SSA 9 Scheldt Delta case

Apportionment of Nitrogen in the Scheldt river basin

Hans van der Kwast,Steven Broekx (VITO) and Fritz Hellmann(IvM)PCRASTER
Steven Broekx (VITO) Economic component
Bert van Eck and Xavier Desmit (Deltares) Estuarine Extend model
Bert van Eck Social component
Jean-Luc de Kok (Joachim Maes) Extend modelling
Jan Vermaat (IvM) reporting

Outline

- Policy issue
- Model Concept
- Implementation of the model concept
  - Social component
  - Economic component
  - Natural component
- Presenting the model by Jean-Luc de Kok

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POLICY ISSUE SCHELDT – DELTA SSA

ESE assessment of the NITRATE versus

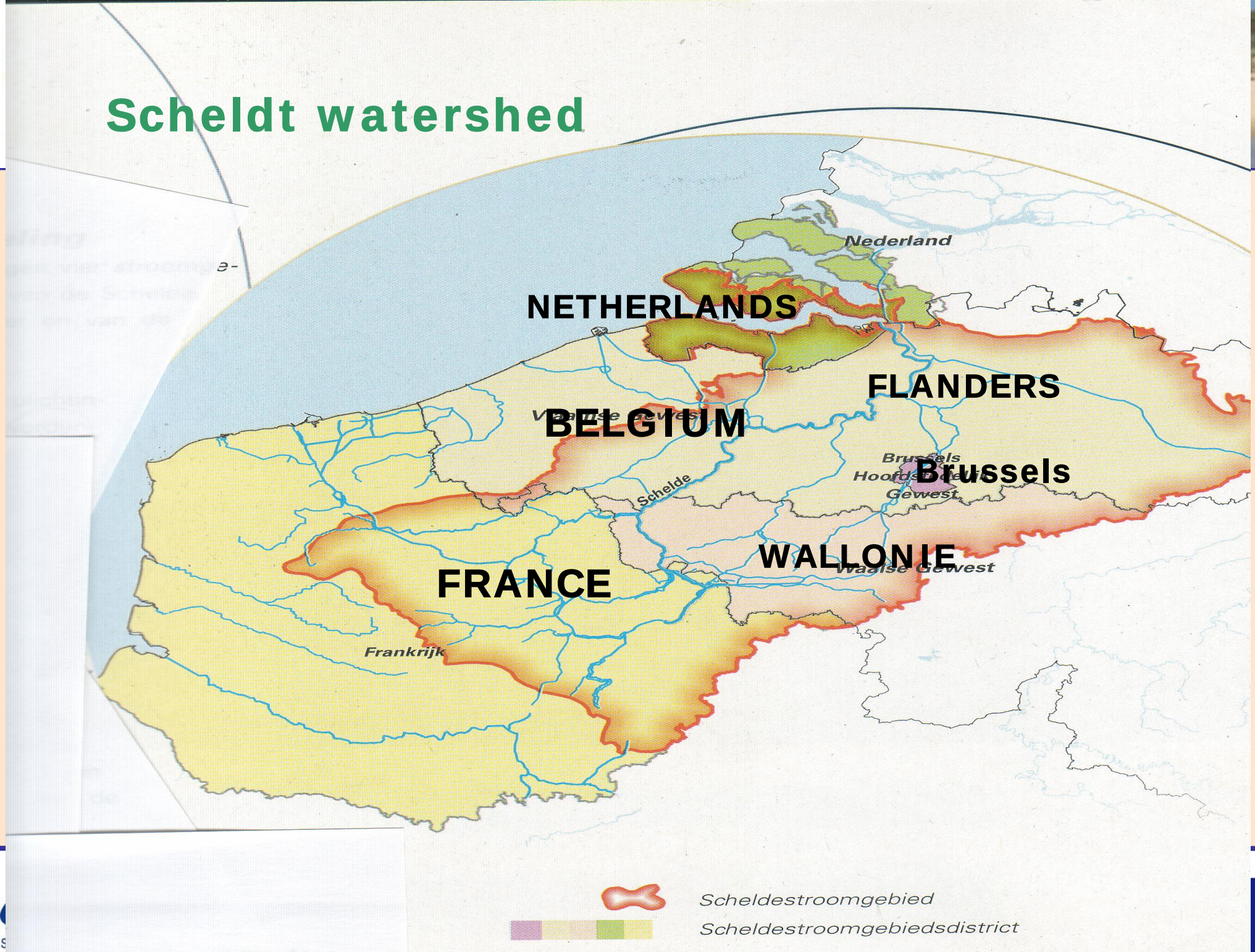
WATER FRAMEWORK DIRECTIVE objectives

in the Scheldt river basin and coastal zone

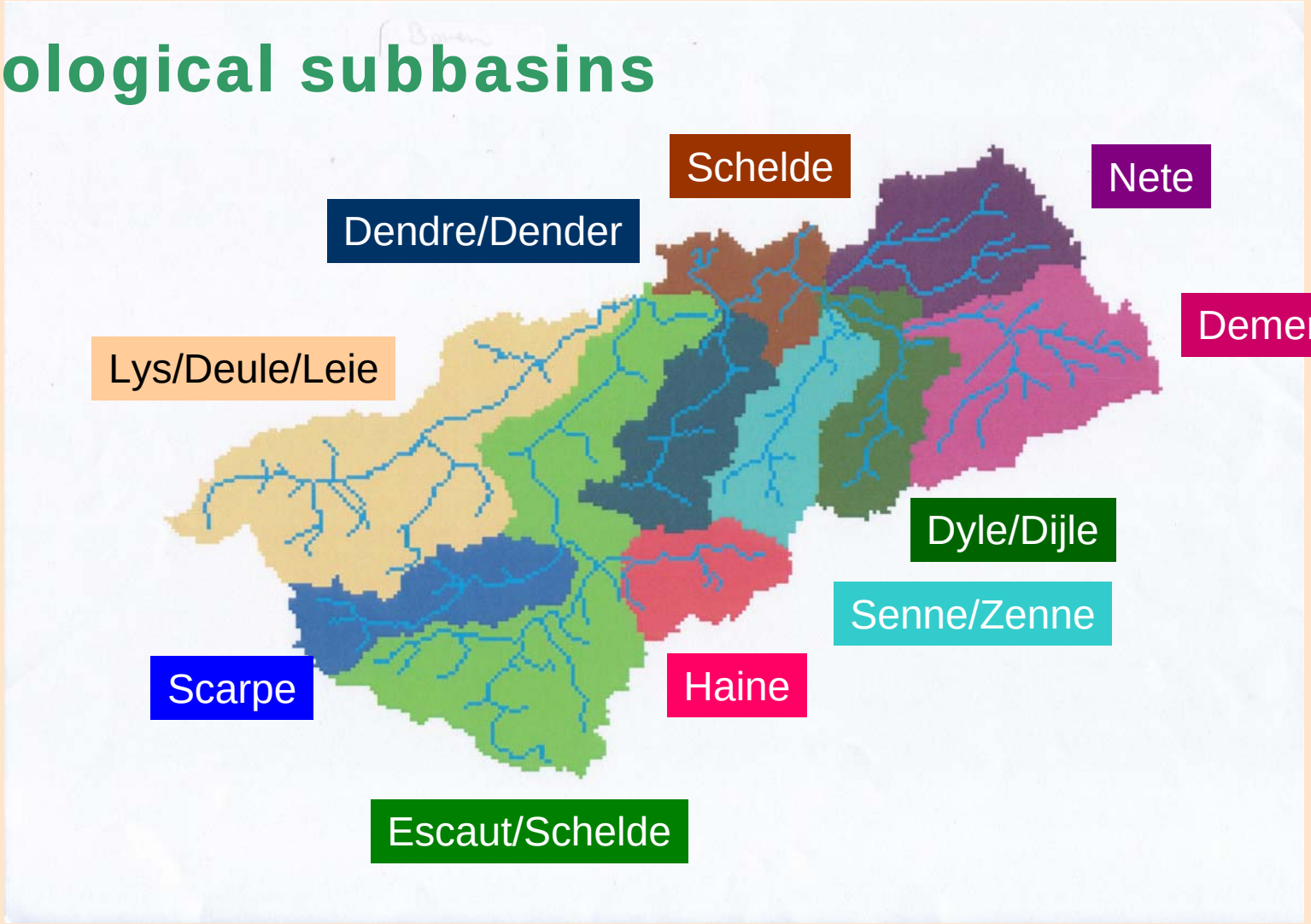
of apportionment of Nitrogen in the river basin

with focus on social and economic analysis

Scheldt watershed

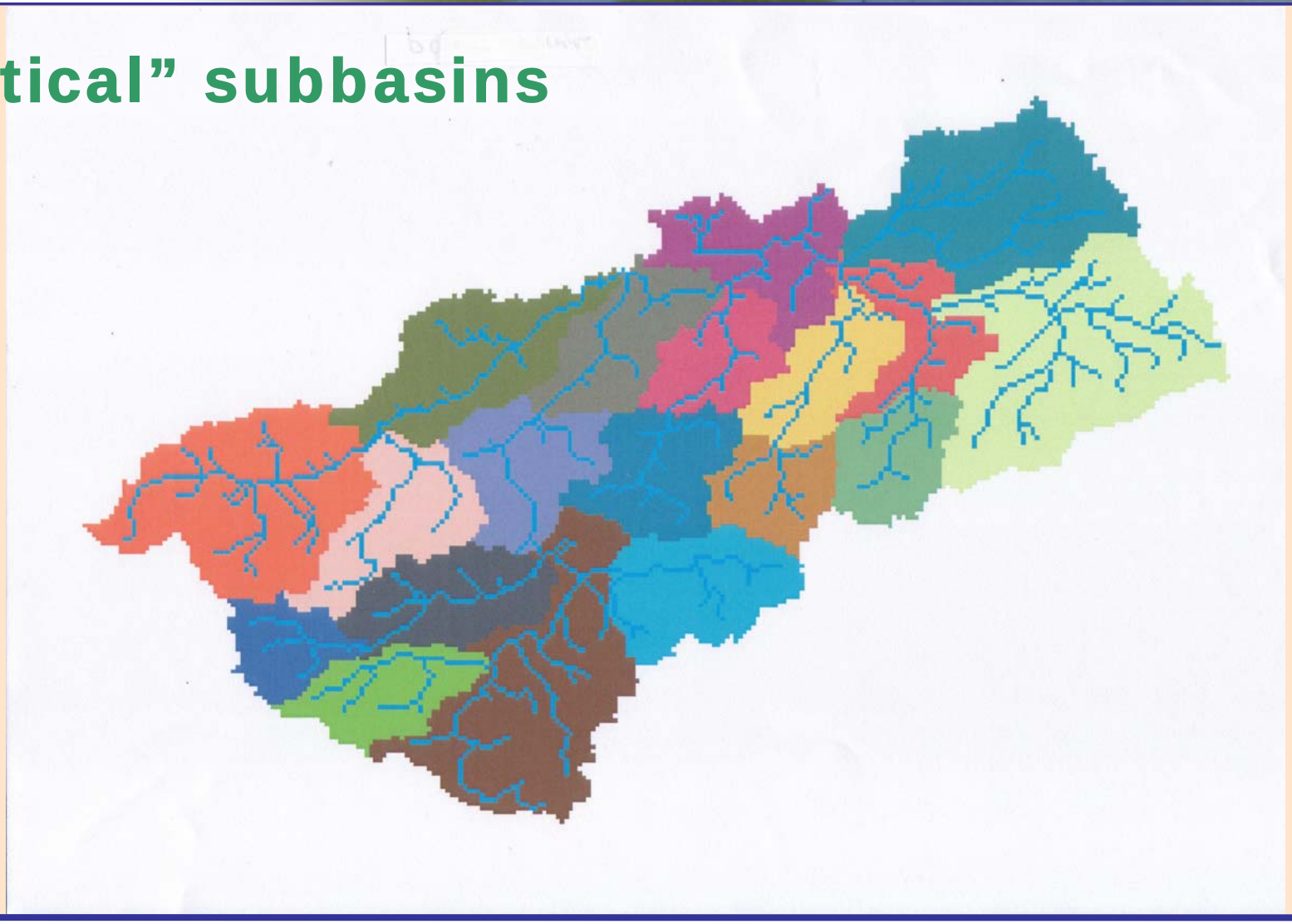


Hydrological subbasins



SPICOSA

“Political” subbasins



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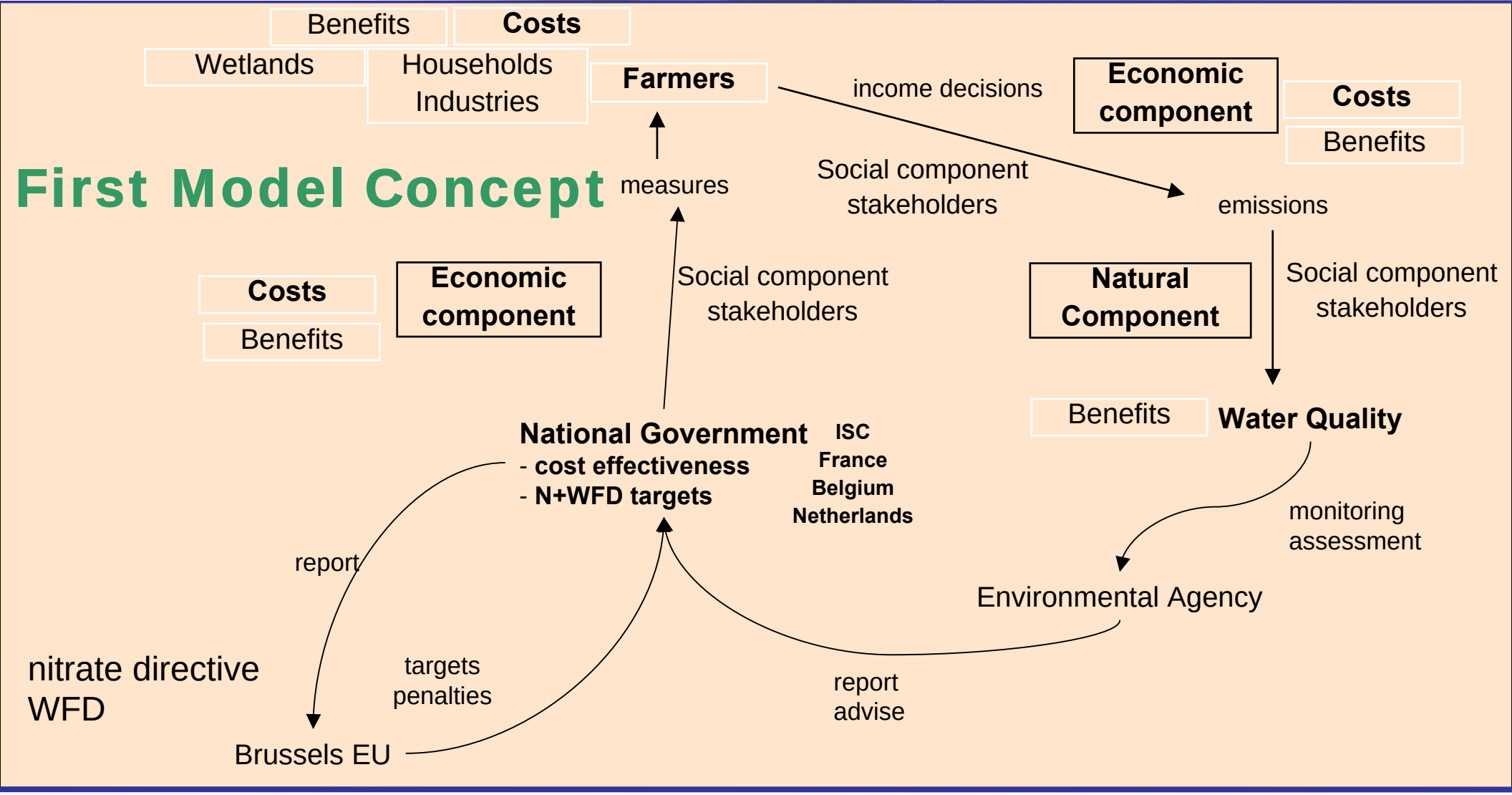
ESE model Scheldt-Delta



Evolution of the Model Concept

Social component

ALEX MINTZ, NEHEMIA GEVA~ AND KARL DEROUEN JR.*

MATHEMATICAL MODELS OF FOREIGN POLICY DECISION-MAKING:

COMPENSATORY VS. NONCOMPENSATORY

Synthese 100: 441-460

A Mathematical Model for the Human Decision-Making Process

S. BEZERRA
ICES-L'Ecole Universitaire 17
Bld des Beiges, BP 691, 85017 La Roche Sur Yon, Prance
Y. CBERRUAULT, J. FOURCADE, G. VERON

Mathl. Comput. Modelling Vol. 24, 21-26.

