Environmental History of the Rhine–Meuse Delta

An ecological story on evolving human–environmental relations coping with climate change and sea-level rise

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Cover illustration: The river Lek at Elshout (Kinderdijk) ca. 1850, painting by Johannes Weissenbruch (1822–1880), Teylers Museum, Haarlem. It is generally believed that the cultural landscape of the Rhine–Meuse Delta had obtained its maximum biodiversity around 1850, before the complete regulation and canalization of the large rivers, and before the introduction of artificial fertilizer and barbed wire.

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Memory of Holland

Thinking of Holland
I see wide-flowing rivers
slowly traversing
infinite plains,
inconceivably
rarefied poplars
like lofty plumes
on the skyline in lanes;
and submerged in the vastness
of unbounded spaces
the farmhouses
strewn over the land,
tree clumps, villages,
truncated towers,
churches and elm trees -
all wondrously planned.
the sky hangs low
and slowly the sun by
mists of all colours
is stifled and greyed
and in all the regions
the voice of the water
with its endless disasters
is feared and obeyed.

H. Marsman (1936)
Translation Paul Vincent

Contents

Preface

This book presents the environmental history of the Delta of the lowland rivers Rhine and Meuse, an ecological story on evolving human–environmental relations coping with climate change and sea-level rise. It offers a combination of in-depth ecology and environmental history, dealing with exploitation of land and water, the use of everything nature provided, the development of fisheries and agriculture, changes in biodiversity of higher plants, fish, birds, mammals and invasive exotics. It is the first comprehensive book written in English on the integrated environmental history of the Delta, from prehistoric times up to the present day. It covers the legacy of human intervention, the inescapable fate of reclaimed, nevertheless subsiding and sinking polders, 'bathtubs' attacked by numerous floods, reclaimed in the Middle Ages and unwittingly exposed to the rising sea level and the increasing amplitude between high and low water in the rivers. The river channels, constricted and regulated between embankments, lost their flood plains, silted up, degraded and incised. Cultivation of raised bog deposits led to oxidation and compacting of peat and clay, resulting in progressive subsidence and flooding; arable land had to be changed into grassland and wetland. For millennia muscular strength and wind and water powers moulded the country into its basic form. From 1800 onwards, acceleration and scaling up by steam power and electricity, and exponential population growth, resulted in the erection of human structures 'fixed forever', and severe pressure on the environment. The present-day Delta is a large wetland several metres below sea level, where humans 'keep their feet dry' only by the application of advanced technical means. The synthesis presents a blueprint for future management and restoration, from progressive reclamation of land in the past, to adaptation of human needs to the inevitable forces of nature.

A river delta essentially forms a gradient between the sea and the river proper, and elaborating on the ecological history of the Rhine–Meuse Delta assumes both knowledge of the estuarine environment as well as of the river environment. During my career I have worked for almost 25 years on estuarine ecology and management, and for roughly 15 years on the rivers proper. I realise that the aspects I have emphasised in this book, as well as the case studies I have worked out, mirror my subjective choices. This book is meant as a contribution to the environmental history of the Rhine–Meuse Delta, and I hope that my work will

challenge other scientists to falsify my conclusions and to add their own chapters to the blue-green story of the man-made Delta.

I am indebted to many persons for support in the production of this book. I thank my son Arjan Nienhuis, landscape architect (Zaltbommel), for stimulating discussions and for his share in the final chapter on the future of the rivers. Joep Dirkx (Natuurplanbureau Wageningen), Petra van Dam (Free University Amsterdam) and Johan van Rhijn (Open University Heerlen) offered me information on the status of environmental history in the Netherlands. Klaas Bouwer, Gerard van der Velde (both Radboud University Nijmegen), Gerard de Ruiter (Nieuwegein), Willem van der Ham (‘s-Gravenhage) and Aart Vos (Zaltbommel) provided me with relevant literature. Herman van Dam (Amsterdam) enabled me to consult the archives of the Netherlands Society of Aquatic Ecology (Municipal Archives Amsterdam). Jan Bervaes (Zaltbommel) provided information on the medieval history of the Bommelerwaard. Roelof Loenen Martinet (Wageningen) placed at my disposal the family archives of the naturalist J.F. Martinet. Jolanda Hiddink and Lidwien van der Horst of the Department of Graphic Design Radboud University Nijmegen, worked up my sketches into high quality figures. Rob Lenders (Radboud University Nijmegen) and two anonymous reviewers scrutinised the manuscript. I also thank Tamara Welschot and Judith Terpos of Springer Publishers for their efforts in seeing this book to publication. Lastly, I especially want to thank my wife Arine for putting up with me while I was writing this book.

