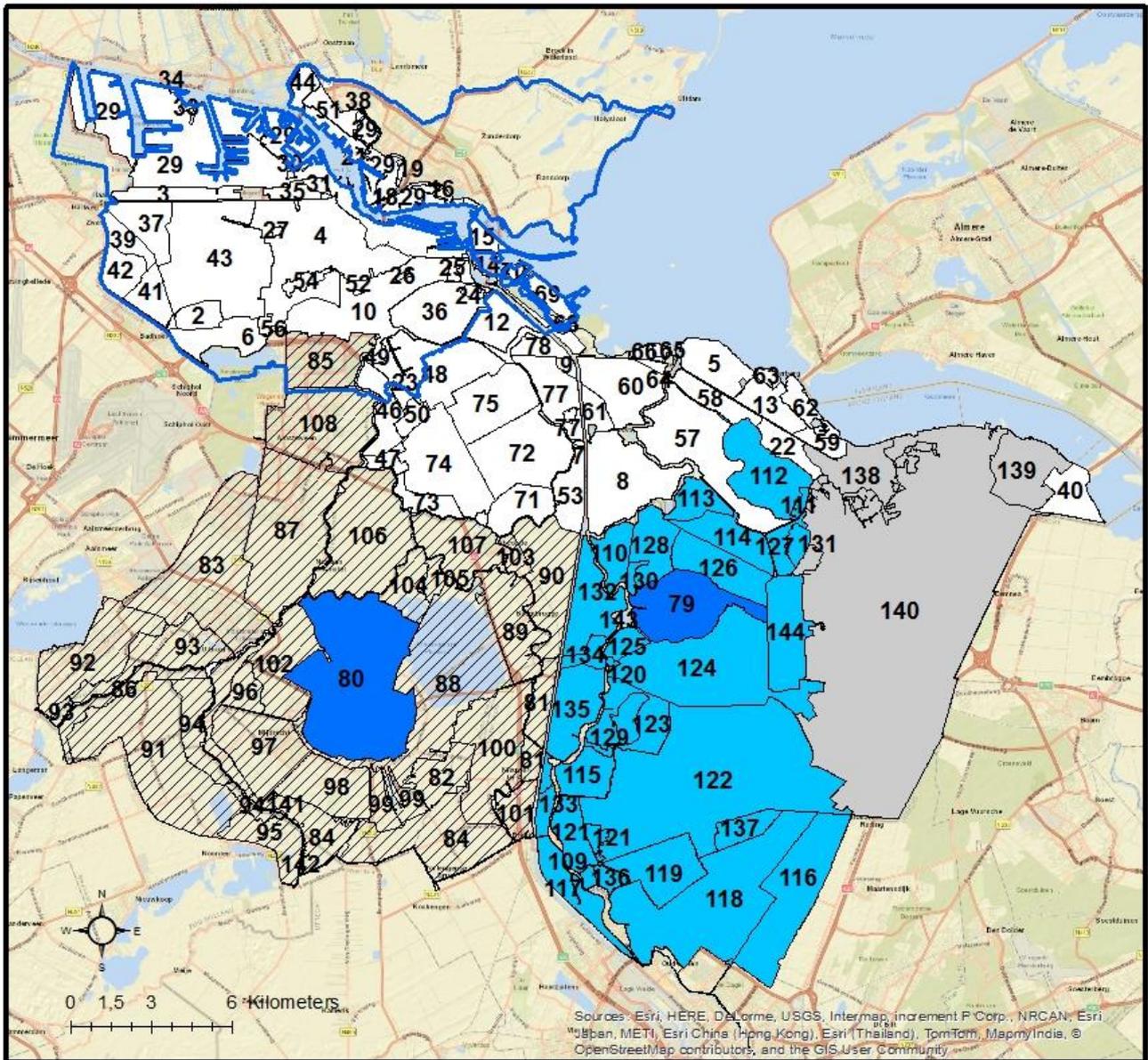


# Supplementary Information



## Polder groups

- Amsterdam city
- Upconing area
- Vecht lakes
- Zuiderzee margin
- Central Holland
- Ice pushed ridge

Figure S1 Polders, boezems of the research area and the groups they belong. The numbers given represent the numbers in Table S1, in which the full names of the polders are given. Polder amounts of each group are: Zuiderzee margin (78), Upconing area (2), Central Holland (28), Vecht lakes (30) and Ice pushed ridge (3).