[our research…] "… confirms the hypothesis that political decision makers gather information and **do not use it**; ask for more information and **ignore it**; make decisions first and look for relevant information **afterwards**; and, collect and process a great deal of information that has little or **no direct relevance** to decisions"

(Sager & Ravlum, 2005)

Economic component

cattle farming is the most important

Natural component

- a model with a balance between scale (Scheldt watershed) and data input
- a model which uses existing easily available datasets with transboundary consistency
- a model with already succesfull applications

Source: Mourad, De Wit & Van der Perk

Decisions concerning the model concept

General

Balance between nitrate directive and WFD

Social component

”Everybody” can make its own “world”/“truth”

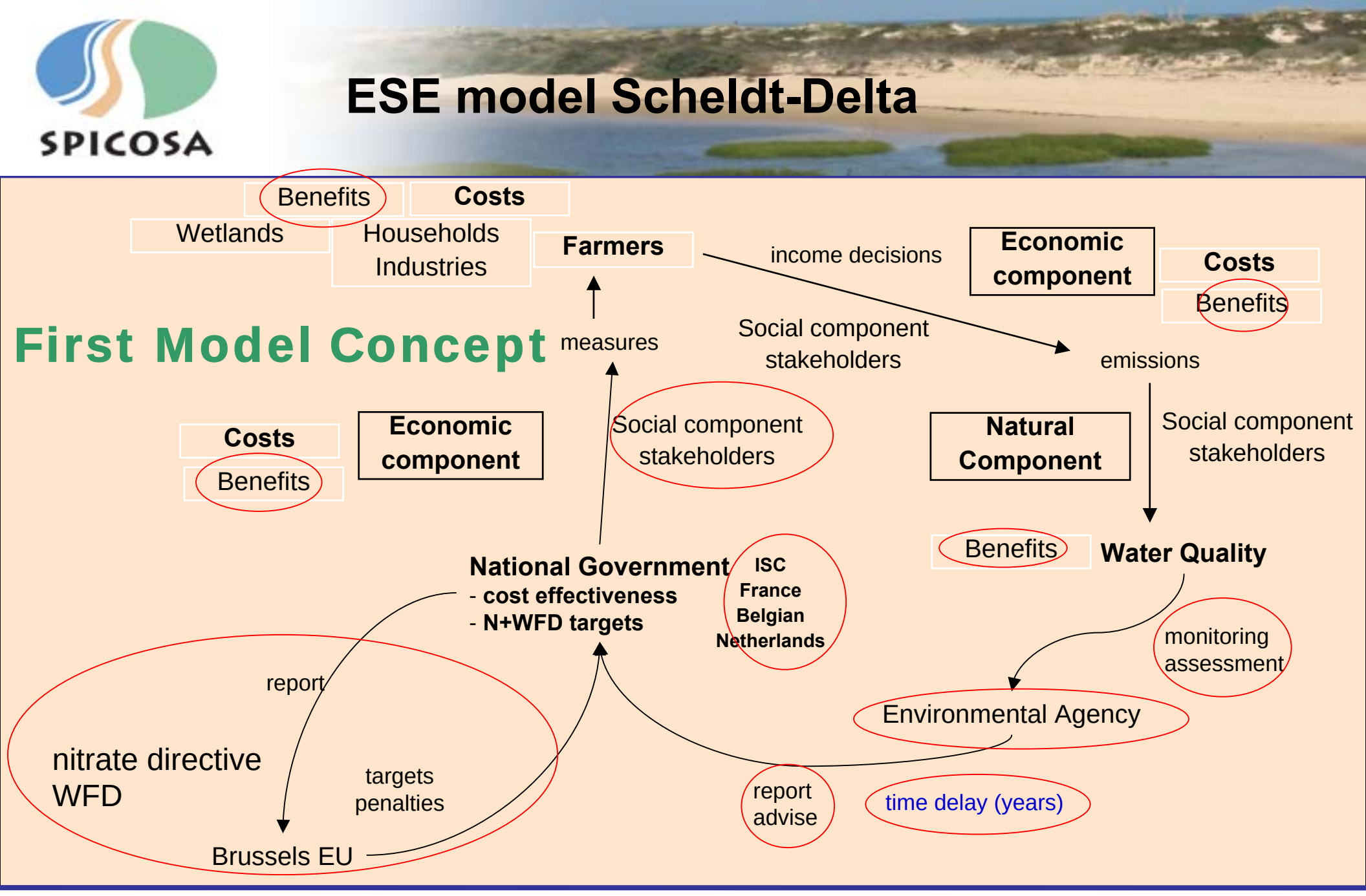
Economic component

choice of cattle farming/farmers,
manure processing and cost effectiveness

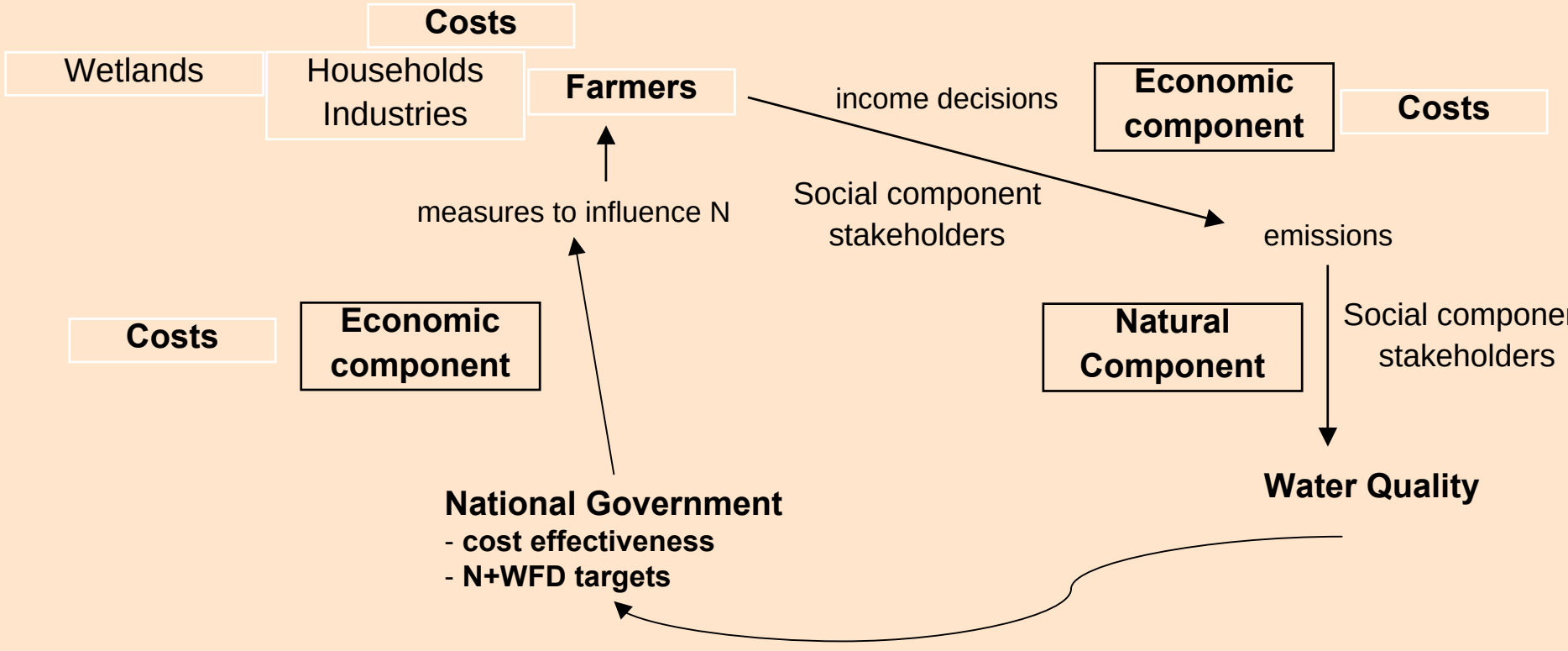
Natural component

PCraster for watershed,1D-box model for the estuary

ESE model Scheldt-Delta



ESE model Scheldt-Delta



Final Model Concept

policy decisions

ND

WFD

Δ manure standard

Δ N budget

income farmer

Manure balance farm

end-of-pipe measures: industry, households, WWTP, others

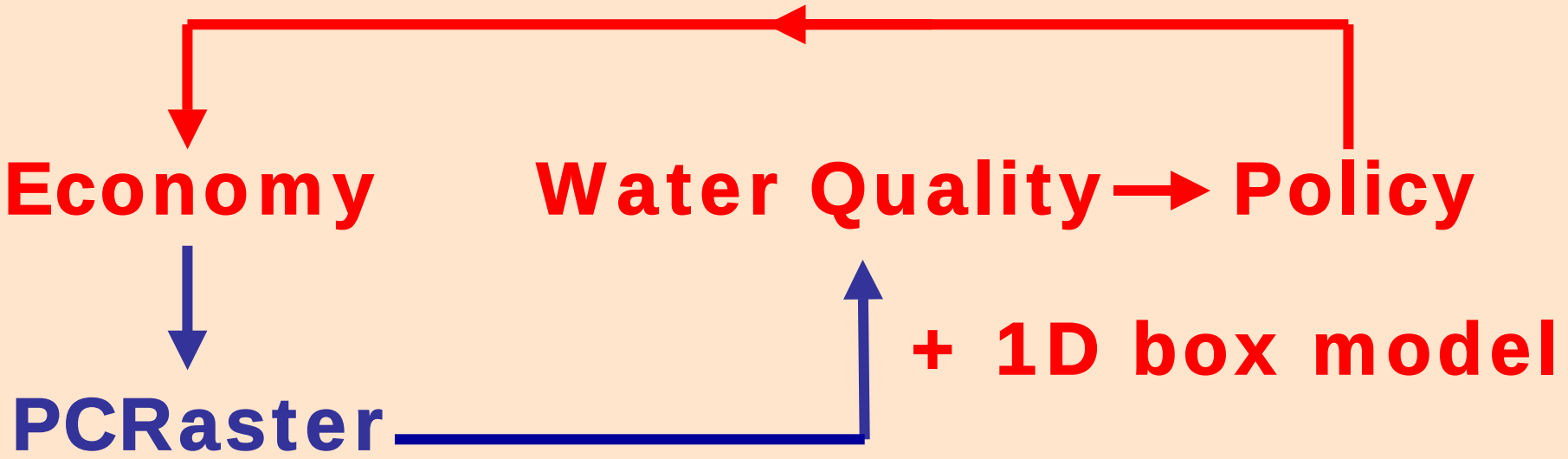
Δ parameters: cattle, crops

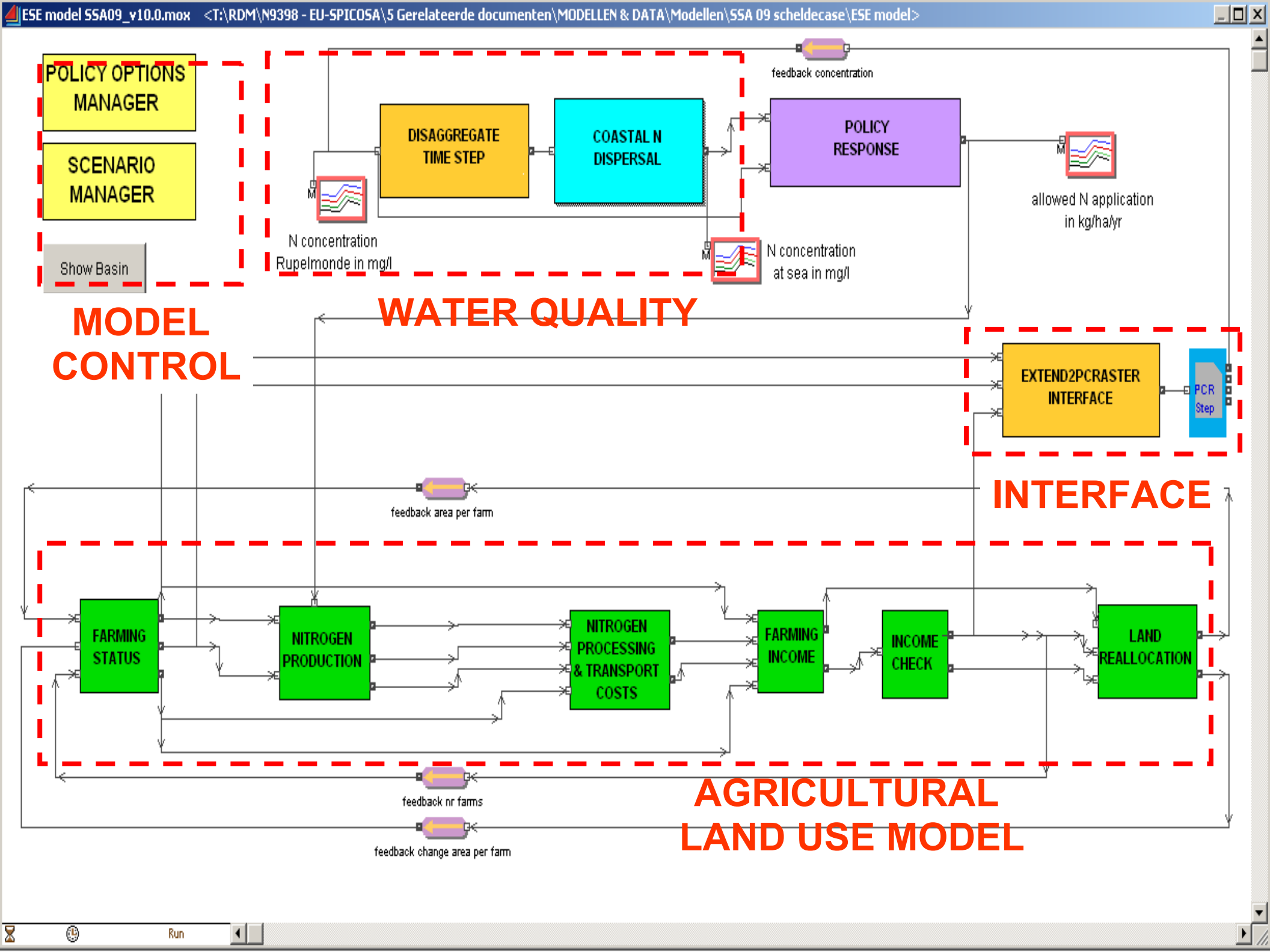
Final Model

N-concentration

check with standard (after X years)

Extend




ESE model SSA09_v10.0.mox <T:\RDM\N9398 - EU-SPICOSA\5 Gerelateerde documenten\MODELLEN & DATA\Modellen\SSA 09 scheldecase\ESE model>
POLICY OPTIONS MANAGER
SCENARIO MANAGER
Show Basin
MODEL CONTROL
feedback concentration
DISAGGREGATE TIME STEP
COASTAL N DISPERSAL
POLICY RESPONSE
allowed N application in kg/ha/yr
N concentration Rupelmonde in mg/l
N concentration at sea in mg/l
WATER QUALITY
EXTEND2PCRASTER INTERFACE
PCR Step
INTERFACE
feedback area per farm
FARMING STATUS
NITROGEN PRODUCTION
NITROGEN PROCESSING & TRANSPORT COSTS
FARMING INCOME
INCOME CHECK
LAND REALLOCATION
feedback nr farms
feedback change area per farm
AGRICULTURAL LAND USE MODEL
Run