Piet H. Nienhuis

Chapter 1
Introduction

1.1 Developments in Environmental History; Motives to Write this Book

Environmental history is the study of humans and nature and their past interrelationships in the broadest sense. Environmental historians base their understanding of human and nature relations primarily on historical methodology, but often borrow from the work of scientists and scholars in fields outside of history. As a result, many scholarly contributions pertinent to environmental history are written by professionals who typically would not identify themselves as historians, and as an aquatic ecologist I am one of those scientists. Professional, integrated environmental history has now been in the making for roughly one generation. It is well recognised that the most influential empirical and theoretical work has been done in the USA, which is also where most of the first teaching programmes emerged and where the large majority of environmental historians are active. The other region with an equivalent number of major universities is Europe, but interchange of ideas on this continent is suffering from the numerous languages used to express beta–gamma integration (Sörlin and Warde, 2005). In 1999 the European Society for Environmental History was founded, counterpart of the American society, aiming at stimulating the dialogue between humanistic scholarship, environmental science and other disciplines in Europe. Indeed, a recent series of essays in the journal *Environmental History* (2005, volume 10, number 1) on the future of the field were written almost entirely by people based in the USA; Europe's contribution being an essay by Petra van Dam (2005) lamenting the difficulties caused by the language of the discipline being English.

The geographical features of a low population density, large stretches of 'wilderness', a mobile 'frontier' and a strong tradition of the 'outdoors', have all been significant for the reception and growth of environmental history in North America. This is also perhaps true of other regions where environmental history has gained a foothold: Australasia, and within Europe, in Scandinavia, in the Alpine countries and in Scotland. Certainly, both the threat of natural forces and the widely recognised ability of humans to radically transform their environments in the relatively recent past seem to have contributed to these global trends. Until very recently, themes within environmental

P.H. Nienhuis, *Environmental History of the Rhine—Meuse Delta,*

history have been largely rural or to do with impacts of human activity on the rural or supposedly 'natural' environments, even when the forcing agent stems from urban development. In continental Europe, environmental history's impact has often been related to local peculiarities, such as the history of water management in the Netherlands, forestry in Germany and the Nordic countries, or pollution in regions of rapid 19th-century industrialisation (Sörlin and Warde, 2005).

It may be suggested that the integrated approach to environmental history has not yet come to full maturity in the Rhine–Meuse Delta (see Figs. 1.1 and 1.2 for position of the Delta), likely owing to the complexity of the subject and to the way the education system at our universities is organised, strictly according to scientific disciplines. (I could only write this book after my retirement in 2003).This lack of integration may be true, but in its disciplinary approach environmental history in the Netherlands is much older than in the USA, for example, in the fields of environmental health care and nature protection. The Dutch Society against Water, Soil and Air Pollution was erected in 1909. It had a long and standing tradition, and numerous publications dominantly in Dutch appeared in the course of the 20th century. The society played an important role in research of water pollution directed to rivers and surface waters. It took several initiatives for legislation with respect to environmental pollution. The organisation merged in 1978 into the action-oriented Foundation Nature and Environment. The archive is a goldmine of facts and data on the environmental history of the Delta not yet published in English (www.iisg.nl/archives).

Publications on nature protection also have a long tradition in the Delta. The journal *De Levende Natuur* (*Living Nature*) was founded in 1896 by the teachers Jac. P. Thijsse and E. Heimans, and this periodical appeared to be the most important medium for articles about nature protection and nature study in the period before World War II. In 1903 for the first time the word 'natuurbescherming' (nature protection) was used in *De Levende Natuur* (Van der Windt and Harle, 1997). In 1905 the Society for the Preservation of Nature in the Netherlands (Vereniging tot Behoud van Natuurmonumenten) was founded. In 2006 this organisation had 913,000 members, it owns 370 nature reserves with a total area of 95,000 ha, and is the most powerful nature conservation organisation in the Delta (www.natuurmonumenten.nl).

Being on familiar terms with water and land–water interactions was anchored in the collective memory of many inhabitants of the Delta. My wife Arine published a genealogical book (Nienhuis-Snaterse, 2008) on her ancestors who lived in the Central Delta from the 16th century onwards, and numerous old trades in her family can easily be associated with the history of the wetland of the river Rhine: fisherman, decoy man, water-miller, shipbuilder, driver of a towing-horse, cooper, farmer, farmer hand, reed-cutter, peat-cutter, member of the polder board and ferryman. Lowland rivers and polders have inspired many pictorial artists, musical composers and writers through the ages (e.g. Schmidt et al., 1995). Many regional novels contain a wealth of hidden environmental history on exploitation of aquatic resources, navigation with sailing boats, dyke breaches caused by drift ice, the consequences of unpredictable river floods, poverty and hard labour, 'the fear of the Lord' and much more (e.g. Van Schendel, 1933; Coolen, 1934 [33rd print in 1977]; Ooms, 1950; Van Toorn, 1999).

