Ecologically sound rural water management in Europe. With a case study on the Slovak Republic (Slovenská republika) and Portugal

Erik P.C. ROMBAUT,Master in Biology , Asst. Prof. , LUCA.
Hoger Architectuurinstituut Sint-Lucas (LUCA, school of Arts),
Hoogstraat 51, B-9000 Gent / Paleizenstraat 65-67, B-1030 Brussels.
KaHo Sint-Lieven, Hospitaalstraat 23, B-9100 Sint-Niklaas.
+ 32 (0)3 7707147. erik.rombaut@scarlet.be

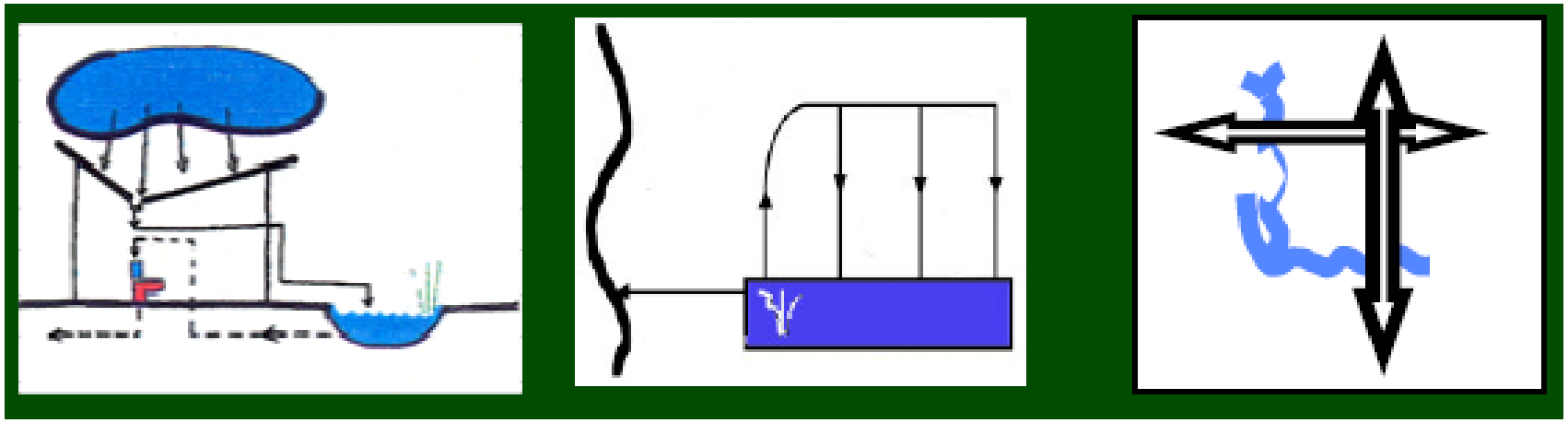
International Master in Architecture. Theme 9

Course Environmental Sustainability.

Theme:
About the impact of rural blue-green networks on biodiversity, soil erosion and flooding in Europe. With case studies 'River Scheldt in Belgium, River Rhine and Danube in Europe and the Slovak republic [1].

1. The Slovakian case study has been documented by the excellent work of**:** **Kravčík, M. et al., 2008.** Water for the recovery of the climate. A new water paradigm. Košice (Slowakia), Typopress-publishing house, ISBN 978-80-89089-71-0. 122 pp. Ill (see on the Toledo website OPO 21 'Environmental sustainability' for this course text).

The use of **water as an organizing principle** at different levels *in urban and rural environment is urgently needed.*



Building level **District level** **City level and rural areas**

= INTEGRAL WATER MANAGEMENT

For integral water management on building level, district level and city level: see theme 6.