Outline

- Policy issue
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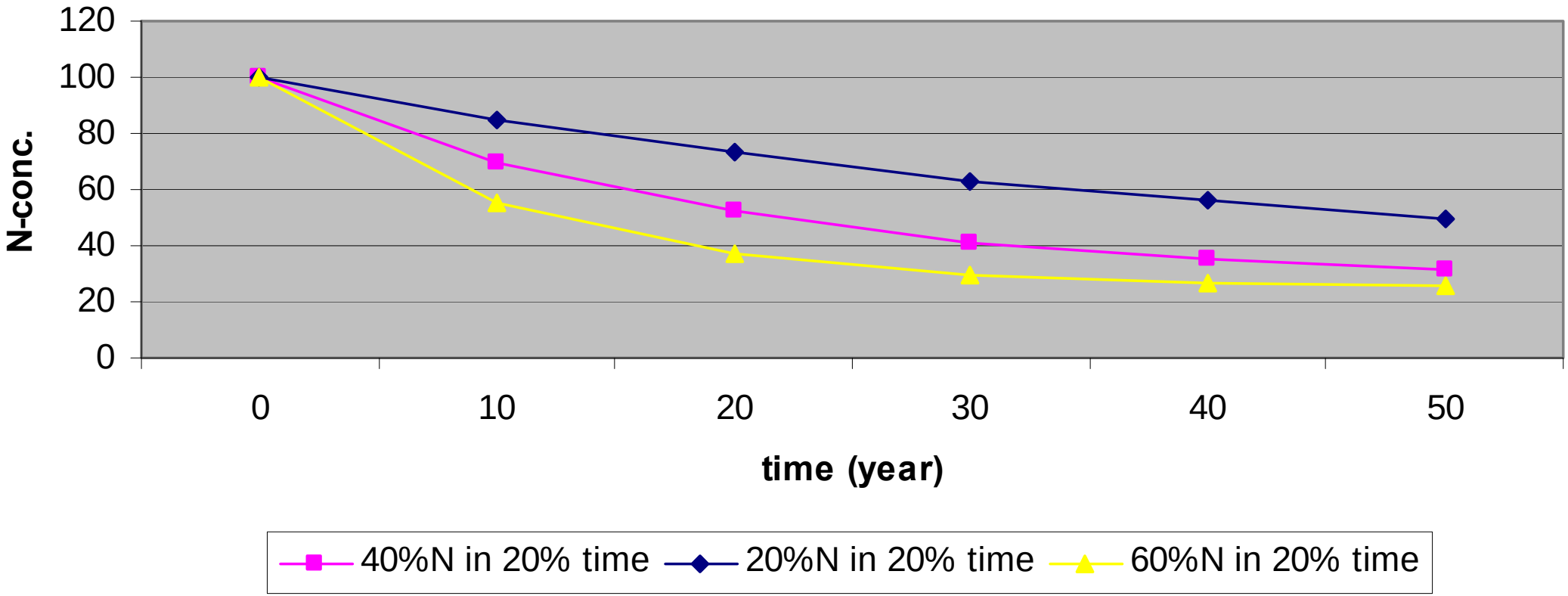
Social component

”Everybody” can make its own “world”/“truth”

Implementation: user has
1. choice of nitrate directive or WFD
2. choice of N-goal and how fast it will be obtained
3. choice of succes of implementation
4. choice of policy feedback: 3 choices

Various choices for obtaining the desired nitrogen standard



Economic component

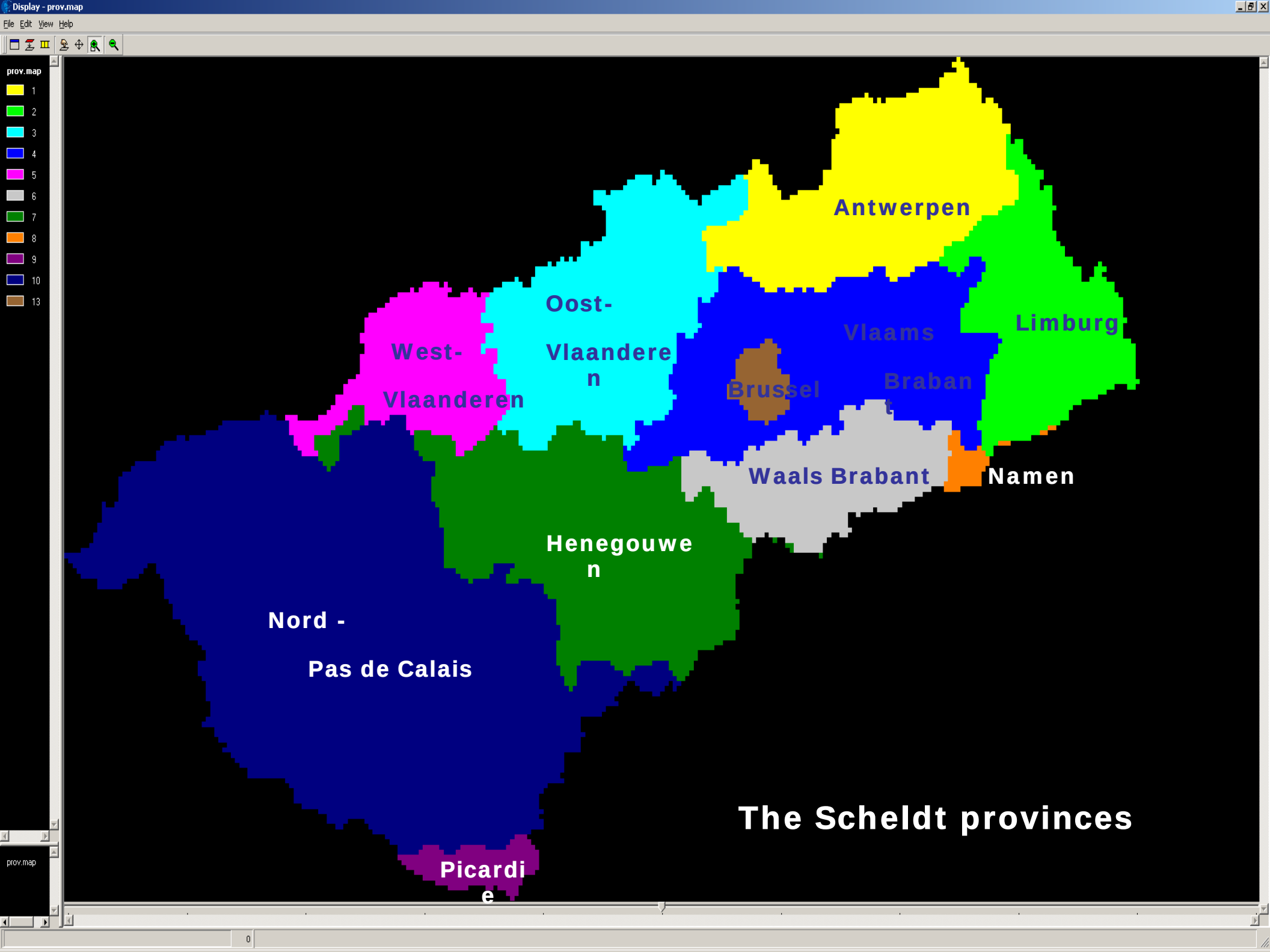
Agriculture economic model :

8 farm types

5 animal types

10 crop types

lumped at the level of regions in the Scheldt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File Edit View Help
prov.map
1
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Antwerpen
Limburg
Oost-
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West-
Vlaanderen
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Braban
t
Brussel
Waals Brabant
Namen
Henegouwe
n
Nord -
Pas de Calais
Picardi
e
The Scheldt provinces
prov.map

Steps in the agriculture model

1. cattle farming → manure → N production
2. Inter-farm N transport & N processing
3. Income effect of N transport/processing
4. if below norm income farms shut down
5. land reallocation
6. passing changes in cattle stock and crop area to PCraster

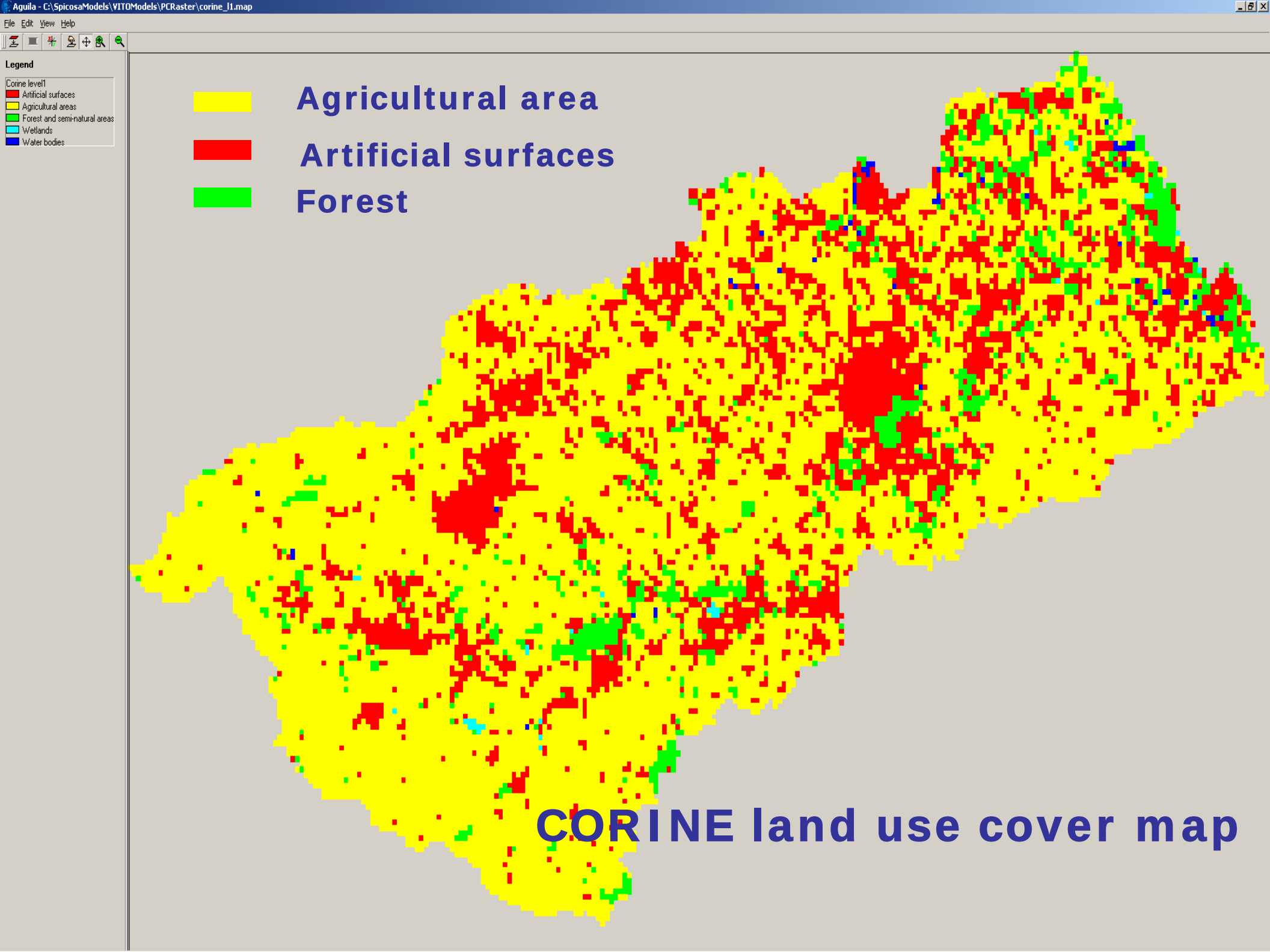
Natural component

The natural component is a Scheldt basin application of PCRaster with:
-a spatial resolution of 1 km2 and
-a temporal resolution of 1 year

Step 1. Define each 1 km2
Step 2. Relate nutrient fluxes to:
- Emissions (point/diffuse sources),
- Hydrological pathways and
- Retention (decay,storage,transformation)

Step 1:
Each 1 km^2 is defined with a:

- Hydrogeological map
- Soil map
- Land use map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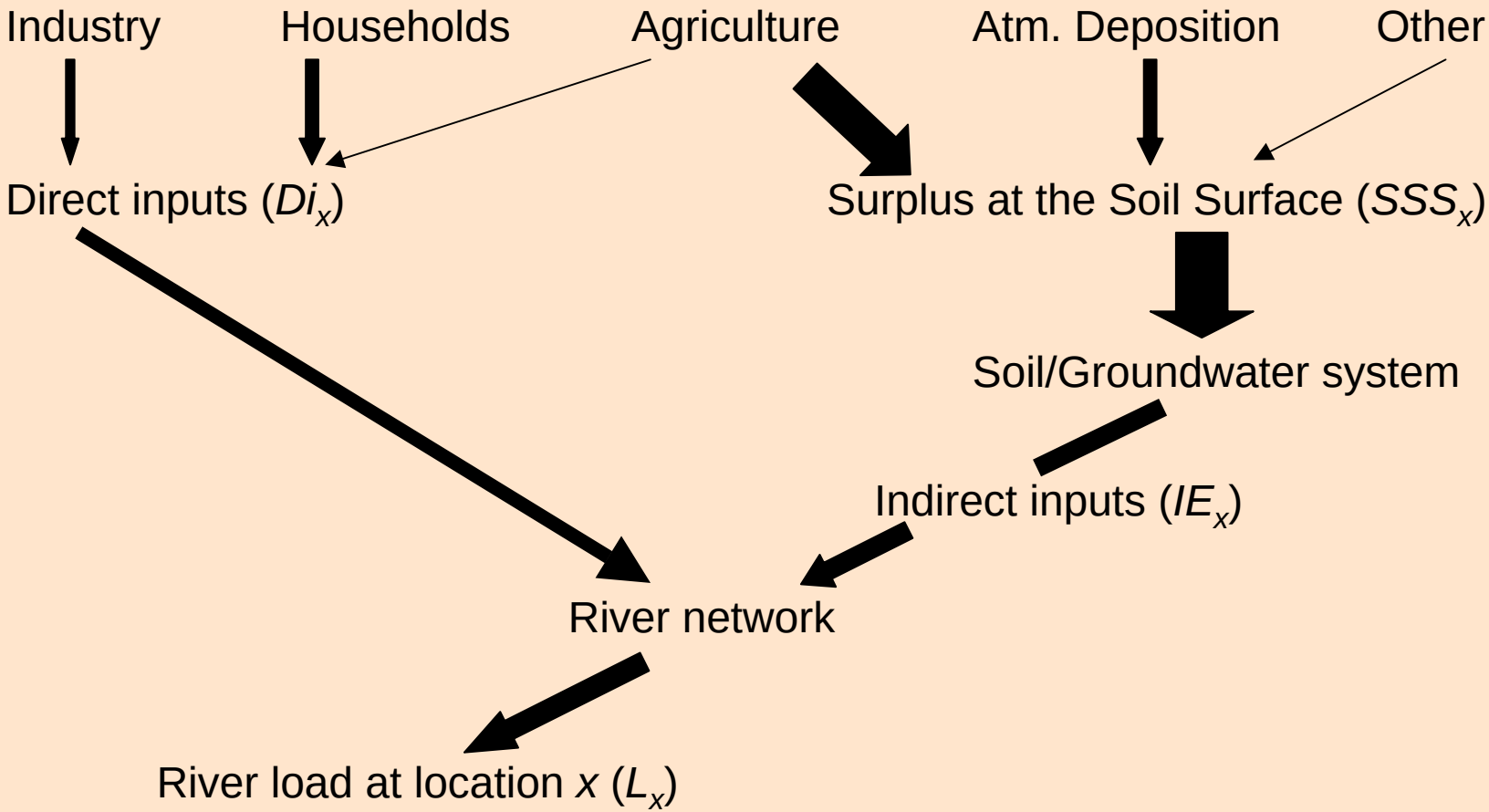
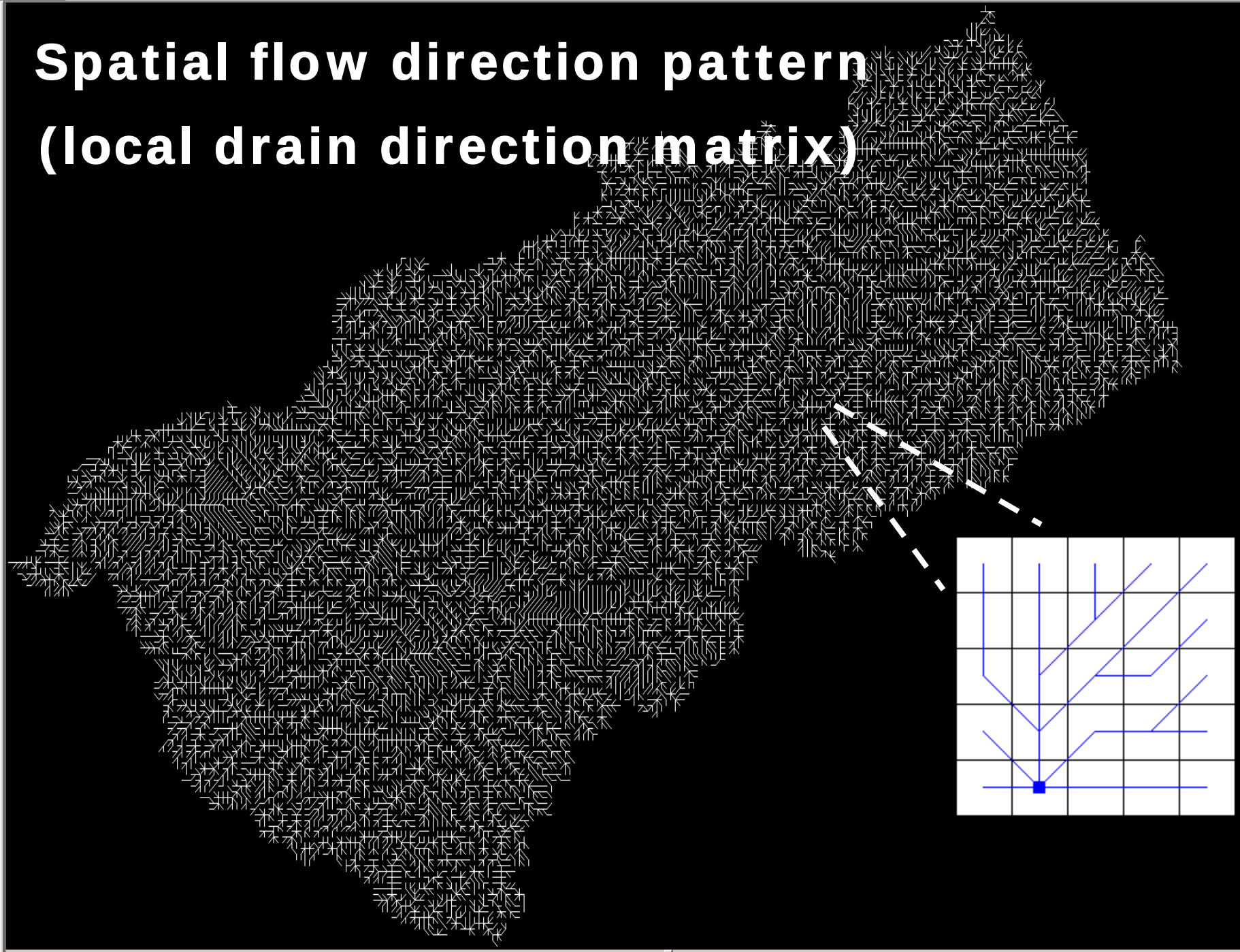
Legend
Corine level1
Artificial surfaces
Agricultural areas
Forest and semi-natural areas
Wetlands
Water bodies
Agricultural area
Artificial surfaces
Forest
CORINE land use cover map

Step 2: transport of nitrogen

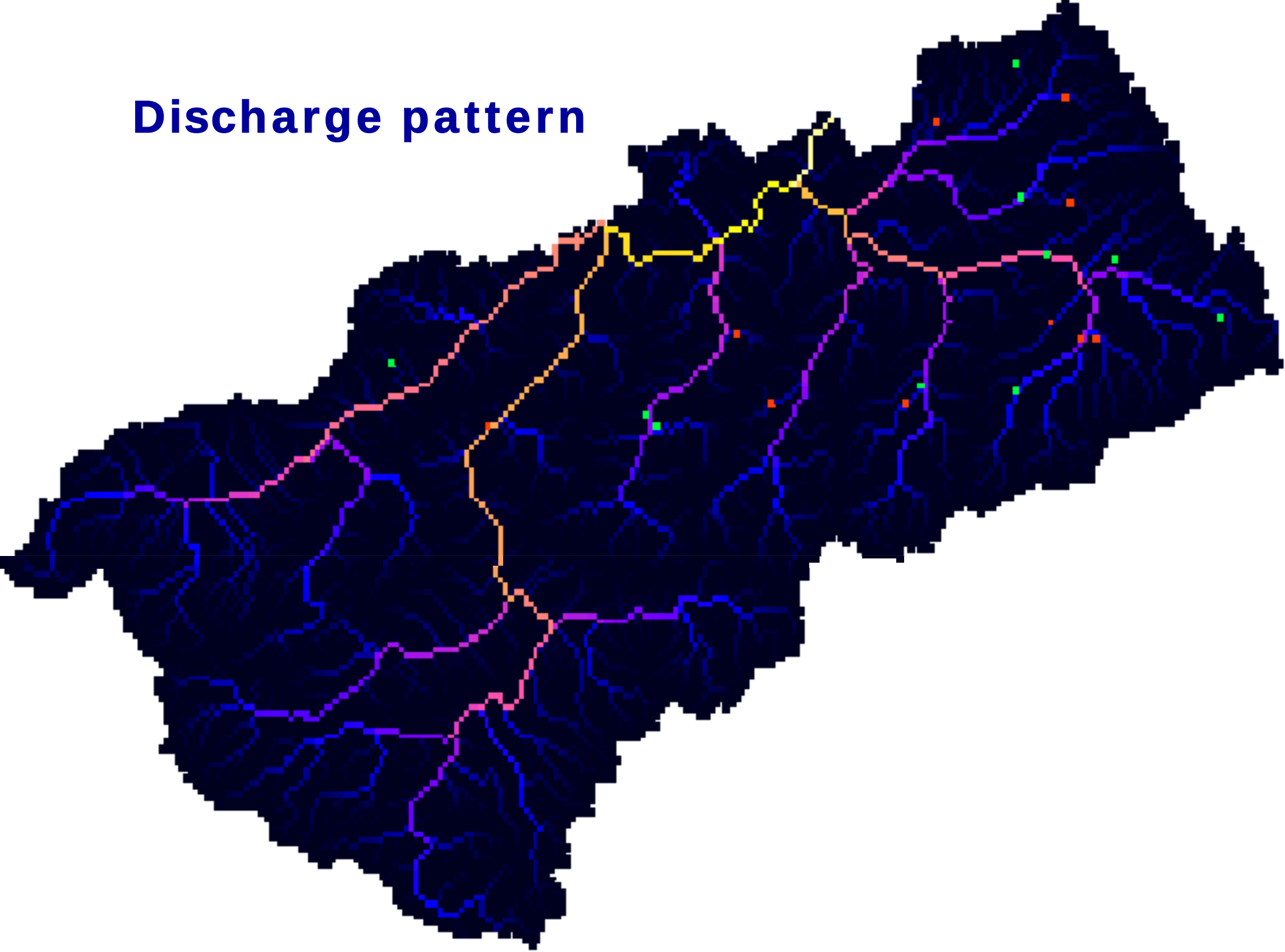


Source: De Wit (1999)

Spatial flow direction pattern (local drain direction matrix)

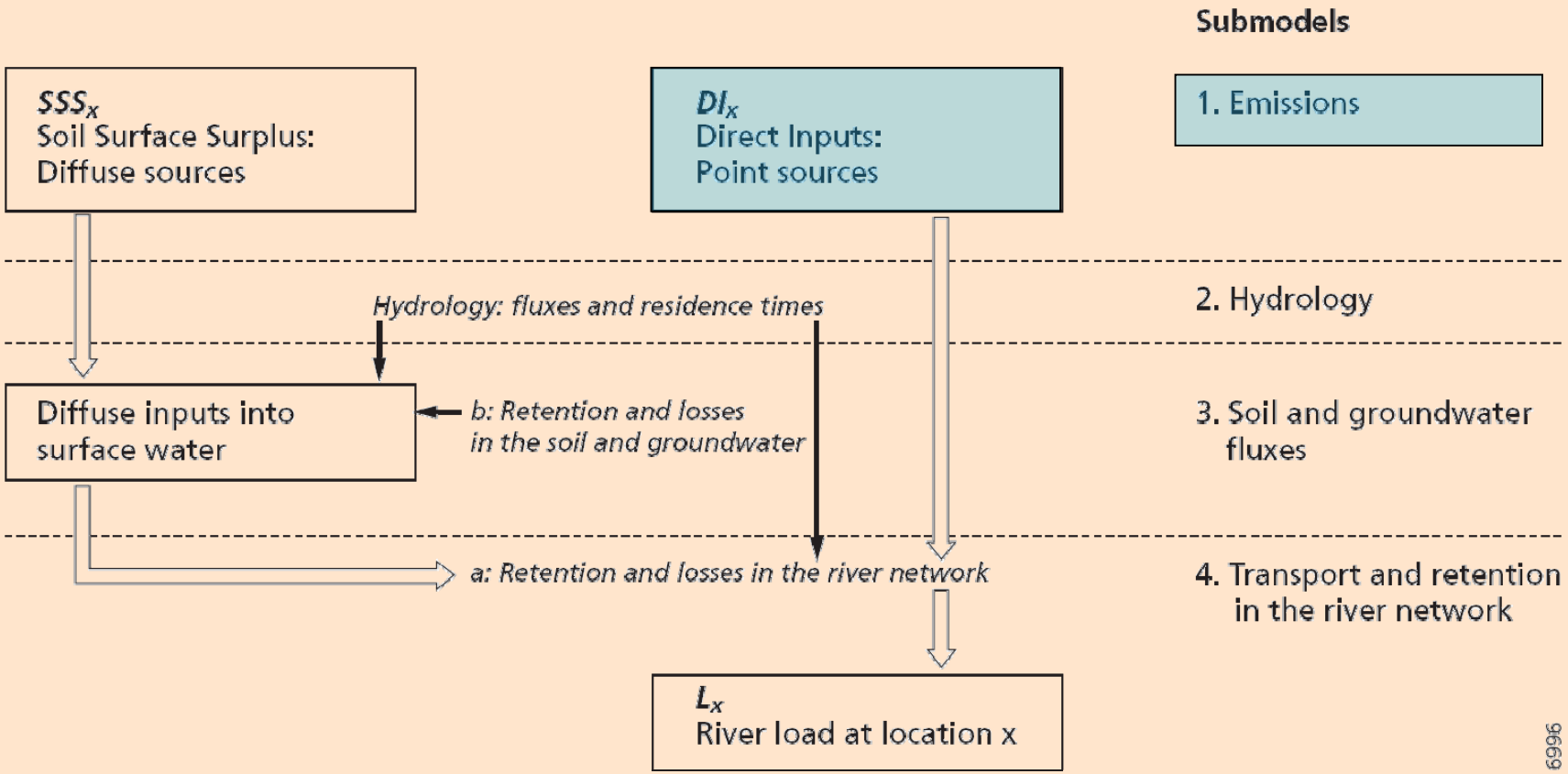


Discharge pattern



Nutrient model of the Scheldt basin

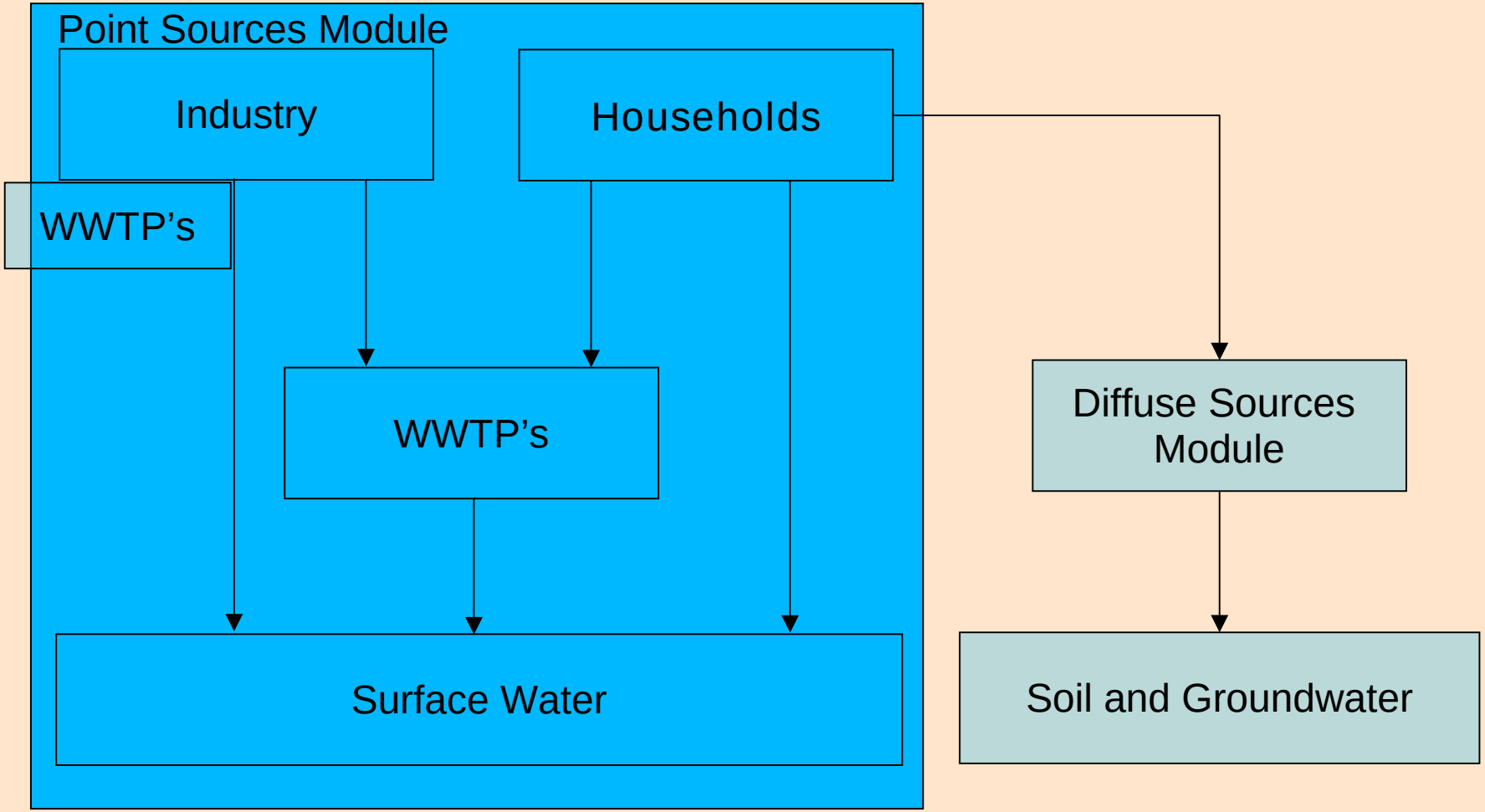
Point sources



Source: Mourad (2008)