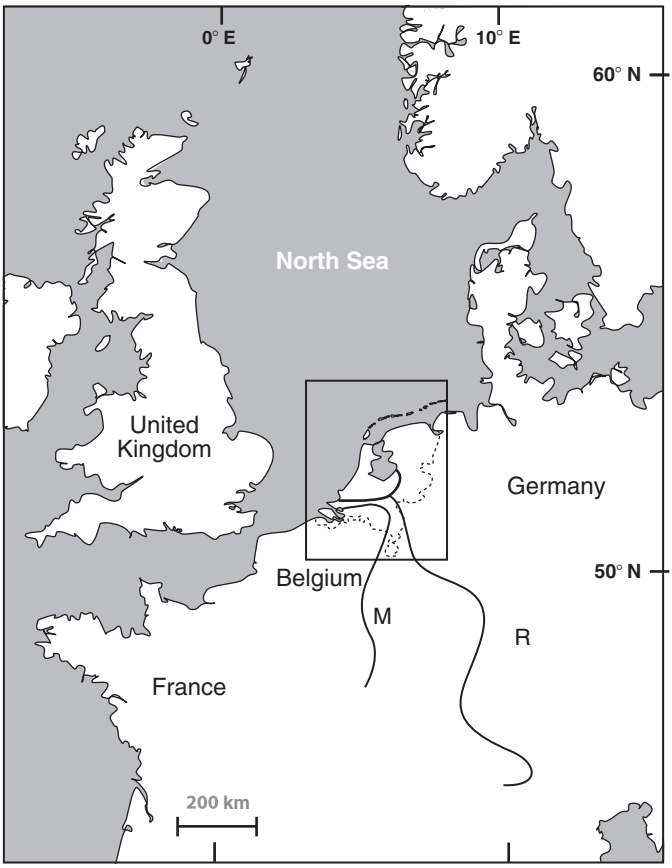

Fig. 1.1 Position of the rivers Rhine (R) and Meuse (M) in Western Europe. Detailed maps of the catchments are published in Chapters 12 and 13. The Delta is positioned in the inset, see Fig. 1.2

The Netherlands has a book on the 'green history' written in Dutch by Van Zanden and Verstegen (1993), and since 1996 the 'Jaarboek voor Ecologische Geschiedenis' (Yearbook for Ecological History) of the 'Vereniging voor Ecologische Geschiedenis (Society for Ecological History) has been published. From 1986 onwards the modest journal 'Contactblad Net Werk voor de Geschiedenis van Hygiëne en Milieu' (Journal Net Work for the History of Environmental Health Care and Environment) functions as an indispensable source for a detailed reconstruction of environmental history. Thus far however, these publications are mainly written in Dutch and have not crossed borders unto an international audience. In 2003 'Environmental Science', journal of integrative environmental research, evolved from the Dutch predecessor 'Milieu' (Environment), associated with the Netherlands Association of Environmental Professionals (VVM), but up to now the

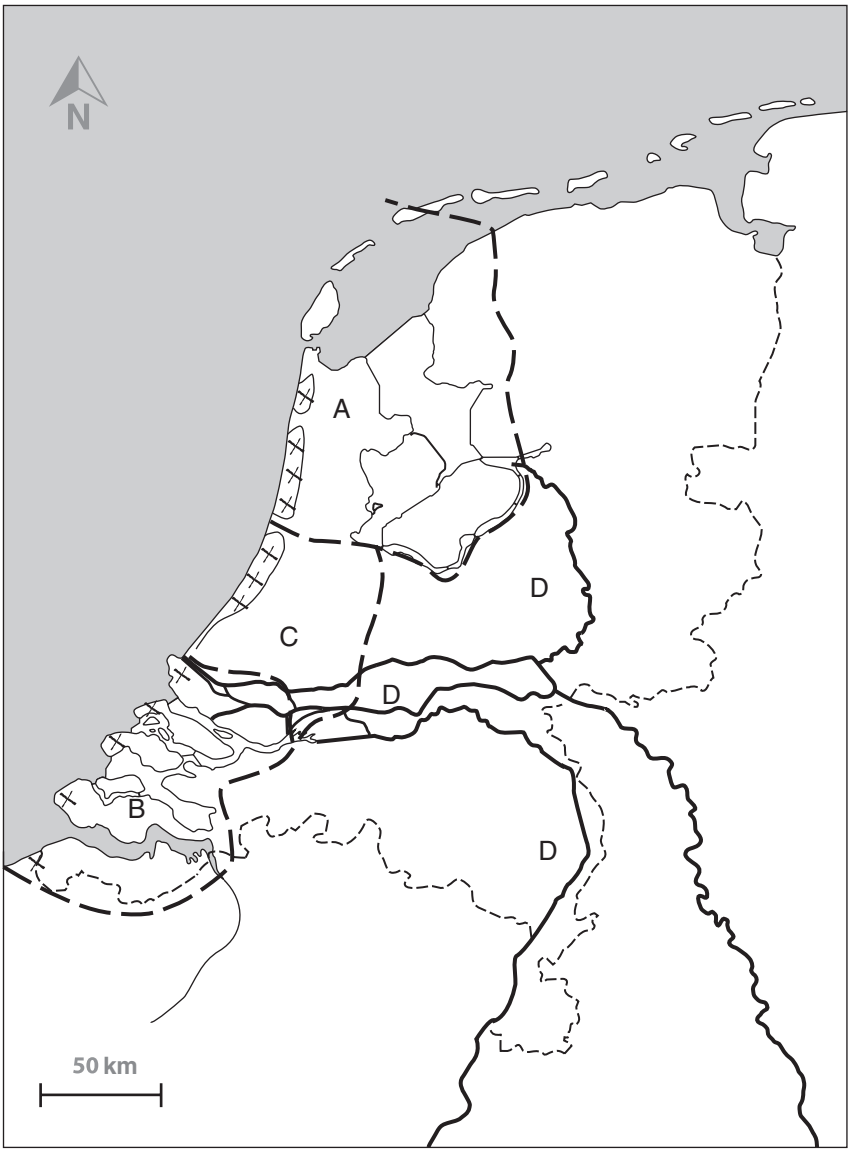

Fig. 1.2 The Delta of the rivers Rhine and Meuse, projected on a present-day map of the Netherlands. The Delta is arbitrarily divided into the NW Delta, including the former Zuiderzee (A), the SW Delta (B), the Central Delta (C), and the area of the Large Rivers Rhine and Meuse (D), crosses = coastal dunes