Table S1 List of all polders and boezems in the study area.  
Numbers correspond to the numbers in Figure S1.

ID	Polder Names
1	Westerpark
2	Nieuw-Sloten
3	De Lange Bretten
4	Stadsboezem Amsterdam
5	Noordpolder beoosten Muiden
6	Riekerpolder
7	Aetsveldse Polder west (Driemond)
8	Aetsveldse Polder Oost
9	Gemeenschapspolder West (Betlem)
10	Boezem Amstelland-West
11	Atekpolder
12	Diempolder
13	B.O.B.M.-polder en Buitendijken tussen Muiderberg en Naarden
14	Eiland Zeeburg (oost)
15	Eiland Zeeburg
16	W.H. Vliegenbos
17	Polder Bernard
18	Florapark (zuid)
19	Forapark (noord)
20	Buiksloterdijk
21	Krasseurstraat
22	Keverdijkse Overscheense Polder
23	Venserpolder (volkstuintuinen Nieuw Vredelust, Ons Lustoord en Dijkzicht)
24	Watergraafsmeer (Anna's Hoeve)
25	Flevopark
26	Oosterpark
27	Erasmuspark
28	Begraafplaats Vredenhof
29	Noordzeekanaal/IJ/Amsterdamrijnkanaalboezem
30	Sportpark Transformatorweg
31	Overbraker Binnenpolder (Zeeheldenbuurt)
32	Westelijk Havengebied (Hemspoorlijn)
33	Westelijk Havengebied (Sicilieweg/Capriweg)
34	Westelijk Havengebied (noord)
35	Overbraker Binnenpolder
36	Watergraafsmeer
37	Osdorperbinnenpolder
38	Sportpark Tuindorp Oostzaan
39	Osdorperbovenpolder
40	De Gooise Zomerkade
41	Middelveldse Akerpolder
42	Lutkemeerpolder
43	Sloterbinnen en Middelveldsepolder

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44	Noorder IJ plas
45	Buiksloterweg
46	Duivendrechtsepolder noord en midden
47	Duivendrechtsepolder (zuid)
48	Venserpolder
49	Venserpolder (volkstuinpark Amstelglorie)
50	Polder De Toekomst
51	Noorder IJ Polder
52	Sarphatipark
53	Aetsveldse Polder west
54	Vondelpark
55	BP Huis Te Vraag
56	SP Zuid
57	Nieuwe Keverdijksche Polder en Hilversumse Bovenmeent
58	Zuidpolder beoosten Muiden
59	Buitendijken ten Noorden van Naarden
60	Bloemendalerpolder en Gemeenschapspolder Oost
61	Gemeenschapspolder zuid-oost
62	Buitendijksgebied Naarden en Muiderberg
63	Buitendijks gebied Muiderberg
64	Bloemendalerpolder
65	Noorder- of Rietpolder (oost)
66	Noorder- of Rietpolder (midden)
67	Noorder- of Rietpolder (west)
68	Over-Diemen
69	Haveneiland en Rieteiland
70	Steigereiland
71	Broekzijdse Polder
72	Zuid Bijlmer
73	Holendrecht- en Bullewijker Polder (zuid en west)
74	Polder de Nieuwe Bullewijk en Holendrecht- en Bullewijker Polder noord
75	Bijlmer
76	Gemeenschapspolder West (Tuincomplex Linnaeus)
77	Gemeenschapspolder West
78	Overdiemerpolder
79	Horstermeerpolder en Meeruiterdijksche Polder
80	Polder Groot Mijdrecht en Polder de Eerste Bedijking (oost)
81	Holland, Sticht, en Voorburg West en Polder het Honderd West
82	Veldhuiswetering
83	Noorder Legmeerpolder
84	Groot Wilnis-Vinkeveen (zuid) en Polder Groot en Klein Oud-Aa
85	Binnendijkse Buitenvelderse Polder
86	Buitendijkse Oosterpolder, Buitenwesterpolder en Blokland (noord)
87	Bovenkerkerpolder
88	Polder Groot Wilnis Vinkeveen
89	Baambrugge Westzijds

