a specified maximum frequency of exceedance. These technical figures are part of the board’s legal regulations and are fixed for periods of six years after which they can be revised by the board’s general meeting. In case of demonstrable negligence by the water board, any party who feels wronged can take the board to court to claim satisfaction. But this rarely happens—most disputes are settled amicably. The board can also enforce its rules on all persons and corporate bodies in case of noncompliance.

Maintenance of the drainage network is an important board responsibility. The board must see that its own drains are mowed and silt removed. The board is also the authority that inspects and enforces annual cleaning of private and municipal ditches. If a violation is found, the board must give the offender written notice within 14 days. In case of
noncompliance, the board arranges for the clean-up and bills the offender for costs incurred plus an indemnification for administrative costs.

Member’s of the board’s professional staff have a duty to report infringements of the rules. The board’s own inspectors have the authority to report people for infractions of the annual cleaning rules for illegal constructions affecting the water system (e.g., illegal subsurface drainage, building of weirs, bridges, culverts, piers). Most inspections today are airborne, making use of digitized maps and global positioning systems.

**Box A1 Subsurface drainage subject to license**

Since 1992, a license from the water board has been needed for each subsurface drainage construction. In areas classified as Predominantly Agricultural Land, subsurface drainage plans have to be reported, and usually receive an exemption without further restrictions. For land classified as Predominantly Nature Land, subsurface drainage, in principle, is not allowed. The norm for land in such zones is that drainage decommissioning should not exceed the “natural” drainage rate (1 l/sec/ha). A farmer who can store water somewhere else on his property, compensating for incremental drainage by the subsurface drainage system, may theoretically obtain a license. In practice, this possibility is more apparent than real. At least one case was reported where a farmer had illegally constructed subsurface drainage through a contractor. After one-and-a-half years of juridical dispute, the board won the case, and ordered the contractor to destroy the drainage system with a subsoiler. The farmer had to pay all costs.

**On institutional reforms**

Until 1986 only landowners (elected every four years) were represented in the board’s General Assembly and thus also on its Executive Council. (21 people, mostly farmers, one seat reserved for country estates, one for the State Forest Service).

<table>
<thead>
<tr>
<th>Interest represented</th>
<th>Seats in Governing Body</th>
<th>Seats on Executive Committee</th>
<th>Share in charges (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbuilt area</td>
<td>12</td>
<td>2</td>
<td>25</td>
</tr>
<tr>
<td>Built properties</td>
<td>8</td>
<td>1</td>
<td>50</td>
</tr>
<tr>
<td>Inhabitants</td>
<td>5</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>


In 1986 (as a consequence of policy changes at the national level), a second interest group obtained representation: “built properties.” In 1992, the third group obtained representation: the “inhabitants” of the board’s area.

The water board’s tasks have broadened over the last decades. Next to the regular tasks of operating the drainage system (moving the gates to maintain optimum water levels and discharge), mowing and dredging, building constructional works, inspecting and enforcing rules, new tasks have been added to facilitate newly recognized
functions of the water system. These new functions are related mainly to flood protection, water conservation, and nature restoration and conservation.

The division of taxes is established by the province and is revised every six years. There are always some differences between some group’s share in water charges and its share in benefits. Structural differences between taxes and benefits per interest group cause many debates.

The changed composition of the General Assembly has not posed many problems. Van Gestel said that today’s younger farmers are much more open to the new water management requirements and less driven by emotions than older farmers.

When the Boven Mark and Aa of Weerijs Water Boards merged, (at the instigation of the next higher authority, the province), a temporary Governing Body was formed, composed of members of the two former boards. This interim body was charged with the preparation of the new water board and the elections to the new General Assembly.

In 2004, another round of water board up-scaling is planned. This time it involves merging four water boards and one Hoogheemraadschap. Then flood protection, water quality management, and water quantity management will be brought under one management structure. The area will cover half of Noord Brabant province and include parts of the Sandy Upland, the Coastal Polder region, and the Main River Plains.