contributions to environmental history of the Delta are close to nil. The history of water management of the Netherlands is fairly good, covered by several authors (e.g. Van de Ven, 2004; Ten Brinke, 2007), mainly written from the state of mind of 'how a small country performs great actions'. But water management is only one side of environmental history, and a critical analysis of the effects of the making of the Delta on landscape structure and ecosystem functioning is lacking in the literature: an ecological story on evolving human–environmental relations coping with climate changes and sea-level rise. In conclusion, an English book on integrated environmental history of the Rhine–Meuse Delta does not exist. That was my first motive to write this book.

1.2 Additional Motives and Aims of the Book

Until the late Middle Ages the reliability of 'data' sampled on whatever field of environmental history is restricted. From the 17th century an increasing number of data on river management, land use, agriculture and fisheries became available, collected with ever-advancing measuring methods. 'Ecological' (the word did not exist) evidence per se remained scarce until the 20th century. The naturalists in the 18th and 19th century were the first to publish in more detail on nature items. The societal need for accessible knowledge about 'nature' was small, and the distinction between 'nature' and land and water exploited by man was hardly made. In the low man-made Delta little wilderness was left, and 'wasteland', i.e. not-cultivated land and water was used for the harvest of many useful products, such as wood, fish and game. According to Holmes (2006), we know surprisingly little about the way wetland communities have been affected in past centuries by natural or man-induced extreme events, and whether these changes are short- or medium term, or permanent. Only very recently, from 1950 onwards, a growing stream of publications on the regional ecology saw the light, including not only (the almost vanished) natural landscapes in the Delta, but also the semi-natural, man-made landscapes. Focused on the large non-tidal rivers in the Delta, an arbitrary choice of regional publications can be listed: Weidema et al. (1974) about the river polders in the Central Delta, Van Diggelen et al. (1992) on the Land van Heusden and Altena (referring to the oldest flora of the region from 1898 by C.A. Backer, present in the Rijksherbarium Leiden), Jonkers (1991) on the Vijfheerenlanden, Manders (1981) on the Land van Maas en Waal, Van Balken et al. (1978) on the Bommelerwaard, Van Heiningen (1971) on the Land van Maas en Waal and Caspers (1992) on the flora and fauna in the Meuse basin (referring to the flora of Van Hoven from 1848).

Now, in the 21st century, superficial interest in natural history is topical; people have a lot of spare time, and the publication of numerous books on popular items of ecology obviously fills a gap, for otherwise the market would not be washed over with these issues. An increasing number of appealing books on plant and animal life show, in glossy pictures, all the wonders of nature that can be observed during

'armchair' excursions. Societies for nature conservation, either national (Nature Conservation Society, Bird Protection Society; Nature Education Society, etc.) or regional (Provincial Landscape Societies; Regional Nature Conservation Societies, etc.) organise excursions and issue field guides, comprising walking routes and cycling tours, and geographic and historic routes. Up to now the superficial interest of civilians in nature is unrestrained, and the frontiers of this market have not been reached. We have to realise that this development is only roughly 40 years old, that is, 'five minutes to twelve' in our prehistoric and historic quest for the environmental history of lowland rivers.

Economic growth and prosperity most often are at the expense of the natural environment. Nevertheless, this book is not a litany on the deterioration of 'nature' in a Delta shaped by man. During the environmental history of the Delta, humans changed the 'natural' landscapes into semi-natural or cultural ones, and in the course of time these acquired an intrinsic value. There is an old saying, 'God created the world, but the Dutch created their country'. The most valuable Dutch landscapes in international and national terms are those whose historic evolution is still recognisable from their topographic patterns and their plant and animal life. These comprise the old marine clay landscapes in the Southwest (SW) and Northwest (NW) Delta, large parts of the peat grassland landscapes in the Central and NW Delta and the larger part of the area of the Large Rivers (Fig. 1.3). It is exactly these landscape types that form the subject of this book. Polders reclaimed from peat lakes pumped dry, old polders on marine clay and land reclaimed from peat, all of which are situated in the lowest parts of the country, have international significance. Over 95% of the polders in NW Europe are situated in the Delta. Peat reclamations with strip plots, originated during the 'cope 'exploitation, and old marine clay polders with dwelling mounds are mainly restricted to the Netherlands. Large-scale land consolidation after World War II and earlier river regulation measures, however, have spoiled many old man-made landscape structures in the low-lying Delta. In contrast, the Pleistocene cover-sand landscapes in the Delta (Fig. 1.3) have a low international value, because that type of landscape is amply available in Europe (Farjon et al., 2001; www.mnp.nl). The Dutch government has a great responsibility to maintain the remainder of the typical and internationally rare landscapes, moulded by the rivers and the sea. Knowledge of the environmental history of these unique landscapes is a prerequisite for future management. The second reason to write this book was to feed the conservation and restoration strategy directed to typical and internationally rare Delta landscapes.