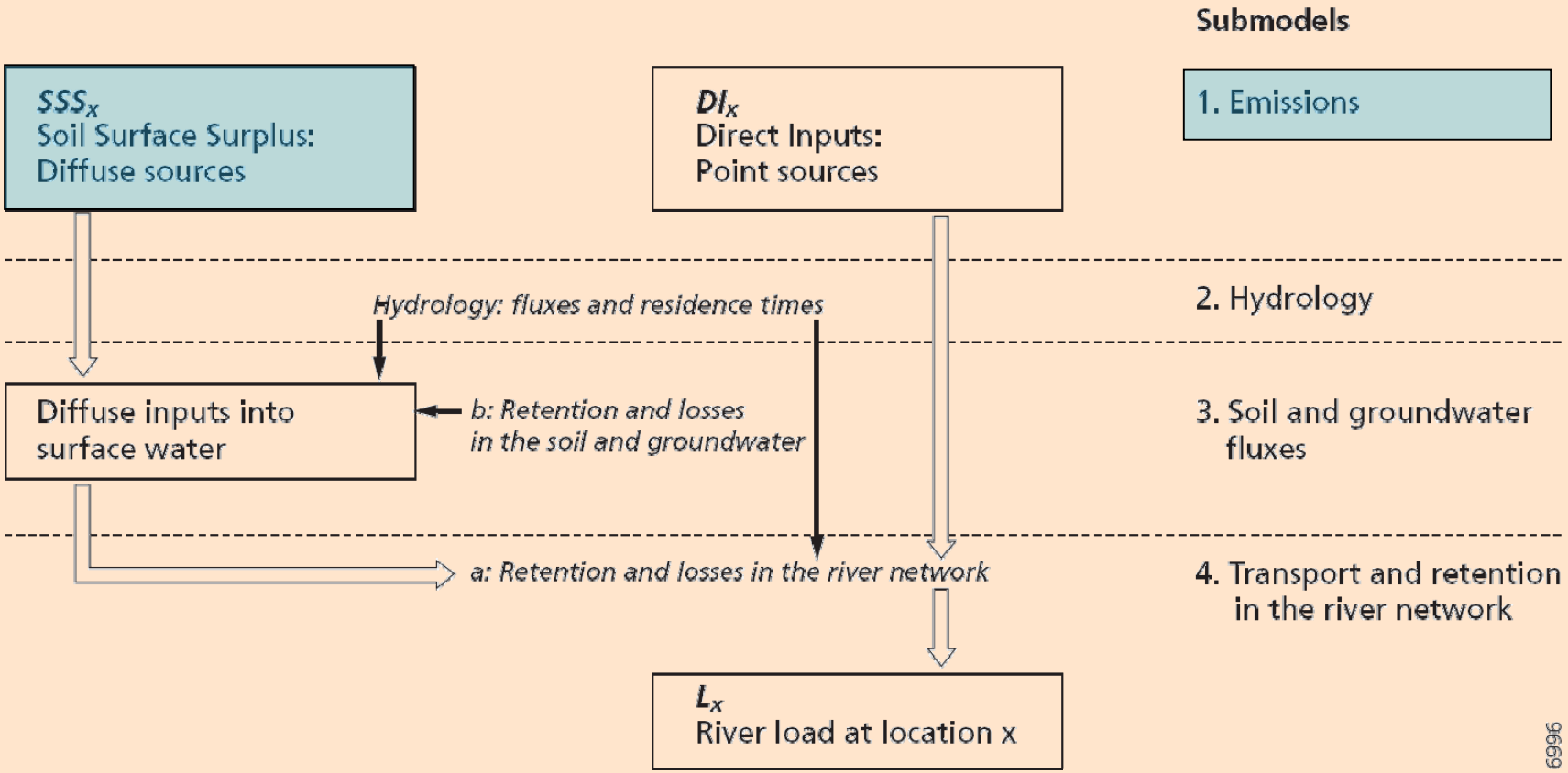
Nutrient model of the Scheldt basin

Point sources



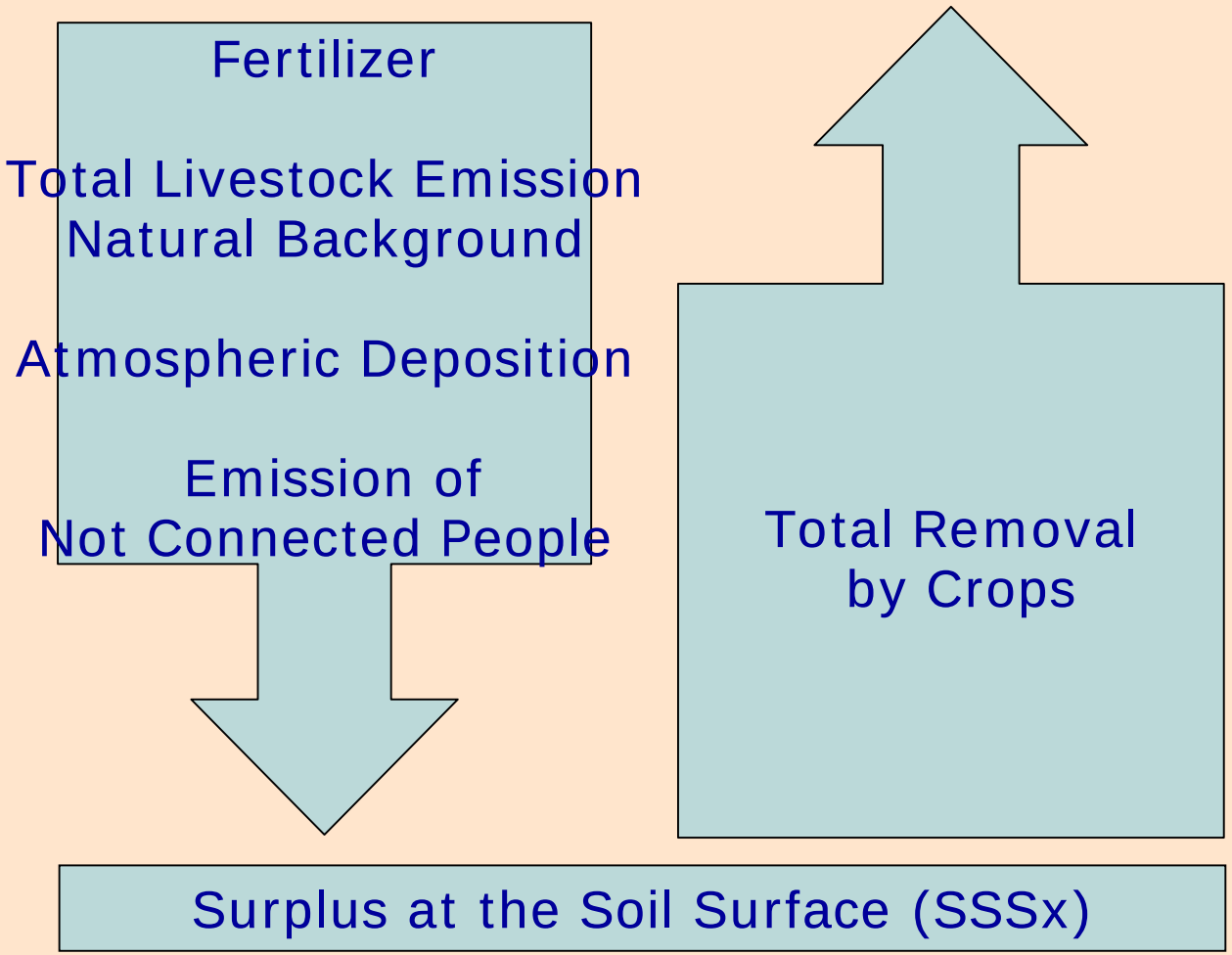
Nutrient model of the Scheldt basin

Diffuse sources



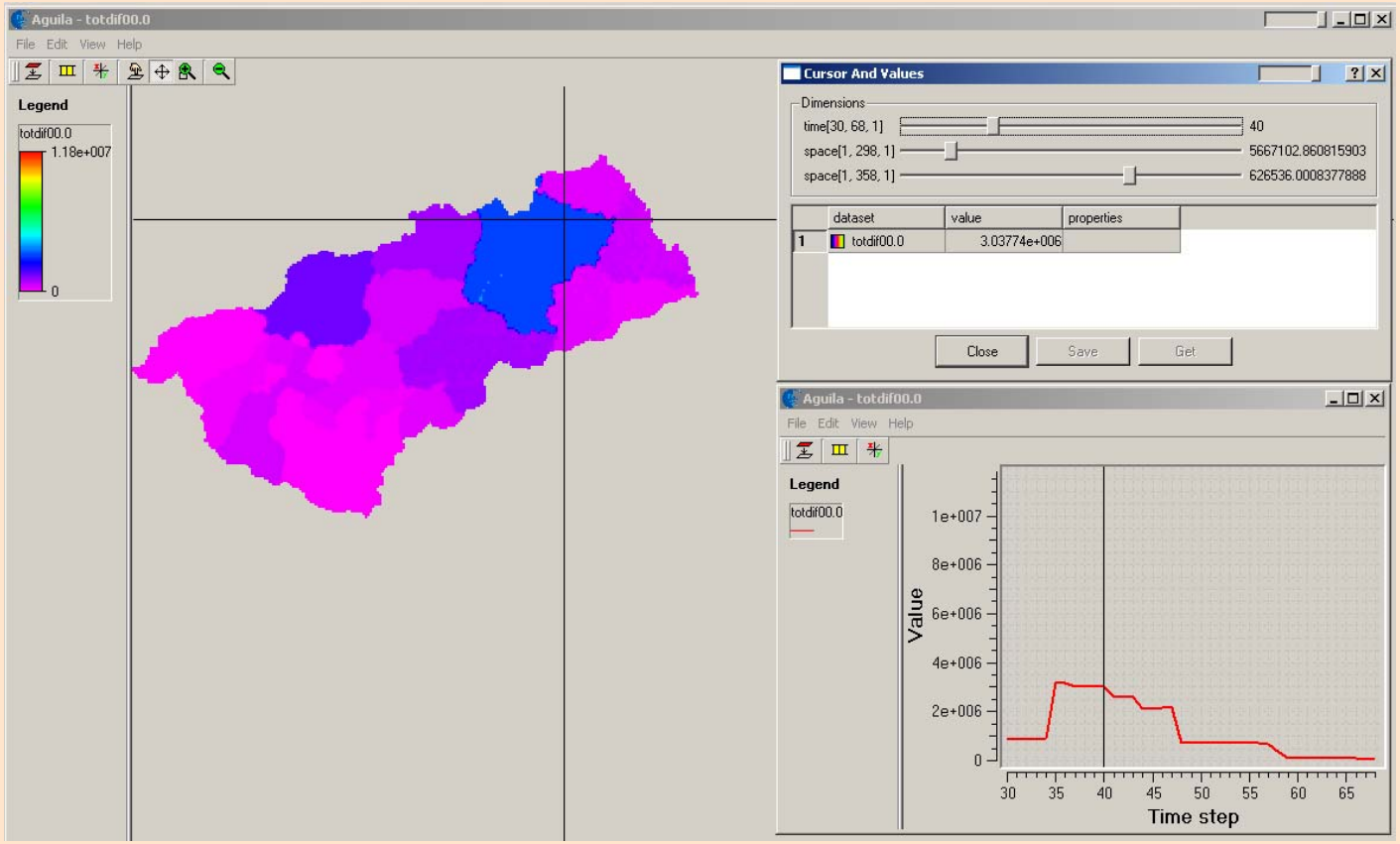
Source: Mourad (2008)

Diffuse sources



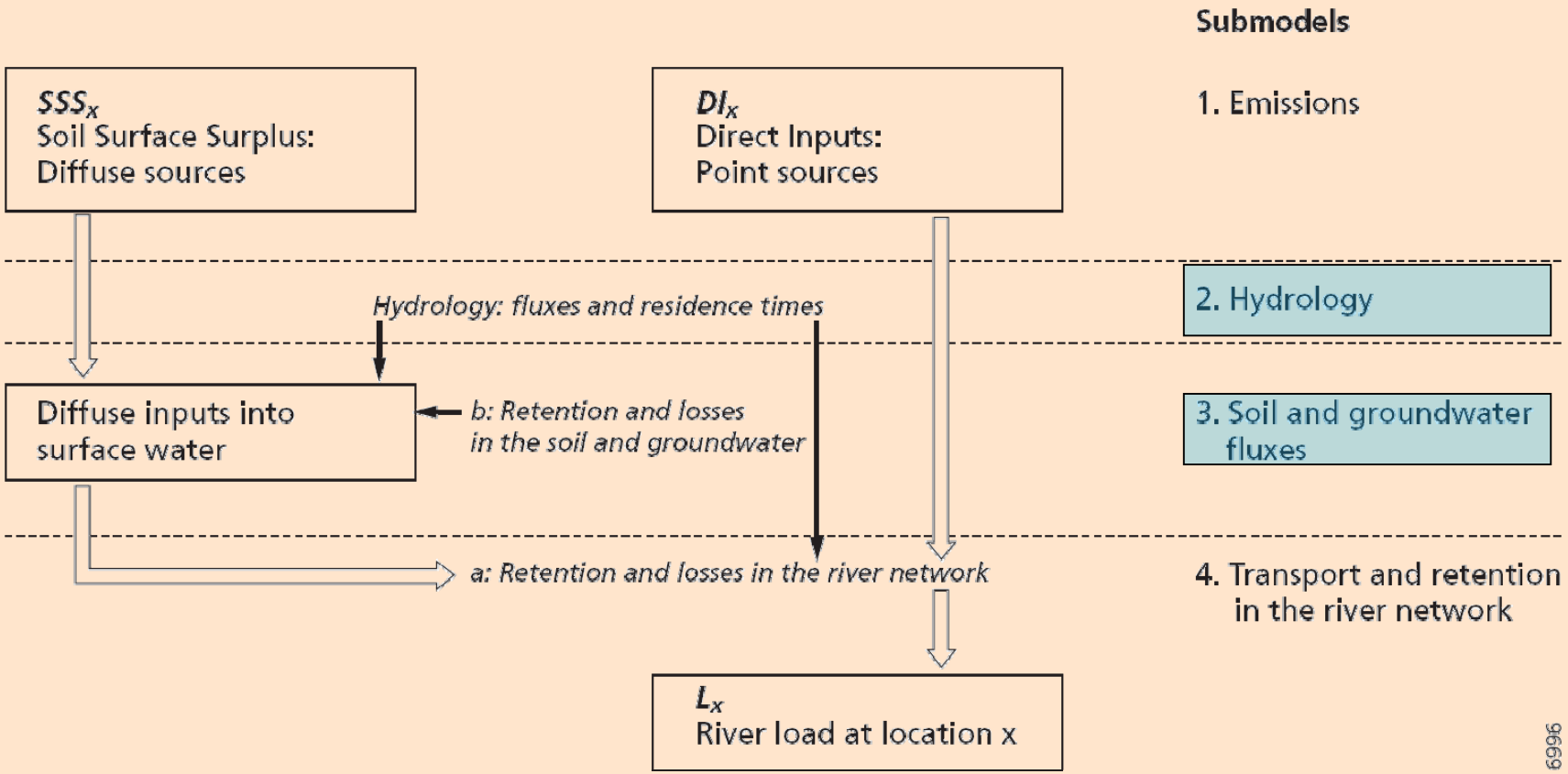
Diffuse sources

Result: total diffuse emmisions [kg/year]