Frank Heijens

The Roer and Overmaas Water Board covers the entire South Limburg Hilly region and part of the Sandy Upland in Limburg province. Frank Heijens is a water board hydrologist. Discussion was confined mainly to the hilly part.

Table A2 The Roer and Overmaas Water Board: Some facts and figures

| Service area: | 95,000 ha |
| Inhabitants: | 750,000 |
| Length of natural systems: | 875 km. |
| Flood retention basins: | 175 |
| Main River Dikes (Meuse): | 73km. |
| Professional Staff: | 110 |
| Annual budget: | US$21 million |

<table>
<thead>
<tr>
<th>Interest represented</th>
<th>Seats in Governing Body</th>
<th>Seats on Executive Committee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbuilt area</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Built properties</td>
<td>13</td>
<td>3</td>
</tr>
<tr>
<td>Inhabitants</td>
<td>8</td>
<td>2</td>
</tr>
</tbody>
</table>


On agricultural drainage

- Next to peak flow management, surface drainage, and erosion and sedimentation control, the water board has responsibility for restoring canalized natural brooks to encourage aquatic life.

- Due to the hilly nature of the land, water management cannot be based on control of ground water levels. The design criterion is to prevent inundations any more frequent than once in 25 years. Water management here has little bearing on agriculture or groundwater conservation. The water board is responsible for streams as far upstream as places the discharge exceeds 500 liters once in 25 years.

- Agricultural groundwater drainage is of little significance in the region.
On erosion control

- The water board has no direct task in erosion control. Retention basins for runoff are built primarily for flood control. A total retention capacity of 400,000 m$^3$ would be needed for safe discharge of the drainage water. This capacity is now partially realized.

- A program to control erosion was initiated by the province in cooperation with the Limburg Organization for Agriculture and Vegetable Growers (LLTO, the regional farmers’ interest group) and with the National Corporation for Crop Production (NCCP). An extensive and precise list of orders and prohibitions on land use, crop selection, and tillage practices resulted from this (semi-) self-regulating action. The list has been up-graded to a Provincial Government Order to give it a legal basis for implementation. In close cooperation with the LLTB, the water board plays an active role in reporting serious erosion cases and solving the related problems.

- Erosion control, to be effective, sometimes needs more drastic interventions such as the reorganization of parcels. Such sweeping measures can be realized more smoothly if they are part of a land consolidation program, which provides a solid legal basis for action.

- Most of the old natural terraces (graffen), which used to limit erosion, have been removed. Those still in existence are legally protected by municipal spatial plans. This means that a farmer may not remove them without a license, and not without mitigating measures.

On institutional aspects

From time to time, conflicts arise between the water board and farmers who lose land to, once again, freely meandering streams. Water mill owners can sometimes prevent the construction of such new items as fish traps, appealing to their age old rights to full discharge of the river or minimum water levels. Sometimes there are conflicts with municipalities, and even the province (a higher authority than the water board) over plans for new construction on unsuitable sites, from the standpoint of water management. Such conflicts can be taken as high as the Supreme Court.

The water board has a new legal instrument to prevent undesirable spatial developments, called the Watertoets or Watertest (VenW 2000). All plans for new construction must be reviewed by the water board. The board can refuse permission or require adaptation of the plans.

The Hilly region has been under a water board only since 1987. This how unimportant agricultural drainage is in this part of the Netherlands. Therefore, historical dominance of the agricultural sector has never existed in the Governing Body. The interest groups here are the same as elsewhere: built property, unbuilt area, and inhabitants. Other water system functions such as nature, recreation, shipping, energy, or fishing are not directly represented, although such interest groups can try to get a seat in one of the main categories. These interest groups have an opportunity to