The general aim of this book is to give a comprehensive overview of the environmental history of the lowland rivers Rhine and Meuse, in fact, an ecological story on evolving human–environmental relations coping with climate change and sea-level rise. Prehistoric and historic changes in river landscapes, in ecosystems and in the diversity of plants and animals have my first consideration. These changes have mostly been caused by use and exploitation of nature by man. History focuses on humans, on man and his noble or awkward deeds (see Section 1.3.4.). My book does not focus on man per se, but on the results of his actions in the 'green' and 'blue' environment. The book delves neither in the development of the 'red'

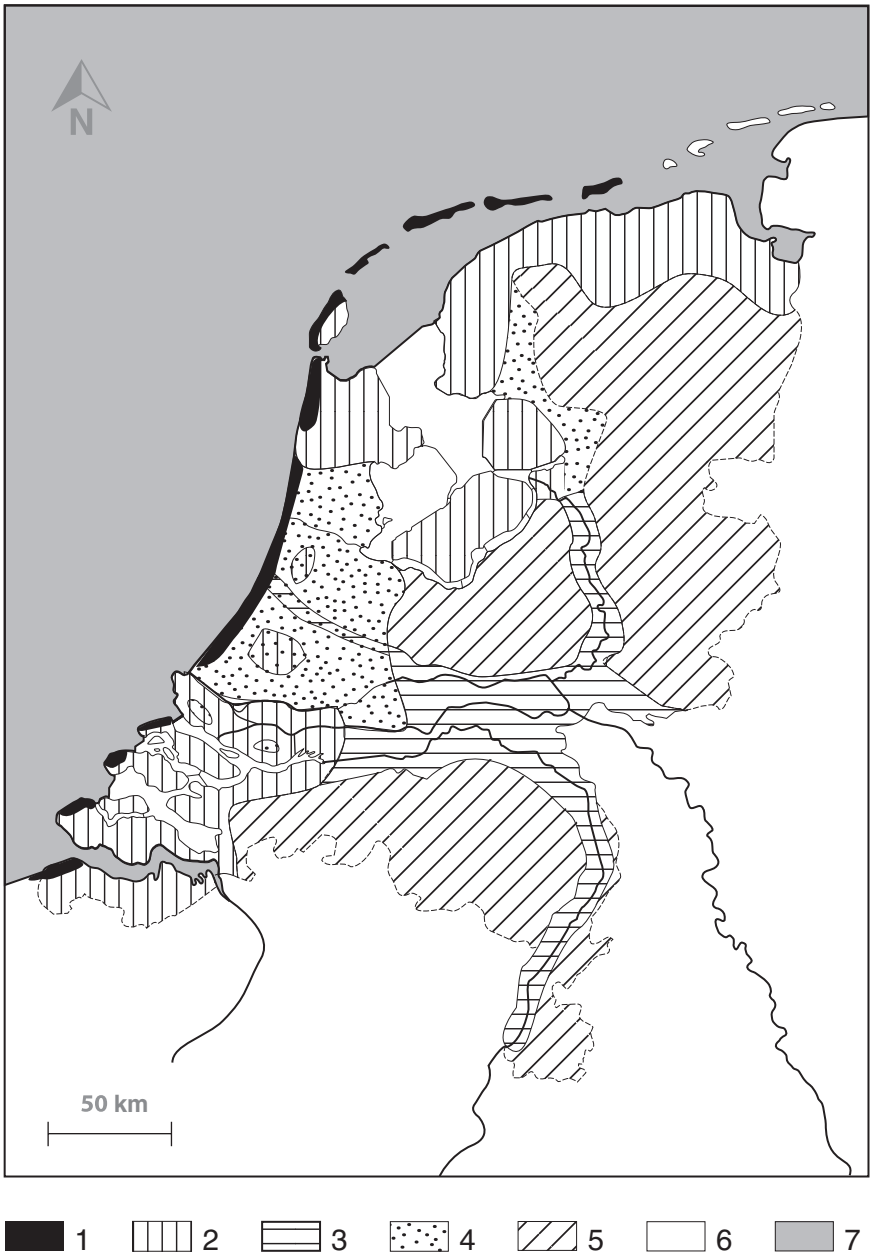

Fig. 1.3 Landscape types in the present-day Delta, characterised by the composition of the soil (www.bosatlas.nl). If there were no dykes and pumping stations, about 65% of the Delta would be flooded periodically by the sea and/or by the rivers, i.e. all landscape types except the Pleistocene cover-sands, and the coastal dunes. The marine clay deposits and peat-bog areas are situated below NAP (Dutch Ordnance Datum) or slightly above that datum level. The river clay deposits are situated above NAP, but they run the risk of being flooded when a river is in spate (www.rdnap.nl). 1 = marine coastal dunes; 2 = marine clay; 3 = river clay; 4 = peat bog; 5 = Pleistocene cover-sands; 6 = non-tidal water; 7 = tidal water

built-up environment, nor in policy, politics or in economy, but again in the resulting effects of all these disciplines on nature.