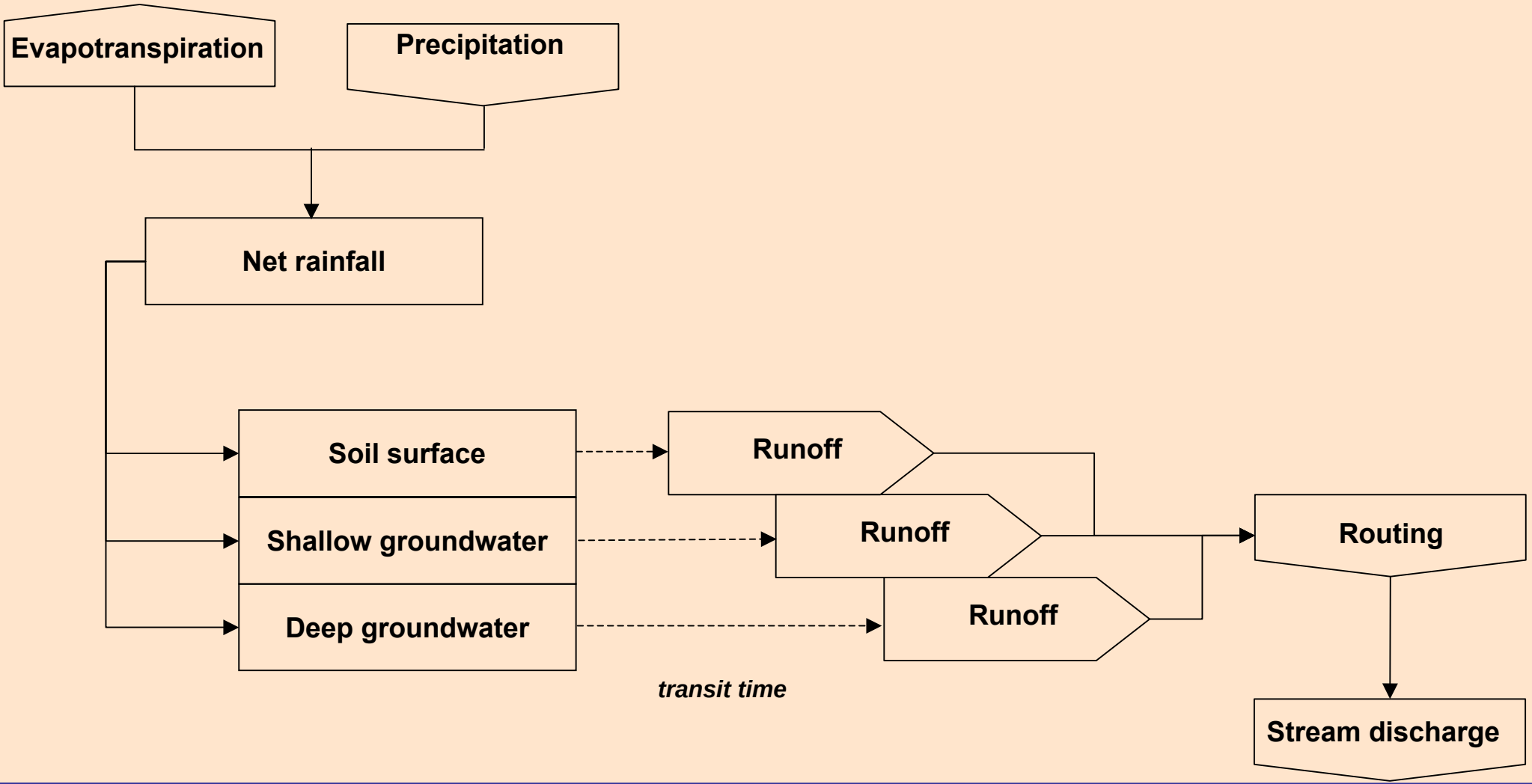


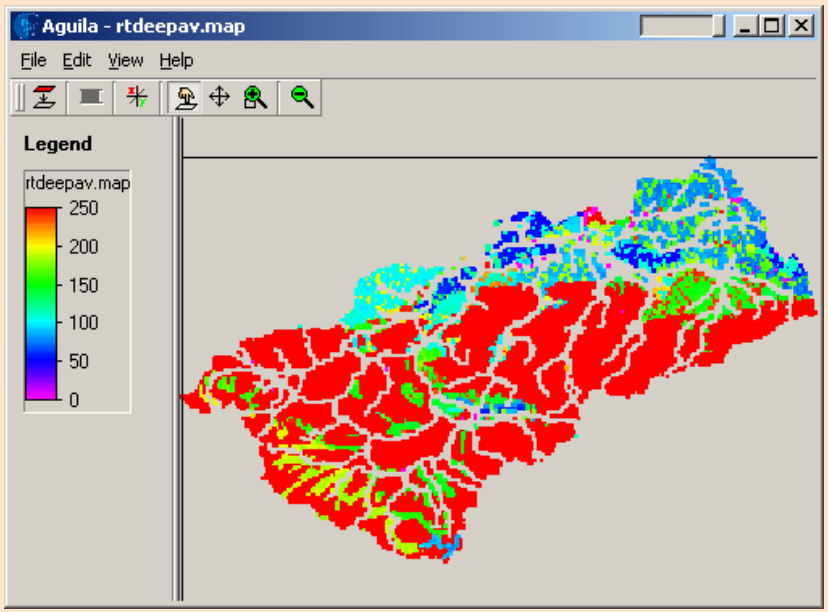
Nutrient model of the Scheldt basin

Hydrology

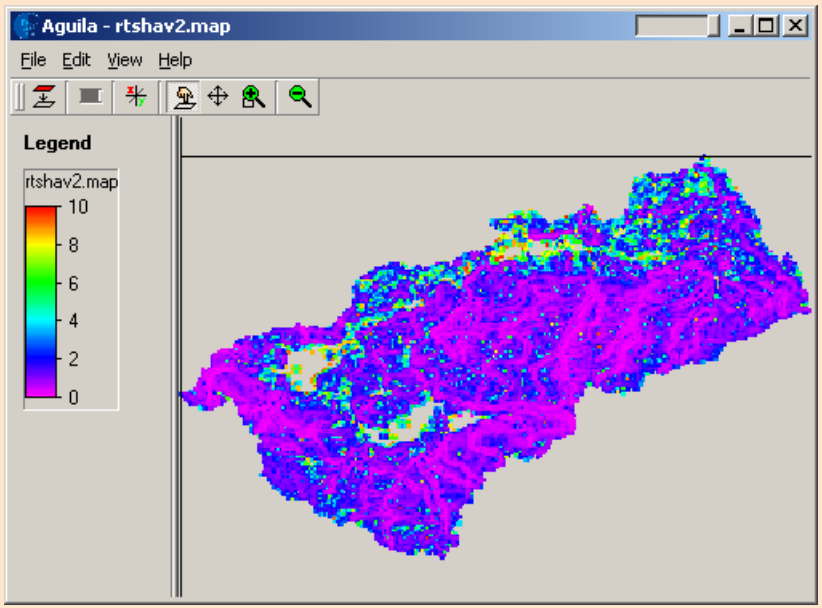


Source: Mourad (2008)


Evapotranspiration
Precipitation
Net rainfall
Soil surface
Shallow groundwater
Deep groundwater
Runoff
Runoff
Runoff
transit time
Routing
Stream discharge



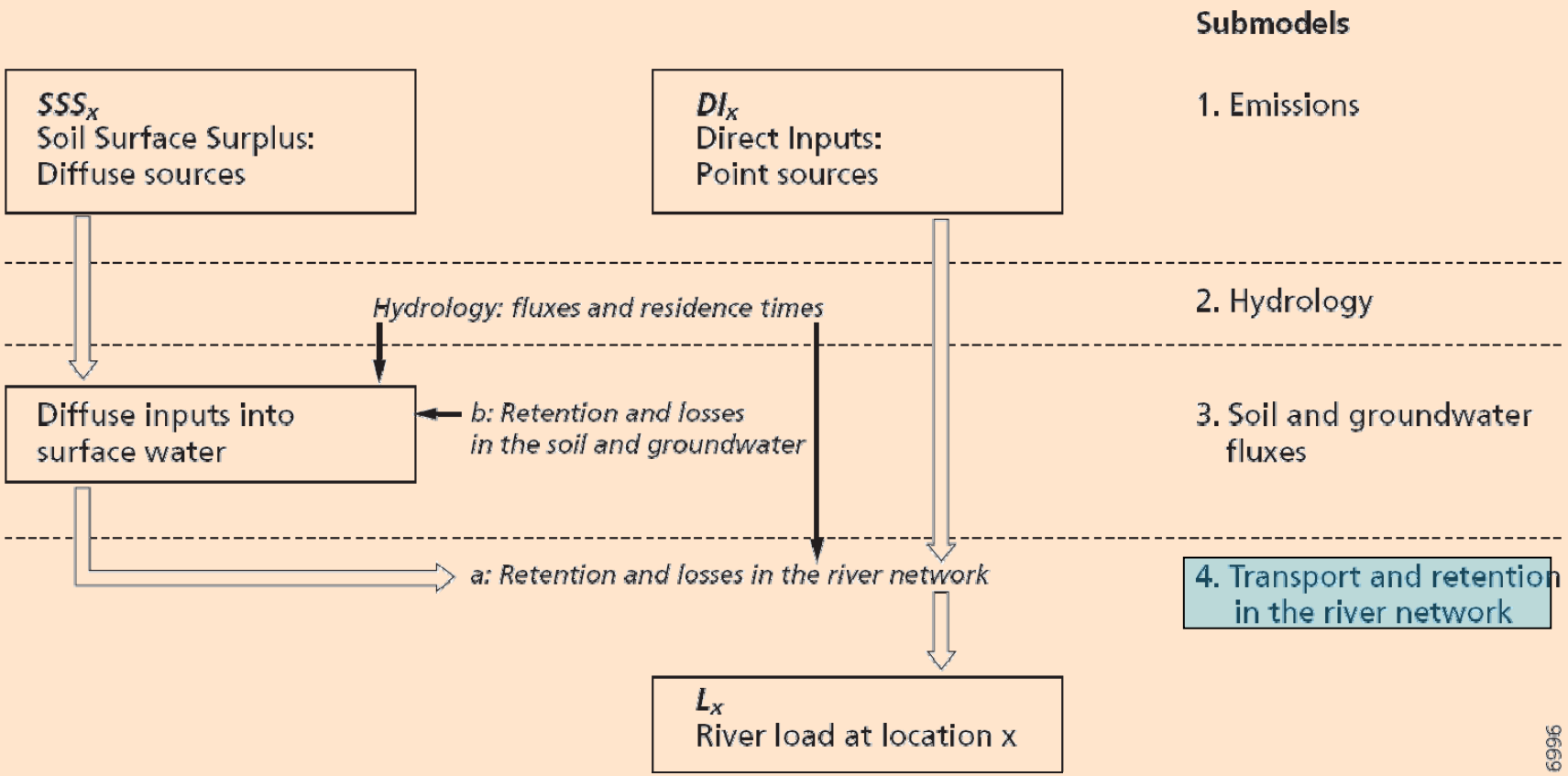
Average residence time [years]
Deep groundwater



Average residence time [years]
Shallow groundwater

Nutrient model of the Scheldt basin

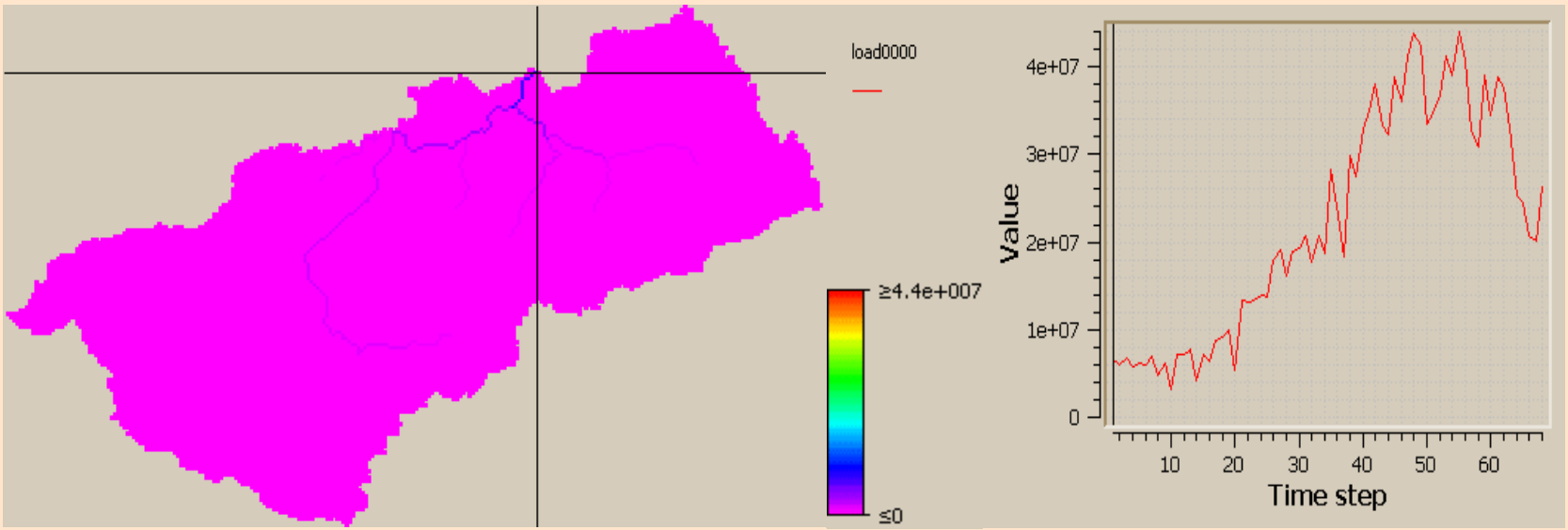
Hydrology



Source: Mourad (2008)

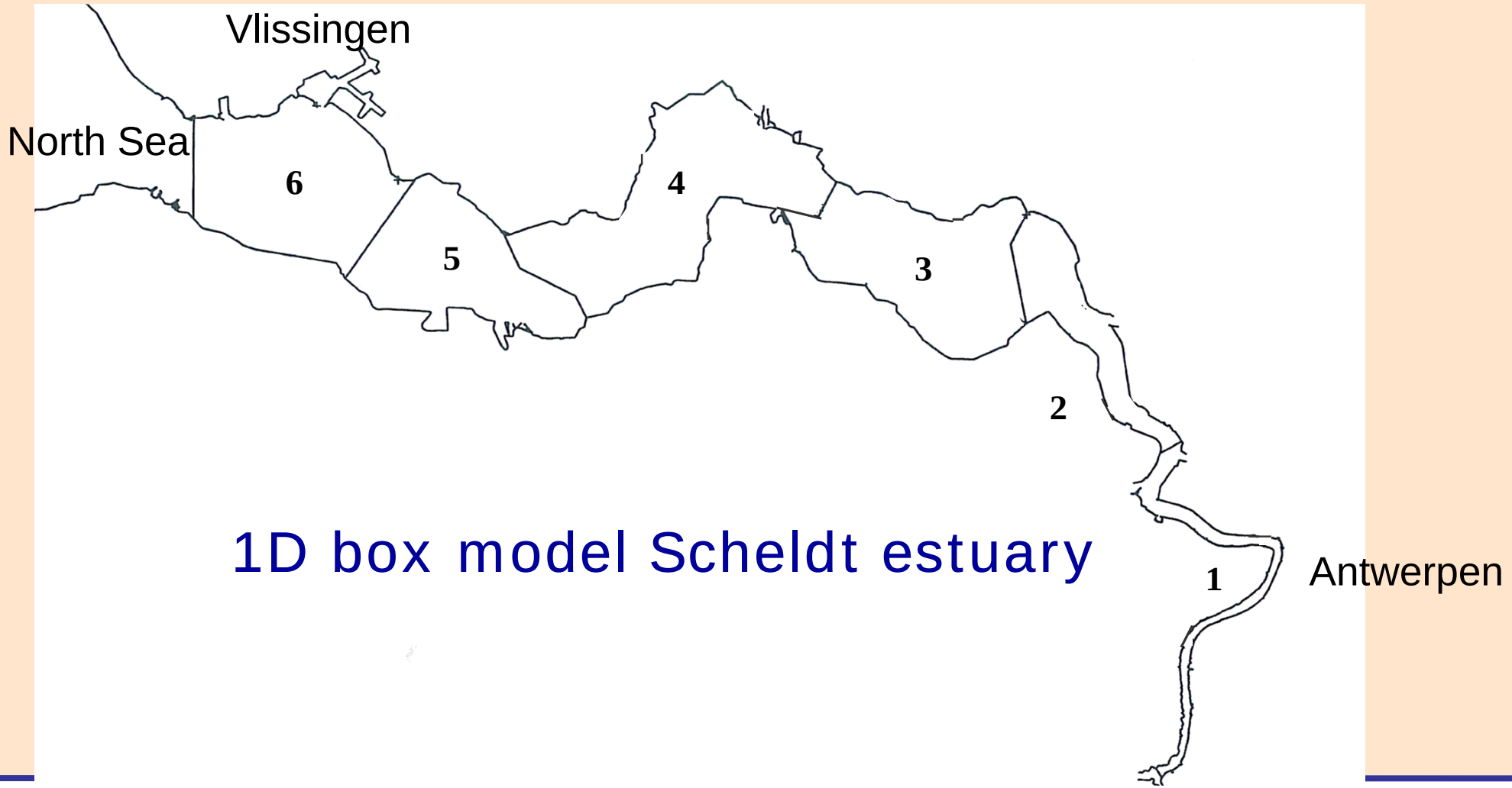
Transport & retention in the river network