<table>
<thead>
<tr>
<th>Box A2 Excerpt from the HPA Erosion Control Agricultural Land Order of 2001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Article 3.2</td>
</tr>
<tr>
<td>The sector manager (of the NCCP) is authorized to order:</td>
</tr>
<tr>
<td>a) the application of a soil cover crop, which may be replaced by a mulch directly after sowing of the main crop;</td>
</tr>
<tr>
<td>b) the permanent conversion of arable land into grassland;</td>
</tr>
<tr>
<td>c) resowing of grassland in autumn;</td>
</tr>
<tr>
<td>d) minimization of soil tillage;</td>
</tr>
<tr>
<td>e) immediate tillage after harvest;</td>
</tr>
<tr>
<td>f) actions to prevent or undo tracks of machinery;</td>
</tr>
<tr>
<td>g) measures to improve soil structure;</td>
</tr>
<tr>
<td>h) drainage;</td>
</tr>
<tr>
<td>i) breaking of impervious soil layers;</td>
</tr>
<tr>
<td>j) contour tillage;</td>
</tr>
<tr>
<td>k) limitation of the downhill length of parcels;</td>
</tr>
<tr>
<td>l) strip-cropping</td>
</tr>
<tr>
<td>m) surface drainage measures (furrowing).</td>
</tr>
</tbody>
</table>

...
Influence the four-year water management plans. They are invited to take part in the preparation phase and to participate in public hearings, which the water board is obliged to organize. In addition, all general meetings and meetings of the Executive Body are public.

Since new-style water boards’ tasks extend beyond agricultural drainage and are regional in scope, elections are becoming politicized as never before. Local and national political parties appreciate the water boards’ growing influence and scope for action and are trying to expand their own power. If they succeed, it will be at the expense of the functional nature of the water board type of government and the principle of “water management at the lowest appropriate level.”

**Sjaak Broekmans**

Sjaak Broekmans is a dairy farmer in Overdiep polder in the Main River Plains, bordering the Meuse river. He has outstanding experience as an elected member of the Executive Committee of the de Dongestroom Water Board and is also a member of the Executive Commission of the West Brabant Hoogheemraadschap. Discussions focused on agricultural drainage in polders and on institutional changes in the water board over the past 15 years

**On agricultural drainage**

The main principle of water management in a polder is maintaining agreed water levels. Every six years the General Assembly establishes summer and winter water levels. In winter, the water level is kept low to allow for accelerated groundwater drainage. In summer, a higher water level is maintained to prevent excessive drainage and keep the soil moist enough to grow crops. Since even in polders there are differences in altitude, the established water levels are a compromise. Where differences become too big, part of the polder can have its own water level and its own pump. This exception is a source of dissatisfaction among landowners, and conflicts can occasionally arise over water level differences of a few decimeters.

**Box A3 Neighbors conflict over water levels**

The owner of a farm located on a low spot in the polder felt he had too much damage from high water tables. The farmer eventually obtained the water board’s permission to dam his farm ditches and part of the board’s main drainage canal and, at his own cost, to pump the surplus water into the drainage canals on the rest of the polder. That meant water from some higher parts had to follow another, longer course to the main pumping station; next, water levels in that area became too high. Serious disagreement among the farmers, and between farmers and the water board, was the result. The water board had to redesign and reconstruct part of the drainage system at its own expense.

In polders, the canal system often has a dual function: discharging surplus water in wet seasons and supplying water in dry seasons. Both are governed by the principle of maintaining the agreed water level. To pump sprinkling water out of the canal system, farmers need a license from the water board.

**On de Dongestroom Water Board**

The de Dongestroom Water Board is relatively small. It resulted in 1998 from a merger of the upper part and the lower part of the small river basin Donge and the merger of a number of polder boards.