The making of the Delta from 3500 BP to 1800, will be described, a time in which muscular strength and water power moulded the country into its basic and still-recognisable form. The further making of the Delta from 1800 to 2000, characterised by acceleration and scaling up by steam-power and electricity, led to the formation of the Delta in its present shape. Through the ages dominant phenomena were the numerous storm floods and river floods, and how humans have coped with these incidents or disasters: the fate of the riparian inhabitants has more often been sealed by neglected maintenance of the protective embankments than by the changing climate. The exploitation of land and water, and particularly the transition land–water, runs as a continuous thread through environmental history, as will be elucidated with stories on fisheries, agriculture and use of seagrasses. History is made by humans, and consequently, some attention will be given to a number of men and women vital to the land- and waterscape, from the historic naturalists to the present-day aquatic ecologists. A view on biodiversity changes in the Delta through the ages will be illustrated with examples of higher plants, fish, birds, mammals and invasive exotics. The Delta comprises only a small part of the catchments of the international rivers Rhine and Meuse, and a few chapters have been devoted to the Delta in wider geographic perspective, in particular focussing on transboundary water and soil pollution and rehabilitation measures The last chapter of the book contains the synthesis, the lessons learnt from the past, and the wider perspective, some ideas about the future of the rivers. The future is to the next generation: of this chapter my son, Arjan, is co-author. As a landscape architect, he is involved in several river rehabilitation projects and schemes for the future physical planning of the Delta. The environmental history of the Delta will continue. A gradual change is to be seen, from the defensive strategy, that is, to claim as much land from the sea and the rivers as possible, to an offensive strategy, to adapt the human needs to the inevitable forces of nature.

Environmental history of lowland rivers is a broad field, and although I tried to cover the entire arena, my focus is biased by my knowledge of the subject, and consequently some aspects might be underestimated, and some other aspects may have got too much attention in the eyes of reviewers. So be it. It is a fact, however, that the environmental history of Delta lowland rivers is a challenging subject waiting to be explored further.

1.3 General Considerations

The environmental history of the Delta is embedded in some major physical, demographic and administrative developments, mainly beyond my focus. A few general considerations concerning these developments should be given, however, returning in almost every chapter of the book.

1.3.1 The Definition of the Delta

The Delta of Rhine and Meuse (in short, the Delta) is situated in NW Europe; it comprises the most stream-downward sections of these large European rivers, debouching into the North Sea in the Netherlands (Fig. 1.1). Long before the Netherlands came into existence (Section 1.3.4), the rivers Rhine, Meuse (and Scheldt) and the North Sea have shaped that piece of land. Therefore, consequently the physical term 'Delta' is used instead of the administrative limitation 'the Netherlands' that came only into use in the 19th century. The Delta is arbitrarily divided into the area of the Large Rivers Rhine and Meuse, and its subdivisions Nederrijn-Lek, Waal-Merwede and IJssel and Maas, where river clay deposits dominate; the NW Delta, including the former Zuiderzee and part of the marine clay deposits in Friesland; the SW Delta, where marine clay is the dominant terrestrial deposit, touching upon the influence of the river Scheldt; and the Central Delta, the peat bog land (Figs. 1.2 and 1.3). Dutch geographic names are used throughout the book, unless international waters are indicated (Rhine, Meuse, North Sea, Wadden Sea, etc.).

The concept 'polder' is typically Dutch, and a bit of the polder-vocabulary is indispensable in the context of this book. A polder is a low-lying tract of land that forms an artificial hydrological entity, enclosed by embankments known as dykes. Polders in the SW, NW and Central Delta constitute areas of land reclaimed from a body of water, such as a lake or the sea, and are consequently situated below the surrounding water level. A distinction is made between areas reclaimed by embanking salt marshes, land gained on the sea, and areas reclaimed by pumping dry lakes, the drained lakes (see Fig. 5.9). A 'waard' is a river polder, that is, a polder entirely enclosed by rivers, and surrounded by a ring-dyke ('bandijk'), a dyke expelling the influence of river water. River polders are situated in the area of the Large Rivers.

The northernmost part of the Delta does not belong to the delta of the Rhine in the strict sense. It is an area shaped by the sea, mainly consisting of marine clay deposits. Circa 2,500 years BP, humans have settled there on natural levees and later on man made dwelling mounds. In the Middle Ages large areas were embanked. The area is geomorphologically but also historically characterised by gradients between land and water. Long after man started to protect large areas of fertile ground by embankments, storm floods threatened the reclaimed land and ravaged the human settlements unto the town of Groningen. Nowadays, massive seawalls form a sharp border between inhabited land and water. A special issue of Helgoland Marine Research (2005, volume 59, number 1) is devoted to the ecological history of the Wadden Sea, mainly focusing on the present Wadden Sea, the estuary disconnected from the inhabited land (Lotze et al., 2005). The comprehensive environmental history of the dynamic Wadden Sea and 'Wadden land' of the past is waiting to be exemplified.