N-load [kg/year] at the outflow point of the Scheldt basin



Estuarine 1D box model

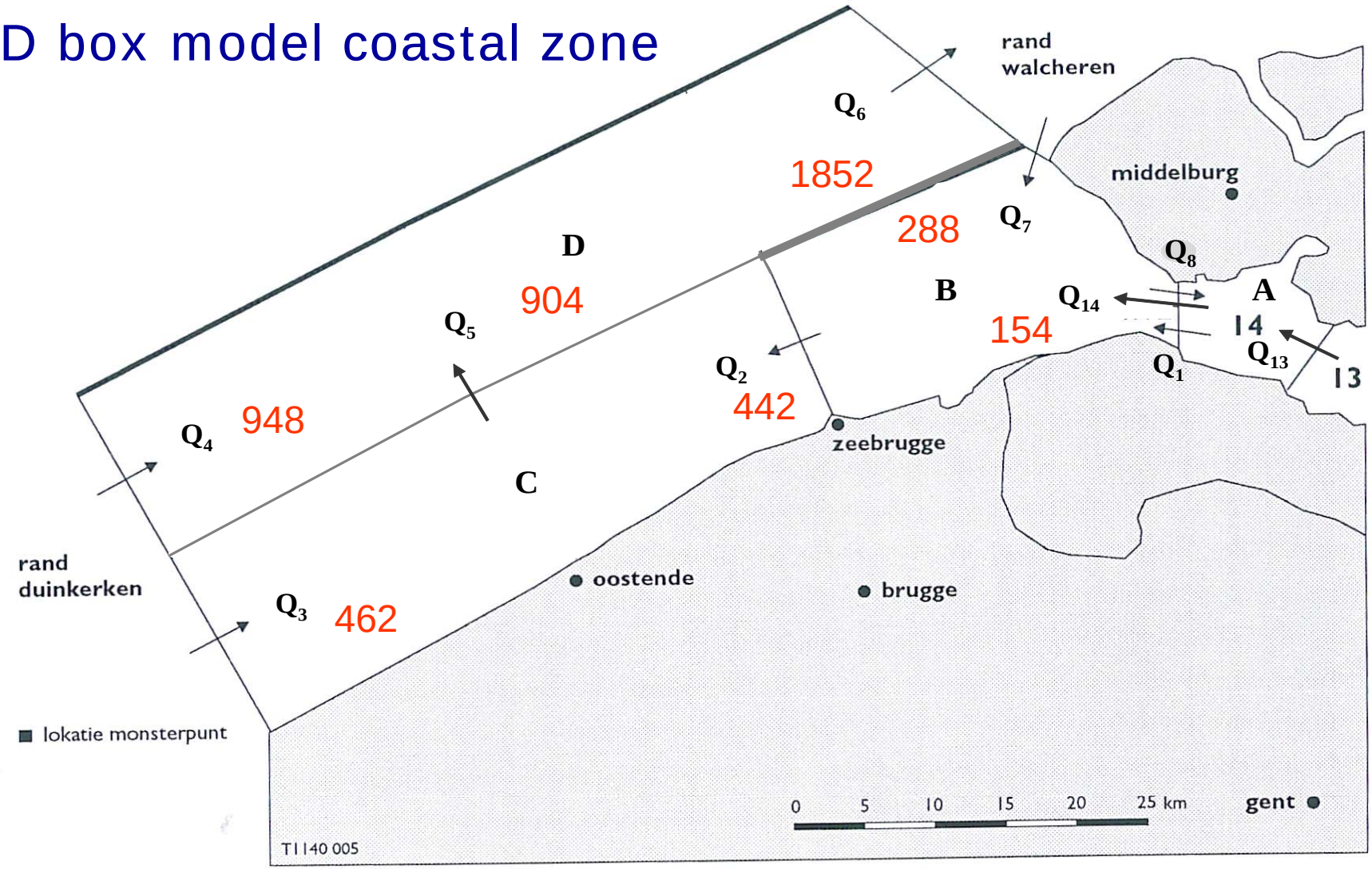
1. spatial resolution
2. waterbalance and salinity
3. nitrogen model
4. nitrogen emissions
5. coastal harmful blooms



1D box model Scheldt estuary

SPICOSA

1D box model coastal zone



SIXTH FRAMEWORK PROGRAMME

Science and Policy Integration for COastal Systems Assessment

Formulation nitrogen retention

$$\frac{\partial(DIN)}{\partial T} = -RC_{BDEN} \cdot \frac{(DIN)}{H} \cdot f(T).g_N(O_2)$$

nitrogen concentration

nitrogen retention rate

average water depth

temperature function nitrogen retention

oxygen function denitrification (=1)

Fuzzy-logic model Phaeocystis spring bloom assessment (removed)

Assessment of a risk for *Phaeocystis* dominance during spring bloom in BCZ				
		Condition		Risk
NAO index (under present N-concentrations)	-2 <	NAOi	< 2	high
NAO index (under present N-concentrations)		NAOi	> 2	low
NAO index (under present N-concentrations)		NAOi	< -2	low
Future N-reduction in Belgian coastal zone	winter NO_3^-	< 0.3 - 0.4	g m^{-3}	low

Based on Breton et al. (2006) ; see text for assumptions regarding the risk.

Measures and Scenarios

Measures

Sigma plan = 2000 ha extra wetlands

(PCRaster)

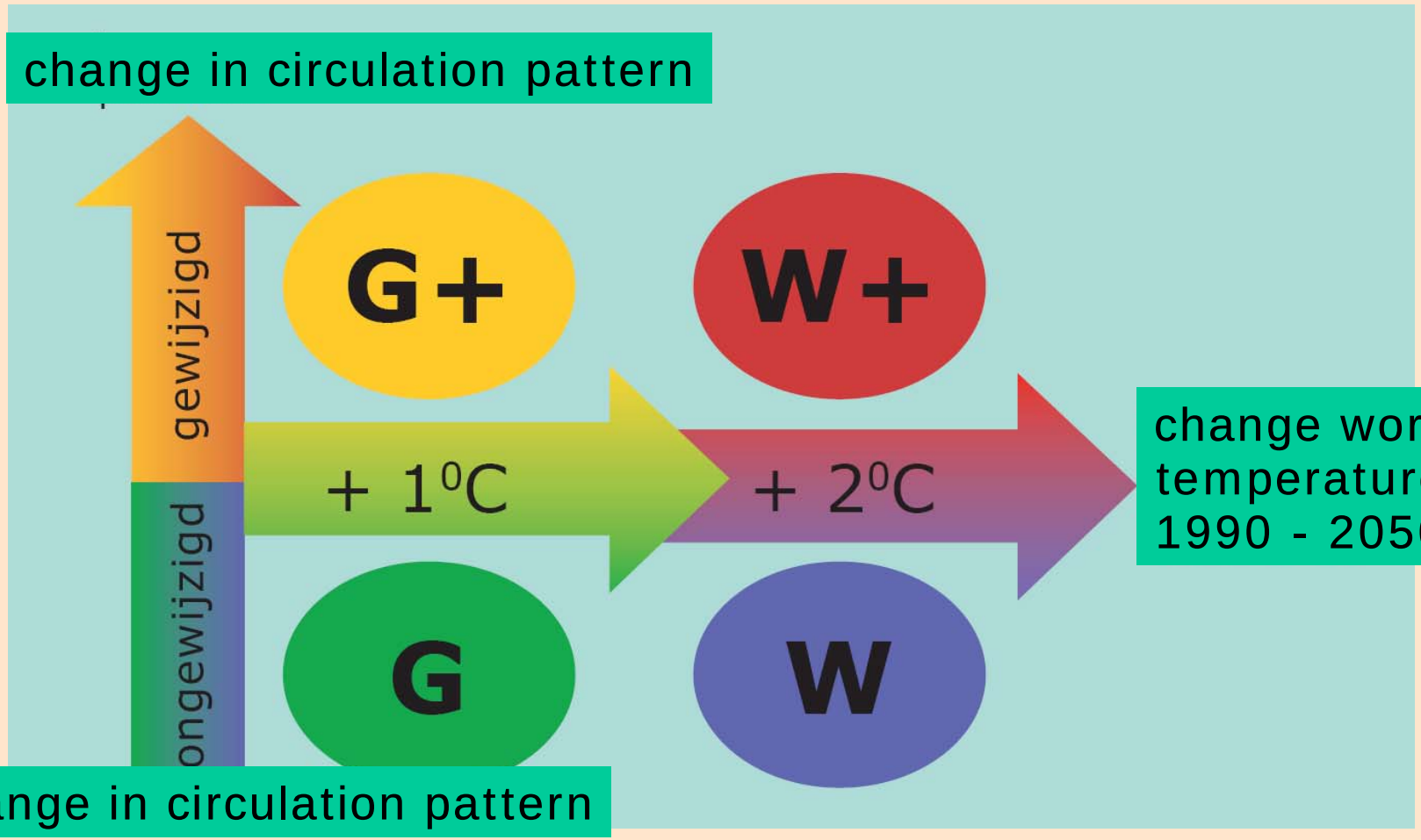
GGG = controlled tidal inlet

GOG = controlled dike height


Hedwige-Prosper polder
Turnhout
Antwerpen
Sint-Niklaas
Kruibeke-Bazel-Rupelmonde
Geel
Lier
Cluster Durme en haar vallei
Lokeren
Grote Nete
GOG Vlassenbroekse polder
GOG Grote Wal-Kleine Wal-Zwijn
Cluster Dijlemonding
Mechelen
Cluster Kalkense Meersen
Aarschot
Aalst

SPICOSA

Scenarios



Source : Climate in the 21st century - Royal Dutch Meteorological Institute (KNMI)

www.knmi.nl\climatescenarios

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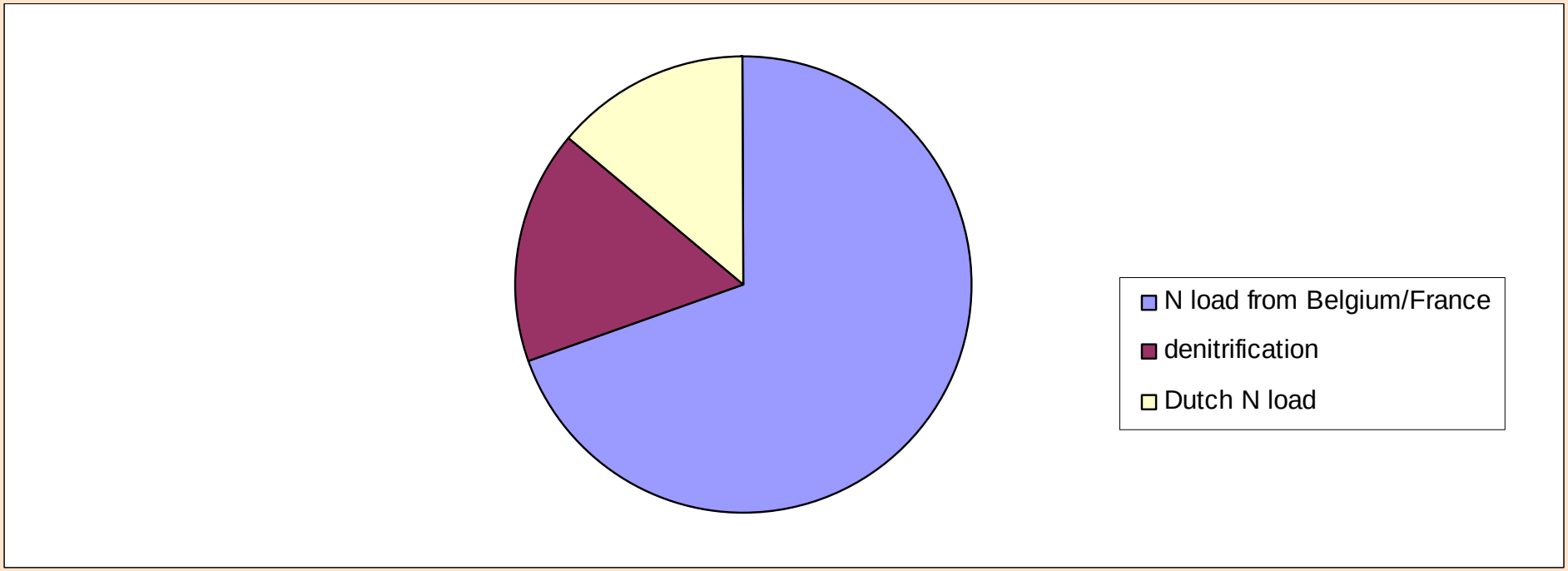
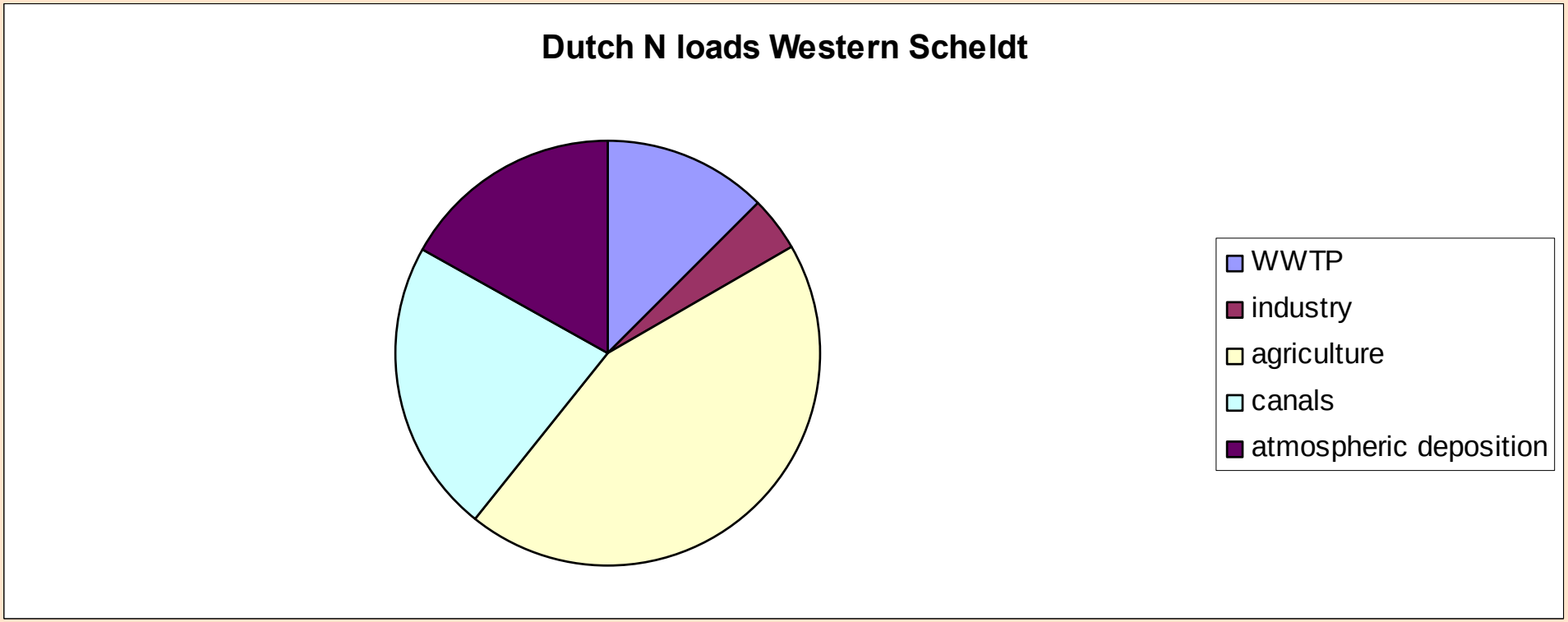
Thank you for your attention