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90	Baambrugge Oostzijds
91	Polder Zevenhoven
92	Zuider Legmeerpolder
93	Uithoornsche Polder
94	Blokland en Noordse Buurt (bovenland)
95	Noordse Buurt en Westveense Polder
96	Polder de Tweede Bedijking
97	Polder de Derde Bedijking
98	Polder Wilnis-Veldzijde
99	Polder Groot Wilnis-Vinkeveen (midden)
100	Polder Oukoop en Polder Groot Wilnis-Vinkeveen (oost)
101	Polder Breukelerwaard West
102	Polder de Eerste Bedijking (west)
103	Baambrugge Oostzijds (west)
104	Noorderpolder of Botshol (zuid en west)
105	Noorderpolder of Botshol (Nellestein)
106	Polder de Rondehoep
107	Polder Waardassacker en Holendrecht
108	Middelpolder onder Amstelveen
109	Gansenhoef west
110	Horn- en Kuyerpolder
111	Meerlanden
112	Naardermeer
113	Heintjesrak- en Broekerpolder
114	Hollandsch Ankeveensche Polder
115	Polder Mijnden
116	Polder Achtienhoven
117	Polder Nijenrode
118	Polder Maarsseveen-Westbroek
119	Bethunepolder
120	Vreeland (oost)
121	Polder Breukelen-Proostdij
122	Muyeveld
123	Loenderveen
124	Polder Kortenhoef
125	Polder Dorssewaard
126	Stichtsch Ankeveensche Polder
127	Hilversumse Ondermeent
128	Spiegelpolder
129	Loenderveen (GWA)
130	Blijkpolder
131	Hilversumse Meent
132	Hoeker- en Garstenpolder
133	Breukelen Noord
134	Holland, Sticht, Voorburg oost (noord)
135	Holland, Sticht, Voorburg oost, Polder het Honderd oost en Polder Breukelerwaard oost

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136	Gansenhoef oost
137	Oostelijke Binnenpolder van Tienhoven
138	's-Gravelandsche vaartboezem
139	Huizen
140	't Gooi
141	Hoogwaterzone Amstelkade P1
142	Hoogwaterzone Amstelkade P2
143	Vechtboezem
144	's-Gravelandsche Polder

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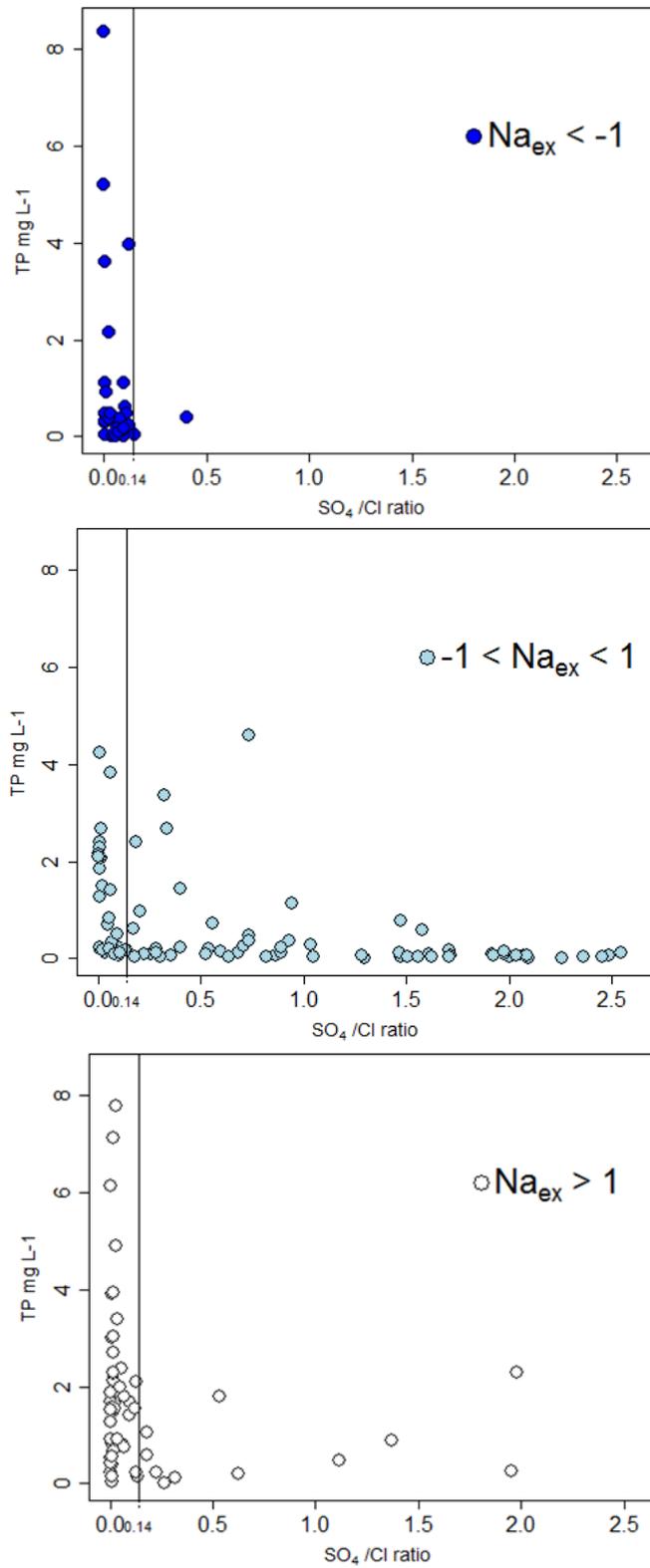