1.3.2 The Demographic Developments Underlying the Ecological History

The Delta was, and still is shaped by humans. A salient feature of the Delta is the growth of the human population through the ages. The population increased slowly in the period 800–1800, from 0.1 to 2 million people, on average 0.2 million per century. A rapid increase took place from 1800 to 1900, from 2 to 5 million inhabitants, an average increase of 3 million per century. From 1900 to 2000 the population increased extremely rapidly from 5 to 16 million, that is, 11 million in a century. The prognosis is that the population will increase to 17 million in 2035, and further will decrease to 16.9 million in 2050, which is a major break with the current tendency (Fig.1.4; www.cbs.nl). The causes of these demographic developments are only slightly touched upon, because they are largely beyond the subject of this book. The consequences of the exponential population growth, however, have been decisive for the layout and the use of the Delta and demographic shrinkage will be of crucial importance for the future use of land and water. In several chapters these effects are a matter of consideration.

1.3.3 Sea-Level Rise and Ordnance Datum

Sea-level rise is a complicated process: not only the sea level is rising after the last ice age (65 m in 10,000 years; Fig. 2.2), but at the same time the land is sinking. Sea-level rise should therefore be considered as relative sea-level rise. Northern Europe was pushed downwards under the increasing pressure of the 4 km thick ice mass during the last ice age. The semi-fluid interior material of the earth underneath northern Europe escaped to the borders of the massive ice cap and this resulted in an upwards pressure of a large area bordering the ice mass, including the Rhine–Meuse Delta. When the ice mass melted and retreated to the north the reverse process took place. In the past 10,000 years Scandinavia has risen more than 300 m, and in contrast with this process the Rhine–Meuse Delta has sunk; and there is yet another process complicating the relative sea-level rise. The Delta is slightly tilting into the direction of the North Sea. The coastal areas of the North Sea and the Wadden Sea are sinking several centimetres per century, whereas the Pleistocene eastern and southeastern parts of the Delta are coming up with roughly the same rate. Real-time measurements of physical and chemical parameters only started at the lowest point of the Little Ice Age, around 1830, and that is a drawback for the interpretation of recent climate change events. No wonder that many data series show an upwards trend, viz. temperature followed by CO_2; we simply do not have enough data to look back over even a very small-scale climate cycle. All data sampled in the past were proxy data, indirect measurements based on pollen grains, tree rings, market prices of resources, historic data and old maps, with all implicit difficulties of interpretation (Kroonenberg, 2006).

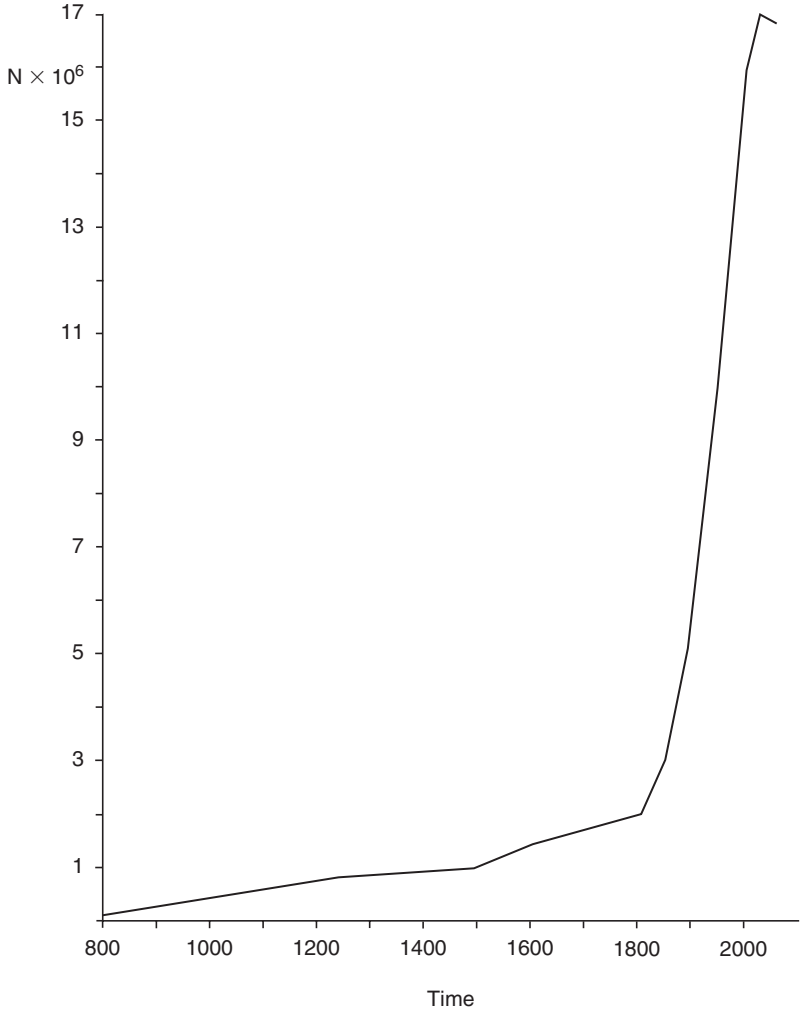

Fig. 1.4 The development of the human population in the Netherlands ($N \times 10^6$) over the period 800–2000, and a prognosis for the period 2000–2050. The predicted decrease of the population after 2035 is a significant break with the current trend (www.cbs.nl). The decrease in population during the pest epidemics, particularly in the 14th century, is not indicated, because data for the entire country are unreliable (cf. Slicher van Bath, 1960)