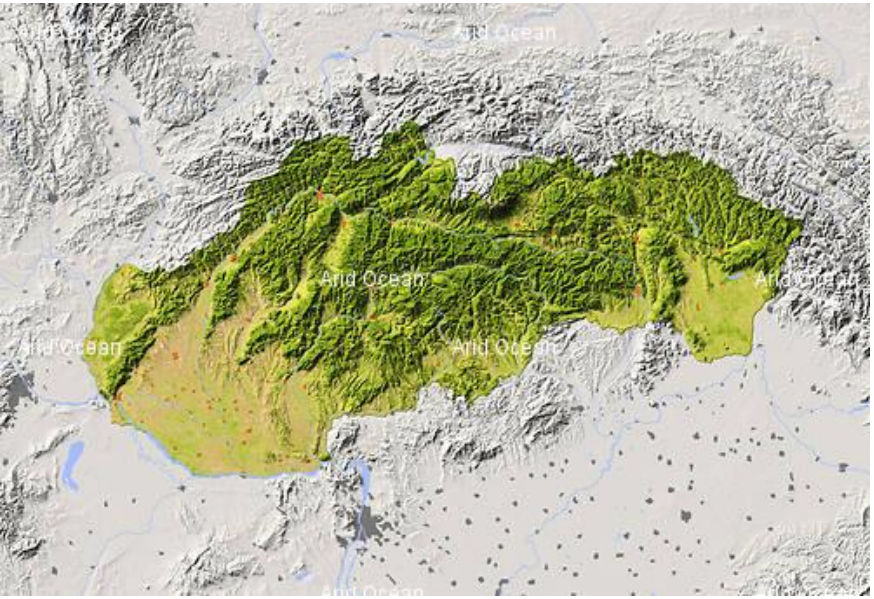
From Tjallingii, 2009.

Location of Slovakia within the EU-28

Slovakia / Slovenská republika

www.schoolplaten.com/slowakije-t17500.jpg

The relief of Slovakia



maps.aridocean.com/maps_of_slovakia_en.php

www.world-atlas.biz/images/slovakia-map.gif

The problem: As in urban areas, the hydraulic roughness (sponge effect) of the rural areas, all over Europe, is also being lost .

- The green infrastructure (such as tree rows, hedges, sunken roads,, ….) in rural areas is not only of ecological importance (remember the horizontal ecological relations in landscapes, see theme 8), but has also economic advantages:

  Prevention of soil erosion,

  Prevention of flooding.

Main rural causes: Hydraulic rough landscape in the municipality of Voeren (B) suffers from **deforestation** …

Sunken road
(Holle weg)

Noorbeek brook valley

terraces

… followed by **intensification of agriculture** (Heers, Limburg, B), so sponge effect is lost after land consolidation projects

Farmers plowing nowadays perpendicular to contour lines on slopes. (compare direction of plowing by a tractor with plowing by horses or cows)

Sponge effect is lost by sealing rural landscapes.

Sint-Gillis Waas (B)

Before ….

and after land consolidation ….

Increasing soil erosion in loam areas, all over Europe, is a result .

Great Britain, Kent

Erosion Grid, Hoegaarden (B)

***Fig. 10* Agricultural land beneath the Tatra Mountains**
Giant fields that originated during communist era with the collectivizing of tracts of land. Due to the absence of barriers, rapid surface runoff causes water erosion of the soil.

Soil erosion in Slovakia

In Slovakia the real loss of soil through water erosion runs on average in the forested vegetation of the middle to upper mountain regions at about 0.01-0.03 mm/year, in permanent grasslands at around 0.06 mm/year, in cereal fields at 1.8 mm/year, on bare ground above the tree line at 3.4 mm/year and in root crop fields up to 3.6 mm/year.[29] This means that in many regions of Slovakia we lose precious agricultural soil which has been formed over centuries or even millennia. In view of the fact that soil is so slowly created, it can be considered as a non-renewable resource. It can thus be said that we are living off our very foundations.

The soil erosion problem in Slovakia (from Kravčík, M. et al., 2008)

Potential loss of soil

The urgency of measures needed to combat water-caused erosion become still more urgent with the view of potential (possible) water-caused erosion of the soil. This involves erosion which would occur naturally on the surface of the soil if it were not protected by vegetation even without anti-erosion measures. The average intensity of such possible erosion represents in Slovakia 2.3 mm each year (23 m^3 of soil per hectare per year). Water erosion of moderately, strongly and extremely threatened agricultural soil in Slovakia represents 55.6% of all agricultural land in the national land fund. Moderately, strongly or very strongly to catastrophically threatened forested land comprises up to 97.1% of all forested land in the fund (*Tab. 5*).[30] From the comparison of data about real and potential water-caused erosion in forests, it becomes imperative to maintain forestation to the extent that conditions allow. A further conclusion should be the need for urgent forestation, particularly of desolate lands, which would allow for the fulfilling of the anti-erosion and hydric functions of the forest on them.