**Table A3 The de Dongestroom Water Board: some facts and figures**

<table>
<thead>
<tr>
<th>Service area</th>
<th>34,000 ha</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inhabitants</td>
<td>87,000</td>
</tr>
<tr>
<td>Municipalities</td>
<td>11</td>
</tr>
</tbody>
</table>
Table A3 The de Dongestroom Water Board: some facts and figures

<table>
<thead>
<tr>
<th>Length of drainage system</th>
<th>662 km.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Structures</td>
<td>200</td>
</tr>
<tr>
<td>Pumping stations</td>
<td>34</td>
</tr>
<tr>
<td>Professional staff</td>
<td>40</td>
</tr>
<tr>
<td>Annual budget</td>
<td>US$5 million</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Interest group</th>
<th>Seats on General Assembly</th>
<th>Seats on Executive Committee</th>
<th>Share in taxes (percent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unbuilt area (25,000 ha)</td>
<td>11</td>
<td>2</td>
<td>26</td>
</tr>
<tr>
<td>Built area (9,000 ha)</td>
<td>9</td>
<td>2</td>
<td>49</td>
</tr>
<tr>
<td>Inhabitants</td>
<td>5</td>
<td>1</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: www.dongestroom.nl.

The main category “unbuilt” is subdivided into six different water charge classes. The higher agricultural land and nature areas pay less than the lower areas, which needed pump drainage and protective dikes. This subdivision is specific for each water board.

**Tariff structure for the de Dongestroom Water Board**

The main division of water fees per category is fixed by the province every six years. This is based on an estimation of each category’s interest in water management. Guidelines for this estimation are provided by the national government, based on studies and political choices.

Table A4 Water board tariff structure

<table>
<thead>
<tr>
<th>Class</th>
<th>Definition</th>
<th>Weight</th>
<th>Levy ($/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>I</td>
<td>Unbuilt area below contour line 2.5 m above sea level, excluding forest and nature areas</td>
<td>1.30</td>
<td>61.88</td>
</tr>
<tr>
<td>II</td>
<td>Unbuilt area between 2.5 and 5.0 m above sea level, excluding forest and nature areas</td>
<td>1.10</td>
<td>52.36</td>
</tr>
<tr>
<td>III</td>
<td>Unbuilt area, between 5.0 and 7.5 m. above sea level, excluding forest and nature areas</td>
<td>0.90</td>
<td>42.84</td>
</tr>
<tr>
<td>IV</td>
<td>Unbuilt area, above 7.5 m above sea level, excluding forest and nature areas</td>
<td>0.70</td>
<td>33.32</td>
</tr>
<tr>
<td>V</td>
<td>All forests and nature areas, and other areas without furrows, ditches and subsurface drainage</td>
<td>0.40</td>
<td>19.04</td>
</tr>
<tr>
<td>VI</td>
<td>Areas without any interest in water management</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Source: www.dongestroom.nl.

The fees are based on the estimated budget requirements minus some income from other sources (e.g. work for third parties; interest on capital deposits). The first step is to divide the remaining part over the three categories, using the key division in the Provincial Order. For inhabitants, the number of households is counted, regardless how many people belong to the household. The fee for one household amounts to US$13 a year. The basis for the category “built area” is the economic value of the building (e.g., house, office building, factory). The economic value of the buildings is estimated by the municipalities for their own tax system and made available to the water board. The estimation is revised from time to time. The total value is estimated in units not smaller than $2,268. For each value unit, a fee of $0.34 is charged.
**Institutional issues**

Much has changed since 1986 and 1992, when the other interest groups joined the board. The best illustration is a comparison of board meeting agendas 20 years ago and today. In the past, two thirds of the items were related to agricultural land, whereas today the agenda could be one for an environmental lobby group meeting. Debate, though more lively than in the past, never gets out of hand. Most agricultural representatives are now attuned to the “modern” issues, but their mind-set is still distinctive. If, for instance, debate is on cleaning the canals in an environmentally friendly way, the “others” tend to forget about regular cleaning, whereas the farmers ask for a “smart” way to do it, and clean at least the bottom section of the canals.

Water boards are slowly but steadily losing autonomy to the province. The province is imposing on the water boards a growing number of tasks and targets, leaving the boards less room to develop and implement their own policies. Provincial control will certainly increase after a new round of mergers in 2004.