The Amsterdam Level (AP) was introduced in 1683–1684 as a reference level related to the average high water level in the IJ at Amsterdam. This level was marked in several sluices in Amsterdam, where fixed stones were provided with a horizontal groove. At the end of the 19th century the ordnance datum was determined in a more accurate way. Between 1875 and 1894, the Normaal Amsterdams Peil (NAP) (Normal Amsterdam Level) was introduced as a reference level related

to a defined sea level. NAP 0 m level is approximately equal to average sea level at the North Sea. Nowadays, NAP is visualised by thousands of bolts fixed in dykes, bridges and buildings, of which the exact level in relation to NAP is regularly ascertained (cf. Fig. 1.3). The Dutch Ordnance Datum NAP is adopted by several European countries, which facilitates comparisons of flood levels. Although NAP was only introduced in the 19th century, I will refer to that datum from prehistoric times onwards, enabled by palaeographic excavations of reconstructed river landscapes from the past, and by comparison of historic flood levels with recent high water levels. The disadvantage of this reference remains that the Delta is subsiding and the sea level is rising (www.rdnap.nl).

1.3.4 The Constitution of the State of the Netherlands

The Delta of the rivers Rhine and Meuse is nowadays called the Netherlands, but the limitation of the country, as depicted in Figs. 1.2 and 1.3 is of a rather recent date (1840). The history of the state, in this context reduced to a number of (disputable) facts, however, is indispensable for the proper understanding of the environmental history of the lowland rivers.
AD 703: Foundation of the diocese of Utrecht; prince-bishops of Utrecht had secular power over part of the diocese.
AD 922: Foundation of the earldom of Holland.
1096: Foundation of the (earldom later) duchy of Gelre.
1106: Foundation of the duchy of Brabant.
1581: Foundation of the Republic of the Seven United Netherlands.
1813: Foundation of the Kingdom of the Netherlands.
1840: Limitation of the borders of the present provinces in the Netherlands.
(www.ru.nl; 'Het museum van de vaderlandse geschiedenis')

Much progress in water management was accomplished in the past by the dedication to a central government, but many conflicts between regional rulers have frustrated the efforts to conquer the 'water wolf'. About progress: the successful 'cope' exploitation of the raised bogs of the Central Delta from AD 950 onwards (Chapter 3), was directed by the bishop of Utrecht and the earls of Holland. About conflicts: the quarrels on water management affairs between the earldom of Holland and the duchy of Gelre have to be traced back to the political superiority of the earls of Holland, compared to the dukes of Gelre. The Diefdijk between the Vijfheerenlanden in the west (Holland) and the Neder-Betuwe and Tielerwaard in the east (Gelre) (Fig. 3.9), was built by the earls of Holland in 1284 to avoid flooding of their territory when the Rhine was in spate and flooded the Betuwe. The borderline between the diocese of Utrecht and the duchy of Gelre was partly formed by a valley, a marshy bog-peat area in between ice-pushed ridges in the west (Utrecht) and in the east (Gelre). In the south, the Nederrijn penetrated far inland (Fig. 3.4), and in the north a number of brooks, originating on the Veluwe, discharged their water into this valley. This border area has long been an area of political

conflicts. An example: the walled town of Bunschoten on the river Eem was several times razed to the ground after the inhabitants violated their treaty with the bishop of Utrecht and collaborated with the enemy, the duke of Gelre (www.provincie-utrecht.nl).

From the Middle Ages onwards the river Maas has formed the border between the duchy of Gelre and the duchy of Brabant. Until far in the 16th century both duchies were in a state of permanent war, and often Gelre had the upper hand. The Maas, its discharge being ten times smaller than that of the river Waal, was used as an overflow when the Waal was in spate (Beerse Maas at Heerewaardense Overlaat and Beerse Overlaat; Fig. 5.4), a position sustained by the political quarrels between the border states. After 1581 Gelre was a fully fledged province of the Republic, Brabant was not. Brabant was a 'generaliteitsland', that is, it was enrolled by the Republic, placed under the jurisdiction of the States General, but it had no right to vote. Consequently, the Maas could be considered the 'slave' of the Waal: the river was frequently saddled with the burden of flooding caused by the river Waal in Gelre. Long after 1800, when the position of the two provinces Gelre and Brabant became more or less evenly matched, the overflow function of Brabant still existed. The Heerenwaardense Overlaat was closed at the end of the 19th century and the Beerse Overlaat was only closed in 1942.

Part I
Human Occupation and Management of a Fertile Delta