***Tab. 4* Actual water-caused erosion of agricultural soil[31]**

Level of erosion	Linkeš, et al. (1997) (thous. ha)	Environment Ministry SR (2002) (% PPF)
Low erosion	1 198	47
Moderate erosion	514	22
High erosion	49	2
Extremely high erosion	24	1
Total	1 785 thous. ha (73.1 % PPF)	72% PPF

***Tab. 5* Erosion threatening soil according to the type of land in Slovakia under the influence of surface runoff of water (potential water erosion)[32]**

Threat of erosion (degree)	Intensity of potential erosion (bearing away) of soil	Agricultural land		Forested land		Total	
	(mm per year)	(thous. ha)	(%)	(thous. ha)	(%)	(thous. ha)	(%)
1. minute	up to 0.05	107	3.4	3	0.0	110	2.2
2. weak	0.06 – 0.50	1 296	41.7	117	6.6	1 413	28.9
3. moderate	0.51 – 1.50	823	26.5	333	18.7	1 156	23.6
4. strong	1.51 – 5.00	783	25.2	1 075	60.3	1 858	38.0
5. very strong	5.01 – 15.00	100	3.2	255	14.4	355	7.3
6. catastrophic	over 15.00	1	0.0	1	0.0	2	0.0
Average / total	2.30	3 110	63.5	1 784	36.5	4 894	100.0

Increased flooding in river valleys is also a result

Note the yellow color due to the eroded soil (loam).

This is a worldwide problem, think of the 'Yellow River, Huang He ' in China.

- Brief overview of some relevant European legislation

"DIRECTIVE 2000/60/EC, establishing a framework for the community action in the field of water policy" **EU Water Framework Directive** (WFD).

http://ec.europa.eu/environment/water/water-framework/index_en.html ; NL: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32000L0060:nl:HTML en http://www.vmm.be/publicaties/EUKW.pdf

- The WFD strives towards a sustainable water use, also for future generations.
- The WFD aims to secure water resources and water quality in Europe and to weaken the effects of floods and droughts. It stands for an approach by (international) river basin, beyond administrative boundaries and limitations.
- The WFD is imposing specific environmental quality standards of surface and groundwater and proposes different measures through river basin management programs
- The WFD is also imposing all the 28 EU-member-states to readapt the river systems in order to make them accessible again (physically and in terms of water quality) for migratory fish species and other organisms (1).

(1)That is one of the reasons why The Netherlands currently have problems with the European Commission, because they've been building hermetic closed dams along the North Sea to protect against flooding, after the 1953 flood disaster. So The NL will have to adjust these plans, combining flood protection with biodiversity and accessibility of river systems for migratory organisms

The Dutch Delta plan, established after the flood disaster of 1953

http://www.ictam.com/Site_pages_NL/-EUROPE/nederland_n.htm
http://www.geschiedeniszeeland.nl/tab_themas/themas/deltawerken/deltawerken/

Brief overview (1) of some ecological problems of the Deltaplan (NL)

Eastern Scheldt storm surge barrier.

http://www.coastlearn.org/pp/caseholland.html
www.scheldenet.n

Brief overview (2) of some ecological problems of the Deltaplan (NL)

- The ***gradient salt-brackish-fresh*** water, crucial for a wide variety of wildlife has suddenly disappeared and was replaced by a ***sharp boundary between salt and fresh***.

- The fresh water at the ***inland side*** of the dams suffers from ***pollution*** (minerals from agriculture) which leads to ***bloom of poisonous algae***. In summer time, more and more risks for anaerobic fermentation because periods with anaerobic conditions increase (due to less tidal refreshment of water bodies)

Brief overview (3) of some ecological problems of the Deltaplan (NL)

- More and more ***discharge problems*** of growing amounts of ***fresh river water*** are occurring (due to precipitation changes and due to increasing rainwater run-off from urban areas).

- The disappearance of the tidal regime and dynamics has consequences for water quality and for wildlife. A lot of ***migratory organisms*** cannot reach inland areas, nor can they come back to sea. As a result there are severe ecological consequences felt far inland.