Broekmans said that the influence of political parties over the board is negligible at this moment. However, he fears a political invasion after the water boards have been scaled up and cover half of Noord Brabant province. Another negative effect of this continuous scaling up is a growing gap between government and the field, which will increase bureaucracy and decrease knowledge about local conditions. The decisionmaking process will be increasingly influenced by the professional staff, who have the status of civil servants. Decisionmaking may become a precooked affair.

**Adriaan van den Boogaart**

Adriaan van den Boogaart is a modern diary farmer. In 1999, the State Forest Service, in cooperation with the Mark and Weerijs Water Board, implemented a water conservation plan in the forest areas near Gilze. When the forest was planted around 1900, the land was laid out in beds and furrows connected to a main drainage system. The forest’s main drainage canals originate in up-stream farm land (figure A1a). Under the water conservation plan, most of the furrows were plugged with soil, and fixed weirs were placed in the main drainage system, causing the water level to rise even beyond the forest boundaries. Part of the agricultural land became waterlogged in spring, land preparation was delayed, and grassland could not be used for grazing.
Three injured farmers lodged a complaint with the water board, which is obliged by law to manage water with minimal damage to agriculture. In consultation with the farmers, the water conservation plan was modified. The State Forest Service had to replace a weir farther down stream and remove one altogether (figure A1b). A diversion canal was dug at the edge of the forest to lower the groundwater level for the adjacent farm fields and to discharge that water to the reopened drainage canal. In return, the three farmers agreed to the installation of a new, adjustable weir in the drainage canal mainly to discharge agricultural drainage water. The farmer most affected by the weir can open the gate when water rises above a specified minimum level and close it to save groundwater in the summer.

**Jac van Poppel**

Jac van Poppel, a dairy farmer, is a board member of the regional ZLTO (farmers union). His case is an example of a transfer of water management and institutional performance from official drainage management to farmer-initiated and controlled management on farm scale.

Van Poppel runs a 30-ha dairy farm, obtained in 1982 after the local land consolidation project ended. The project, which involved extensive land grading, drastically changed the topography. High land had been simply sheared off and bulldozed onto lower areas, leaving some land without any top soil and burying other land under fertile top soil but lacking a good substructure. Therefore, the drainage characteristics of the land are unequal. The soil is poor—coarse and sandy. The drainage infrastructure was designed to drain even the lowest parts to the maximum, normal practice at that time. The rationale was that excessively dry parts could easily and cheaply be irrigated. Energy prices were low, and groundwater pumping was free for all takers. The whole farm was provided with subsurface drainage. Water management seemed fully under control. The four or five neighboring farms were similarly organized.
In the mid-1990s, after some dry summers and high sprinkling costs, the ZLTO did a survey of its members’ biggest worries. Increasing drought vulnerability and escalating irrigation costs were the most striking survey findings. At the same time, the groundwater level was dropping at an alarming rate, and the provincial government began to prepare regulations to restrict free pumping. Irrigation was to be permitted only between 6 P.M. and 11 P.M., and only in May, June, and July. To avert these inflexible rules or worse, a complete ban on irrigation, ZLTO started a self-regulating water conservation program, followed a year later with tailor-made program to increase irrigation efficiency. After a successful pilot year, ZLTO and the Noord Brabant province were able to agree on a new Provincial Order, requiring a license for a pumping installation, limiting the extractable volume of groundwater per farmer to 40,000 m$^3$ a year, regardless farm area, and, for exceeding this allocation, imposing fines equivalent to US$0.225 on the total amount extracted in that year (thus, at least US$9,075). Farmers can apply the irrigation water whenever they want. The volume of water extracted is measured by first calibrating the pump and then counting the kilowatt-hours consumed. Installing water meters would be too costly and too prone to clogging.