Figure S2 Total phosphorus (TP) concentration against SO<sub>4</sub>:Cl, distinguished by Na exchange (freshening: Na<sub>ex</sub> > 1, not defined: Na<sub>ex</sub> between -1 and 1, and salinizing: Na<sub>ex</sub> < -1)

Figure S3 shows the spatial distribution of N and P agricultural input ( $\text{kg ha}^{-1} \text{y}^{-1}$ ) in the study area. Similar to the N and P agricultural input, agricultural land percentage shows no correlation with other variables (absolute values lower than 0.4) except with N and P inputs (0.99) (Table S2). This high correlation with agriculture land percentage suggests that the N and P inputs do not vary much between different types of agriculture, which may be caused by the maximum application rates as defined in the Dutch Manure Legislation. As shown in Fig.S3, nutrient inputs from agriculture mainly concentrate in the Central Holland and the Vecht lakes area. The values in most cases are much higher than the annual load per area in surface water (Fig. 11) as most of the agricultural inputs are taken up by the crops and removed from the system. However, in the urban areas, especially the city of Amsterdam, high concentrations of N and P appear in groundwater and surface water whereas the agricultural inputs in those areas are minimal (Fig. S3). And their surface water N and P load per area are higher than agricultural N and P inputs as showed in Table S3.