- ***Unpleasant consequences*** for fishing, mussel and oyster breeding and local communities depending on these ***fishery activities.***

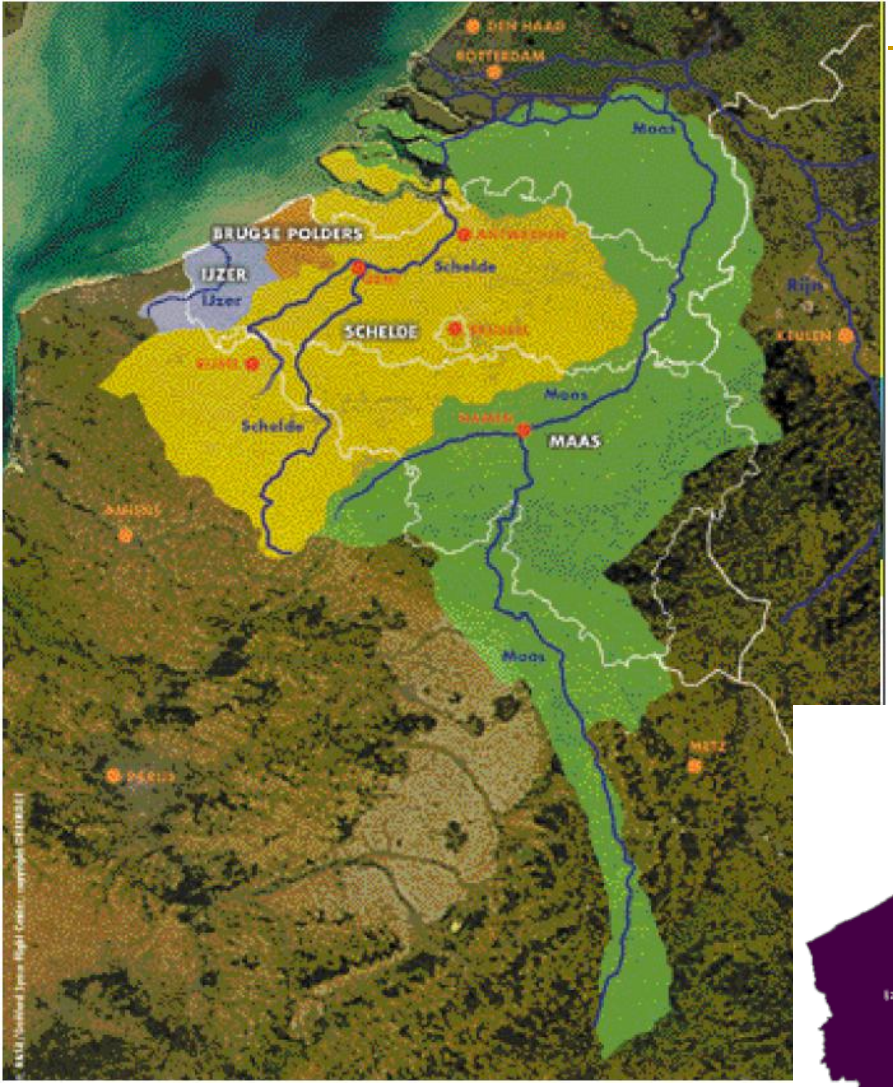
DIRECTIVE 2006/118/EC (12/12/2006)
on protection of groundwater against pollution and deterioration.
The EU groundwater directive. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2006:372:0019:0031:EN:PDF) ; (NL: http://www.ciwvlaanderen.be/wetgeving/europese-wetgeving-1/Dochterrichtlijn%20Grondwater.pdf)

- The groundwater directive, which is a daughter of the WFD, provides a framework for prevention and control measures to prevent pollution of **groundwater**. These measures aim to assess the chemical status of groundwater and to decrease the presence of polluting substances.

DIRECTIVE 2007/60/EC (23/10/2007)
on the assessment and management of flood risks.
The EU Flood directive. http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=OJ:L:2007:288:0027:0034:EN:PDF ; NL: http://www.ciwvlaanderen.be/wetgeving/europese-wetgeving-1/Overstromingsrichtlijn.pdf

- The Floods Directive requires EU Member States to make an **inventory of areas are at risk of flooding**. They have to be mapped, and management plans have to be set up. Guidelines are: international solidarity, a river basin approach, prevention measures.