Because Van Poppel’s irrigation costs were also rising yearly, he started water conservation on his own—rather illegally. He used earth to dam the main drainage ditch, owned and maintained by the water board. Later, when the earth dam washed away, he used wooden planks. In fall, the provisional construction was removed by the contractor, hired to clean the canal on behalf of the water board. The following year (1996), Van Poppel asked the water board for an official adjustable weir to be operated by himself. First the board refused his request without giving any reason. Then van Poppel and four neighbors formed a small group with the same interest: conserving water for their crops. As a group, they approached the water board with the request for five adjustable weirs, one at each downstream end of a farm. This time they were successful, and the five weirs were constructed that year—and operated by each farmer. The spontaneous gathering of a small group of farmers has much in common with the early formation of water boards in the Coastal Polders some 600 years ago. This small group has also to consult one another before opening the gates to prevent damage from the released water to someone downstream.
Weir operation is not easy, and it took van Poppel about four years to master it. The art is to close the gate in spring just in time—not too early, not too late. The important variables are: the moment for land preparation, which is determined by the cumulative temperature from February 1 on. The second important parameter is the time the land needs to restore its water storage buffer (between saturated soil and field capacity). Most of van Poppels land requires about 14 days of dry weather for that. Due to the imperfect land grading under the land consolidation project, quite a few patches need more time, which is a big disadvantage. Since weather forecasts are reliable for only about 5 days, there is always a risk of having some land that is too wet. Subsurface drainage is a prerequisite for this kind of water management. It helps restore water storage capacity quickly and minimizes the risk of temporary waterlogging. On the other hand, subsurface drains help the stored water infiltrate back into the soil. Van Poppel is considering an experiment, using his irrigation pump to supply his drainage system and infiltrate the water instead of sprinkling it at much higher energy costs and counted kilowatt-hours.

The benefits of the system are not easy to determine. Van Poppel sees it as a saving on irrigation costs. The water conservation system does not cost much but requires alertness. The cost of sprinkling works out at about $0.64 per m$^3$. If he saves only 30 percent on irrigation, the financial benefit would amount to about $2,500 a year. Van Poppel sees increased ecological diversity on his farm as another, “intangible,” benefit. For the moment, this is his private opinion.

For Van Poppel’s 28 ha of irrigable land, the annual cost of sprinkling comes to $ 254/ha. As a reference: Huinink, Verstraten and Janssen (1998) spends $295/ha on grassland sprinkling.

### A. Corporaal

A. Corporaal, a landscape ecologist, has worked since 2000 for Alterra: Green World Research, the largest Dutch research institute in the field of natural resources management (box A4). Previously, he worked for the University of Nijmegen and the Ministry of Agriculture, Environment and Fisheries.
Box A4 Alterra’s research mission

“Among the many themes in which Alterra is involved, national as well as international, are: relations between urban and rural areas; multiple use of the green environment; economy and ecology; integrated water management; sustainable farming systems; future reconnaissance, expert systems, and modeling; biodiversity; landscape development and signification values; integrated forest management, Geographical Information Systems and remote sensing, spatial planning for recreation, nature development in marine and estuarine waters; spatial ecological networks; pollution and values of nature related to spatial fragmentation.”

Source: www.alterra.nl. unofficial translation from Dutch text.

Development of function valuation

Corporaal is leader of the Alterra research project, “Farmers for Nature.” Alterra was hired to do the project by the local commission for the Olst-Wesepe Land Development Project (previously called Land Consolidation Program). Other project partners are the Salland Water Board and the DLG (Government Service for Land and Water Management). Finding space for new nature and for water retention to diminish the risk of downstream flooding is one project objective. This shows the value assigned to the extra land functions: water retention, maintenance of valuable scenery with a social-cultural value, and contributions to ecosystem sustainability. Instead of bypassing the farmers by purchasing the necessary land, the Alterra project will work with farmers to realize these objectives on an economically sound basis in a 400-ha pilot area.