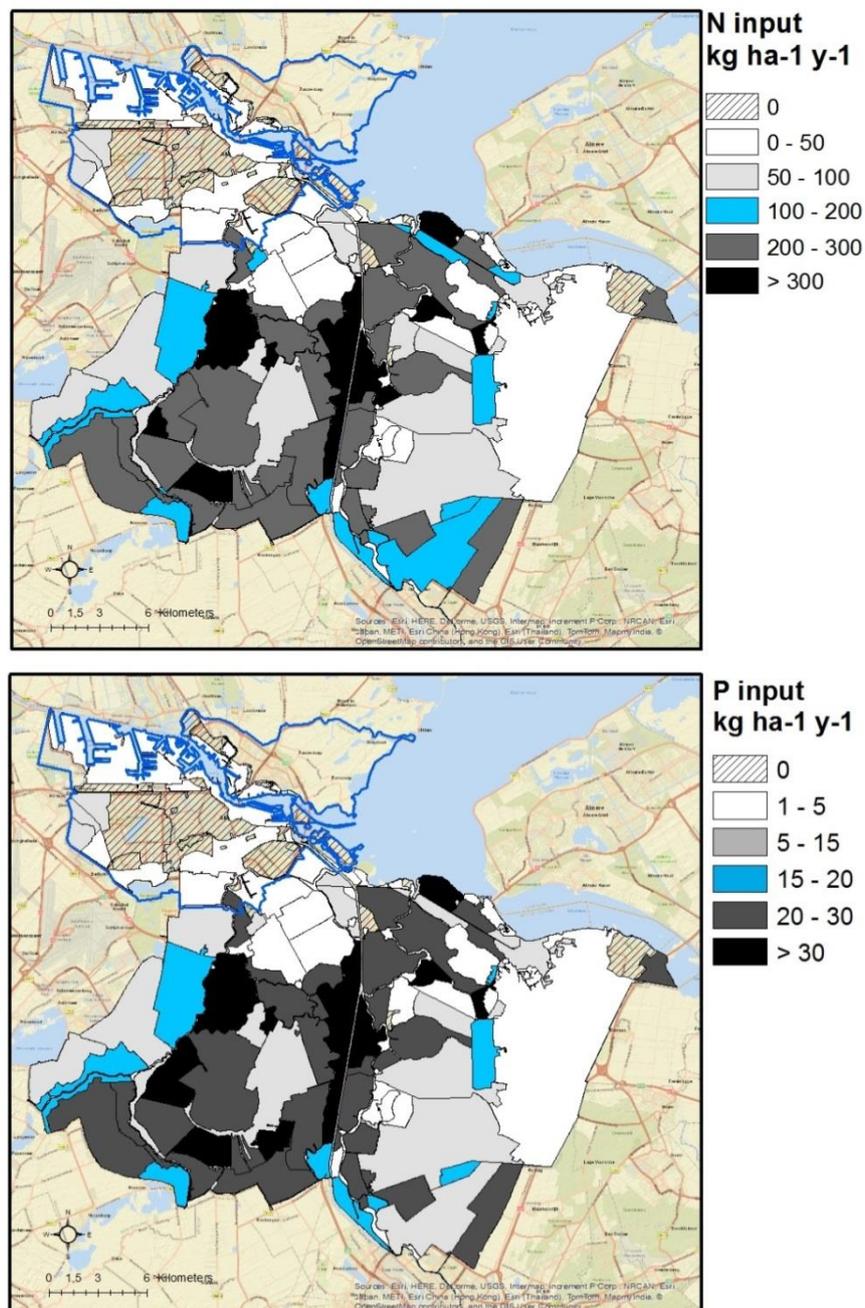


Figure S3 Spatial distribution of N and P inputs from agricultural land use (2011) in  $\text{kg ha}^{-1} \text{y}^{-1}$ .

Table S2 Coefficients of determination between N and P input with groundwater and surface water quality and landscape variables

	N input kg ha <sup>-1</sup> y <sup>-1</sup>	P input kg ha <sup>-1</sup> y <sup>-1</sup>		N input kg ha <sup>-1</sup> y <sup>-1</sup>	P input kg ha <sup>-1</sup> y <sup>-1</sup>		N input kg ha <sup>-1</sup> y <sup>-1</sup>	P input kg ha <sup>-1</sup> y <sup>-1</sup>
TP <sub>SW</sub>	-0,12	-0,11	TP <sub>GW</sub>	-0,15	-0,14	Paved area %	-0,22	-0,23
TN <sub>SW</sub>	0,18	0,21	TN <sub>GW</sub>	-0,33	-0,32	Elevation	-0,15	-0,18
NH <sub>4</sub> <sub>SW</sub>	-0,03	0,00	NH <sub>4</sub> <sub>GW</sub>	-0,24	-0,23	Seepage rate	0,02	0,03
NO <sub>3</sub> <sub>SW</sub>	0,25	0,26	NO <sub>3</sub> <sub>GW</sub>	-0,19	-0,20	Surface water %	-0,04	-0,04
HCO <sub>3</sub> <sub>SW</sub>	-0,32	-0,31	HCO <sub>3</sub> <sub>GW</sub>	-0,24	-0,23	Lutum %	0,24	0,23
SO <sub>4</sub> <sub>SW</sub>	0,25	0,27	SO <sub>4</sub> <sub>GW</sub>	0,10	0,09	Humus %	-0,18	-0,15
Ca <sub>SW</sub>	-0,26	-0,25	Ca <sub>GW</sub>	-0,10	-0,10	Calcite %	0,09	0,06
Cl <sub>SW</sub>	-0,19	-0,18	Cl <sub>GW</sub>	-0,15	-0,15	Agricultural land %	0,99	0,99