N load from Belgium/France
denitrification
Dutch N load


Dutch N loads Western Scheldt
WWTP
industry
agriculture
canals
atmospheric deposition

Nutrient model of the Scheldt basin

- PCraster is Based on PolFlow (De Wit, 1999) and a daptationsby Mourad (2008)
- Applied to large river basins
- Rhine, Elbe, Po
- Used for modelling of N and P fluxes
- Temporal resolution: ≥1 year
- Spatial resolution: 1 ha - 1 km^2

Natural component

- Relate nutrient fluxes to:
  - Emissions (point/diffuse sources)
  - Hydrological pathways
  - Retention (decay,storage,transformation)

Source: Mourad, De Wit & Van der Perk

Natural component model

- Emissions modules
- Hydrology module
- Soil & groundwater fluxes module
- Transport & retention in the river network module

Point sources

- Outputs:
  - Total point sources emissions (DI_x [kg/year])
    → input to **transport and retention in the river network module**
  - Emission from not connected people considered as diffuse sources [kg/year]
    → input to **diffuse sources module**

Point sources

- Datasets:
  - Direct emissions from WWTP's
    - Location of WWTP's + year of construction
    - connected people and industry
    - efficiency of nutrient removal
    - startyear of WWTP's
  - Direct emissions from industry
    - Location of not connected industry

Point sources

- Fraction not connected people considered as point sources + their excretion factor (10gN/day)

Nutrient model of the Scheldt basin

Diffuse sources

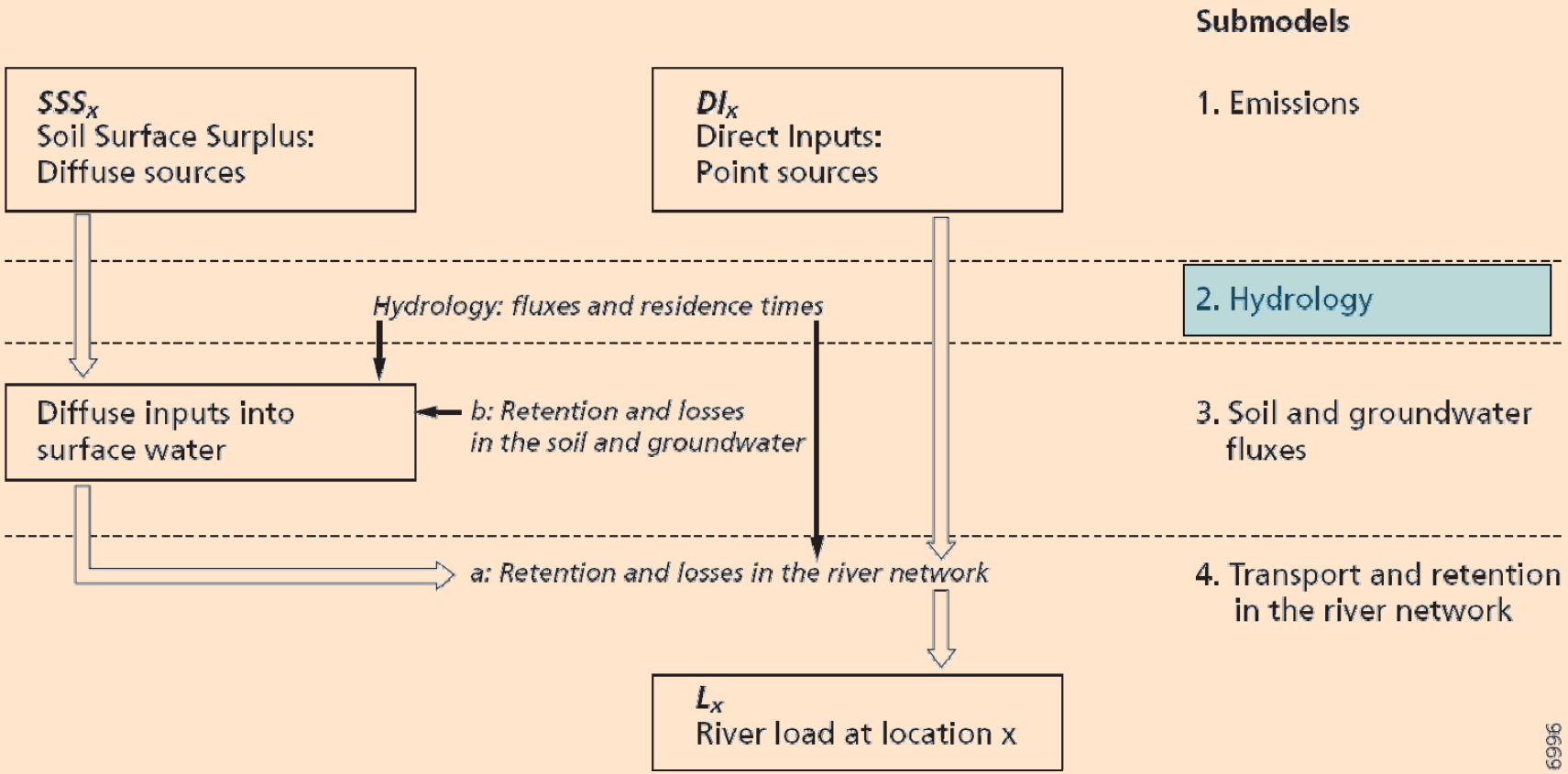
- Datasets:
  - Livestock data EUROSTAT, per province
    - Number of animals
    - Excretion factors
  - Crop data EUROSTAT, per province
    - Crop yield
    - Crop factor
  - Atmospheric deposition: EMEP
  - People not connected to WWTP: from point sources module

Diffuse sources

- Outputs:
  - Total emission from diffuse sources (SSS_x [kg/year])
    → input to **soil and groundwater fluxes module**

Nutrient model of the Scheldt basin

Hydrology



Source: Mourad (2008)

Soil & groundwater fluxes

Denitrification functions from De Wit (1999).
Parameters (lookup tables):

- Denitrification reaction constant per aquifer
- Maximum denitrification fraction per aquifer
- Maximum denitrification rate per soil type
- Denitrification constant per soil type

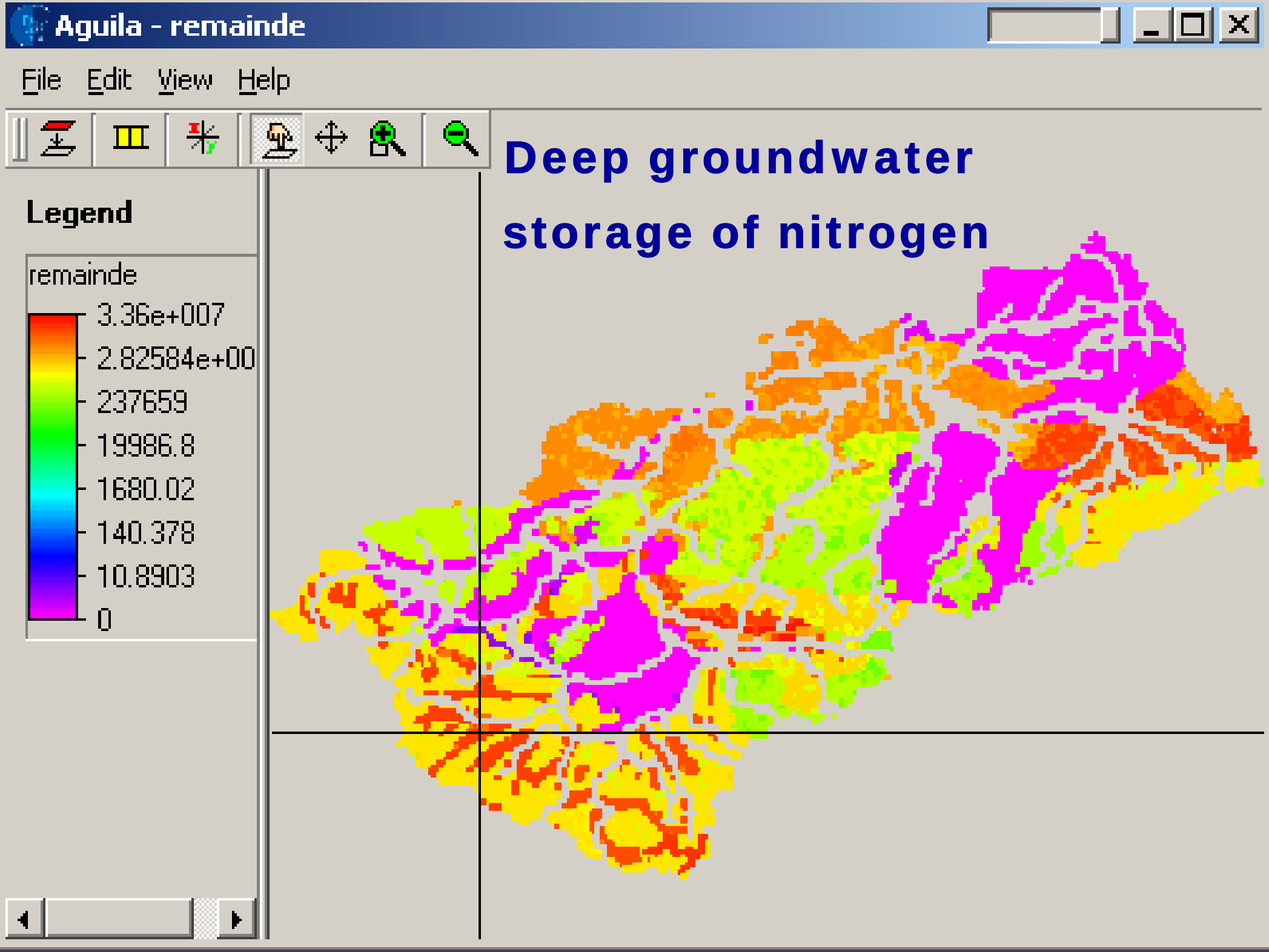
Transport & retention in the river network

Loss in the river network

- denitrification (N)
- sedimentation (P)
- Assimilation by algae and aquatic macrophytes (N and P)

Modelled with transport fraction (*tf*):

- output to downstream cell / total input to the cell
- function of slope and discharge of a cell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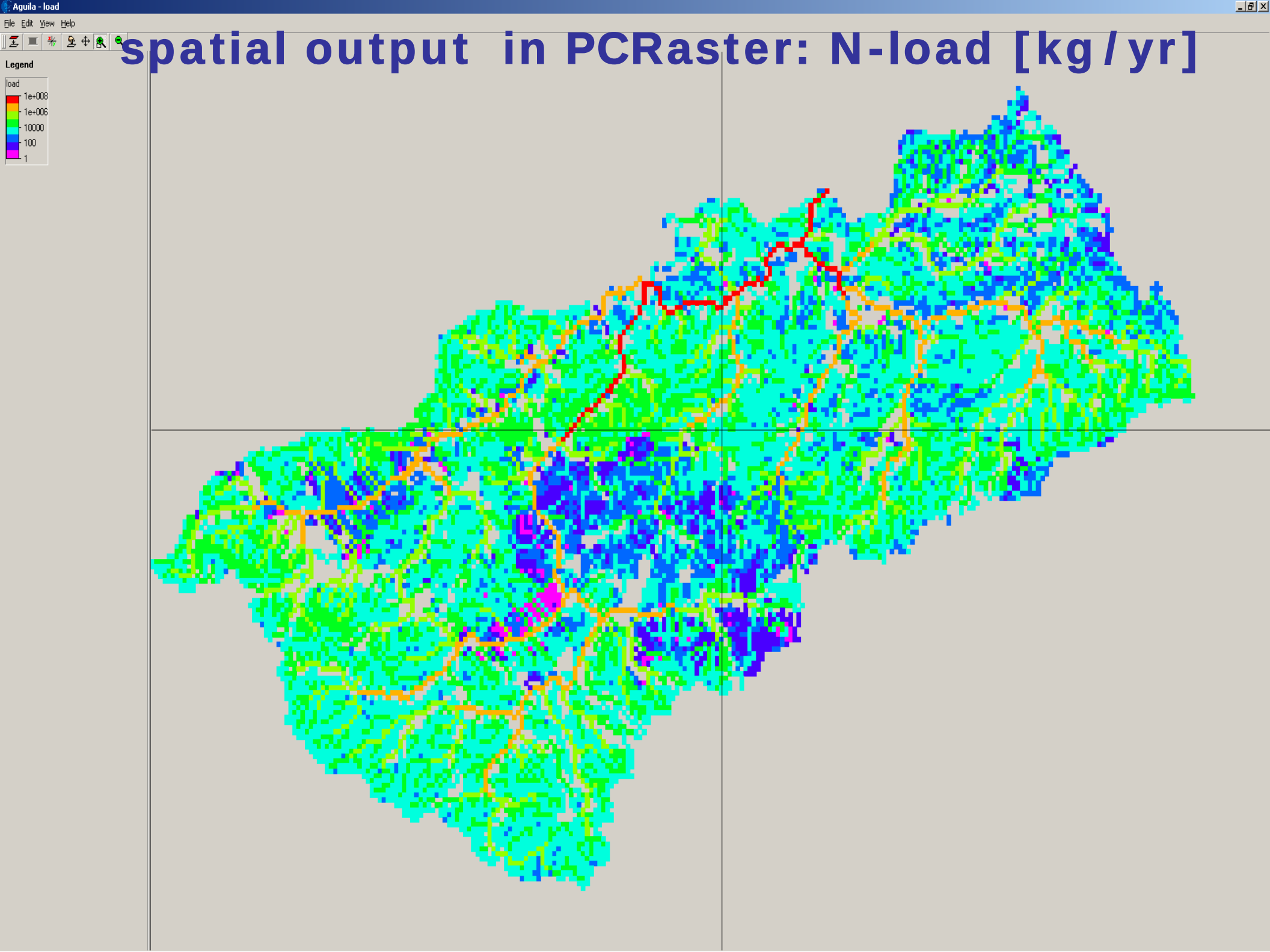
19986.8
1680.02
140.378
10.8903
0
Deep groundwater
storage of nitrogen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1e+006
10000
100
1
spatial output in PCRaster: N-load [kg/yr]

Measures

- Aim: estimate costs and effects of measures WFD
- Main measures:
  - Connection to WWTP
  - Individual treatment households
  - Reduction livestock
  - Spatially defined measures: bufferstrips, green fertilizers