Although agricultural production will decline considerably, a sound economic basis for these “farms with water function” is posited on three premises. First, the inevitable spreading out of production in this new farming system lessens farm produce but also production costs. The net financial loss is therefore not proportional to the loss of production. Second, some production rights (e.g., milk and dung quotas) become superfluous and can be leased out to farmers with shortages. Third, extra income can be generated because government rewards this kind of production practices with extra subsidies on a contractual basis. This farm type has demonstrated its ability to compete financially with classic farms. Family incomes vary from US$27,000 for a 15 ha farm to US$114,000 for a 50 ha farm.

Another source of extra income in the future can probably be found in payments by the water board, which has a strong interest in this type of water retention. Their costs of flood protection for low-lying areas decrease, and they do not have to buy land to create sufficient retention capacity.

Farmers’ low confidence in the reliability of the government’s promises is a major hurdle to be overcome to win their enthusiastic participation. The farmers’ union is advising farmers to be careful—wait and see.

Today, the development of the paradigm of blue-green services (blue for water management, green for nature and scenery) delivered by the agricultural sector on an economic basis is in full swing. The effects are fairly well known (flood protection, recreation, drought prevention, clean drinking water). Political debate revolves around financing these services. The pilot project described here will attempt to deliver some answers.

Reforms in the scientific knowledge subsystem

An important element in the resources management system is the scientific knowledge complex. This complex produces new knowledge through research, and disseminates knowledge through education and publication.

The scientific knowledge complex in the Netherlands has changed in many ways since 1965.

- Mergers have drastically reduced the number of research institutes (previously organized along sectoral lines).
Research programs have evolved from simply mapping the basic plant-water-soil relationships for the main client, agriculture, to research into the effects of interventions in complex natural resource systems, with a variety of societal segments as the client.

Research institutes themselves have to raise more and more of their budgets. In other words, research programs have become demand driven instead of supply driven.

The distance between research and education is steadily narrowing.

Thus, a process of reform is going on in the scientific knowledge subsystem, one that reflects reforms in the overall water management system. In this process, is science in the driver’s seat or are changes in society forcing research establishment to reorganize?

The old scientific system had many symptoms of a corporate society, with oligarchic touches in higher echelons. Although the research institutes were split-up along subject matter lines, agricultural interest ran across many segments. An old-boys network ruled in politics, in the Ministry of Agriculture and its State Services, in the scientific world in Wageningen, and in the farmers unions and agribusiness.

Wageningen’s research agenda was largely determined by the old-boys network. Overlapping of positions and functions in this network were more common than not. However, the importance of agriculture declined after the student revolt of 1968–69, reflecting fundamental attitudinal changes throughout society. The short period between 1968 and 1972, which can be called the revolutionary reform phase, was followed by a more evolutionary period of change.

The result, after some fierce and sometimes personal fights, was a decline in “authority based on position.” Slowly, the agrarian network crumbled. Except for a few visionaries, the scientific establishment did not initiate the reforms. They started with the societal unrest of the late 1960s, which infected students and the lower scientific echelons. Gradually a new, better educated generation, more open to societal change, has taken its place in the scientific knowledge complex.

The “new” scientists welcome new ideas with relevance for a new society. Science today heavily influences the natural resources management system. This influence is now based more on intellectual acumen than on hierarchical position in decisionmaking circles. And agriculture is no longer the only client.

The introduction of a free-market principle (earn your own money) in applied land and water science has improved the representation of all stakeholder groups in this part of the water management system. This democratization prevents the concentration of power (knowledge) in the hands of a privileged few.

Paul van Poppel

Paul van Poppel has been acting director of the Brabant Federation for the Environment for 18 years. Now 58, he is a lawyer in public administration by education and experience.