Table S3 Polders with surface water N and P load per area higher than agricultural N and P inputs

Polder ID	Group	Name	Landscape variables		P	N
			Paved area %	Agricultural land %		
2	1	Nieuw-Sloten	45	0	✓	✓
3	1	De Lange Bretten	8	11	✓	✓
6	1	Riekerpolder	36	7	✓	
25	1	Flevopark	0	0	✓	✓
26	1	Oosterpark	0	0	✓	✓
27	1	Erasmuspark	0	0	✓	✓
35	1	Overbraker Binnenpolder	36	1	✓	✓
36	1	Watergraafsmeer	42	0	✓	✓
37	1	Osdorperbinnenpolder	12	24	✓	
39	1	Osdorperbovenpolder	20	24	✓	
41	1	Middelveldse Akerpolder	31	1	✓	✓
43	1	Sloterbinnen en Middelveldsepolder	44	0	✓	✓
52	1	Sarphatipark	0	0	✓	✓
54	1	Vondelpark	0	0	✓	✓
61	1	Gemeenschapspolder zuid-oost	65	0	✓	✓
74	1	Polder de Nieuwe Bullewijk en Holendrecht- en Bullewijker Polder noord	7	5	✓	✓
75	1	Bijlmer	37	1	✓	✓
85	3	Binnendijkse Buitenvelderse Polder	63	0	✓	✓
92	3	Zuider Legmeerpolder	38	25	✓	✓
130	4	Blijkpolder	51	0	✓	✓
131	4	Hilversumse Meent	45	10	✓	

Table S4 Database description

Variables	Sources	Description	Processing
Discharge	Waternet database	Daily measurements of 2006-2013	Averages of all pumps in each polder
Surface water quality (TN, NO <sub>3</sub> , NH <sub>4</sub> , SO <sub>4</sub> , TP, Ca, HCO <sub>3</sub> , and Cl mg L <sup>-1</sup> )		Monthly measurement of 2006-2013; Measured upstream of the polder pumps.	Converted to daily time series by assuming daily values equalled to the monthly measurement in each month; Assigned zero to concentrations below detection limits; Took averages over 2006-2013.
Groundwater quality (TN, NO <sub>3</sub> , NH <sub>4</sub> , SO <sub>4</sub> , TP, Ca, HCO <sub>3</sub> , and Cl mg L <sup>-1</sup> )	TNO DINO database; Province of Noord-Holland database; "NH_ZH" database	Measurements from 1910 to 2013; Depth from -402.72 m to 40 m	Selected filters located higher than -50 m; Took averages of all screens at one position of all dates; Took averages of monitoring wells located in the same polder to represent the condition of the whole polder.
Agricultural N and P input kg ha <sup>-1</sup> y <sup>-1</sup>	Book keeping data for nutrient fate; transport model calculations using INITIATOR (De Vries, et al., 2003) <sup>1</sup> .	N and P input per area (kg ha <sup>-1</sup> y <sup>-1</sup> ) from manure and fertilizer in each agriculture parcel (15242 parcels) in 2011;	Calculated the area of each parcel in ArcGIS; Calculated a total input (kg) of N and P to each agriculture parcel; Took a sum of all parcels in each polder; N and P input = total input from agriculture (kg)/ total polder area (ha).
Seepage rate mm d <sup>-1</sup>	Waternet database	Modeling results from groundwater models	An average seepage rate was calculated and was assumed to be constant all the time.
Surface water area percent %	Waternet database	From GBKN database	25 polders out of polders without surface water area percentage data were estimated from Google maps
Elevation m N.A.P	Waternet database	Average elevation	
Paved area percentage %	Waternet database	From LGN6 database	24 polders out of polders without paved area percentage data were estimated from Google map
Soil data (clay, humus, and calcite content in %)	Deltares	Soil Map of The Netherlands (scale 1:50000)	Cover layer data of each polder.

<sup>1</sup> De Vries, W., Kros J., Oenema, O., De Klein, J.: Uncertainties in the fate of nitrogen II: A quantitative assessment of the uncertainties in major nitrogen fluxes in the Netherlands, NUTR CYCL AGROECOSYS, 66, 71-102, 2003.