The Brabant Federation for the Environment (BMF in Dutch) is a 30-year old nongovernmental foundation that gathers under one umbrella more than 130 member NGOs based in Noord Brabant province and active in various environmental fields (box A5). The BMF has a salaried staff of 22, many of them academics. Each of the 12 provinces in the Netherlands has an equivalent organization. These 12 provincial federations, together with the national Foundation for Nature and the Environment, meet several times a year to coordinate policies and activities and to develop common positions, allowing them to speak to the government with one voice.
The majority of BMF board members are delegates from the member NGOs (half the board members plus one). Therefore, the BMF is, to some extent, controlled by its grassroots organizations, but as an autonomous foundation, it also has a free hand to act and negotiate for its members. Frequent communication with member NGOs is the panacea to prevent severe conflicts.

The BMF represents at least 40,000 like-minded people—all the active volunteers of the member organizations. More important, the federation feels it represents nature, a common resource with collective value, which has no voice in decisionmaking. This task, which should have been a responsibility of government, was largely neglected in the past.

When the BMF was established in 1972, the queen’s commissioner in Noord Brabant stated that “we can tolerate a watchdog in Brabant’s backyard, but he had better not bite the hand that feeds him!” (source: citation Jeroen Naaykens. In: Annual Journal BMF 2001–2002: 2). The environmentalists’ activist attitude did not lend itself to compromise at that time.

Over the years this attitude has changed, but only after some serious confrontations, especially with the agricultural sector. Farmers, in reaction, had also become more militant, even mounting massive road blockades (1992) to protest against the government’s “too environmental friendly” policies. Since those days, both sides have realized that confrontation creates nothing but losers. The BMF has changed its strategy accordingly. Now it is a recognized and institutionalized partner in several planning and decisionmaking forums. Its objectives have changed from hard, predetermined, blueprint goals to a series of flexible, direction-oriented ambitions. This strategy leaves room for negotiations.

The BMF is one of the civil organizations (like the farmers union ZLTO) involved in the preparation of the Provincial Spatial Plans. In that capacity, it can influence policies for ecological restoration of local rivers, water conservation, withdrawal of land from agriculture for new nature, and other policies that shape the ecosystem.

Because the Water Board Act of 1992 allows for a broader representation of interests in decisionmaking on water management, the BMF has an active strategy to get its own candidates elected, mainly via the broad interest category of “inhabitants.” They also line up with the large owners of nature land, like the Government Service for Forests and the Brabant Landscape Foundation, which sometimes have ex-officio seats on a water board.

The same holds for land consolidation projects. Since 1986, the local commissions, who are the executive authority for these projects, have been opened up to representatives of other societal groups besides landowners and farmers.

The BMF has learned these lessons around the negotiating table:

- Your opponents often have prejudices, are afraid to compromise their interests, and are under enormous pressures from their internal “group loyalties.”
- Take plenty of time to learn to speak your opponents’ “language” so that all parties use and understand the terms in the same way. Thee can be incredible differences in the way different groups understand the same word.
- Try to understand exactly what the other party means and wants.

**Box A5 Objectives of an environmental nongovernmental organization**

The strategic objective of the BMF is to contribute to a sustainable economic, ecological, and sociocultural development. The BMF wants to realize this by:

- Achieving clean air, soil, and water
- Realizing closed resources cycles
- Maintaining and strengthening a rich and biodiversity
- Maintaining and strengthening diverse and inviting rural scenery
- Maintaining and strengthening of vital and compact cities in green surroundings
- Anticipate knowledge, attitude and behavior regarding nature and environment.

Source: Quote Paul van Poppel.
Try to arrange talks with at least three parties. This helps to avoid deadlocks, but avoid government officials if you do not want to become entangled in formalities or hidden agendas.

Start dealing with prescient and open-minded personalities from the opposite side. Avoid the hard-liners if you want to avoid trench warfare.

Be aware of your legal right to contest juridically any decision, but use this weapon only if no agreement can be reached.

Finally, before general political debates, governments welcome discussions between interest groups with conflicting interests that result in mutual compromises and agreements. Such talks blow off the fluff, clearing the way for formal decisions.
References