An integrated river basin approach: international coordination between the 28 EU- member states is obligatory.

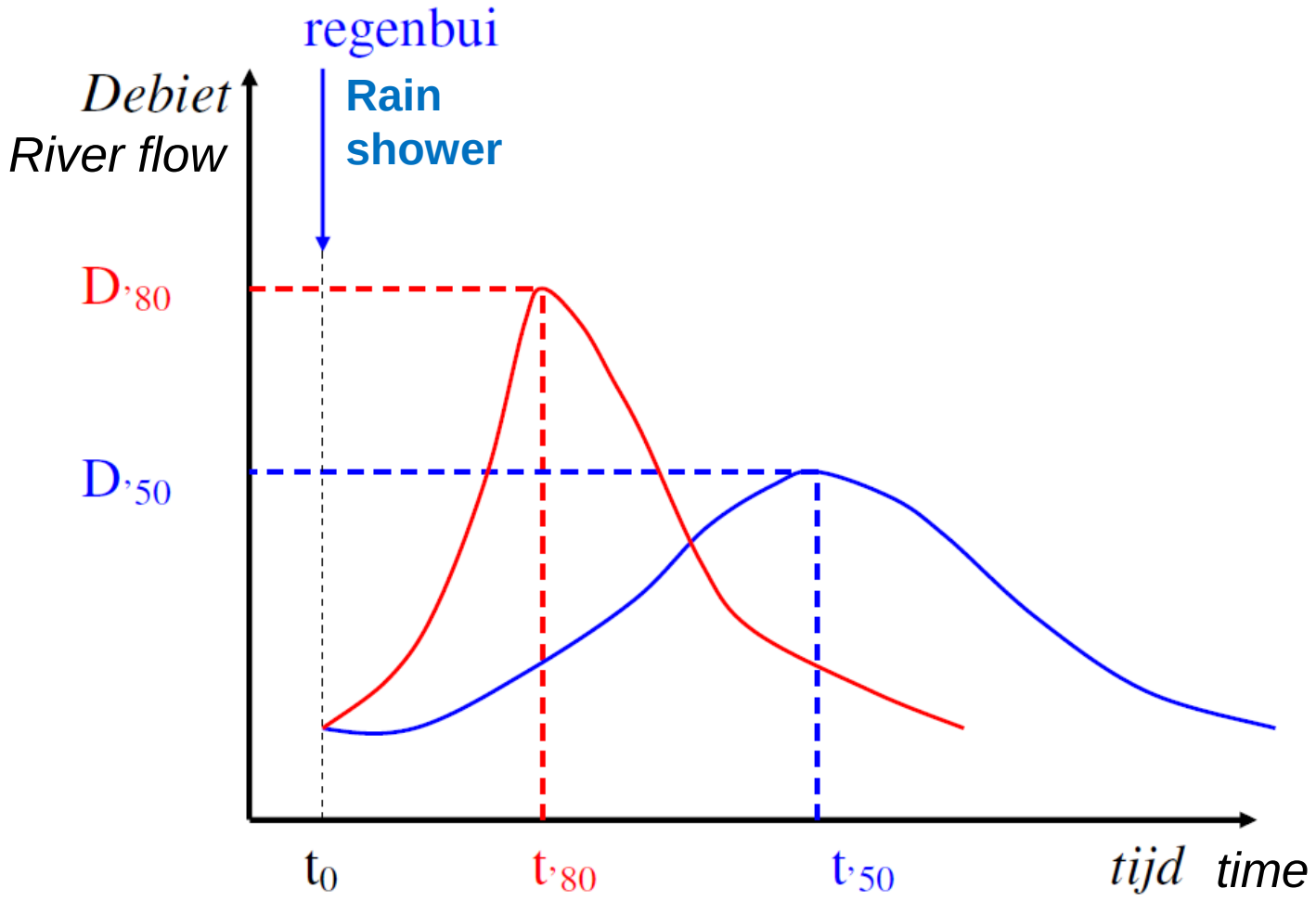


Flemish river and brook basins

Example: River basins of the river *Yser*, *Scheldt* and *Meuse* in Belgium are also extending into **The Netherlands**, **France** and **Germany**,

So the management committee is composed internationally,

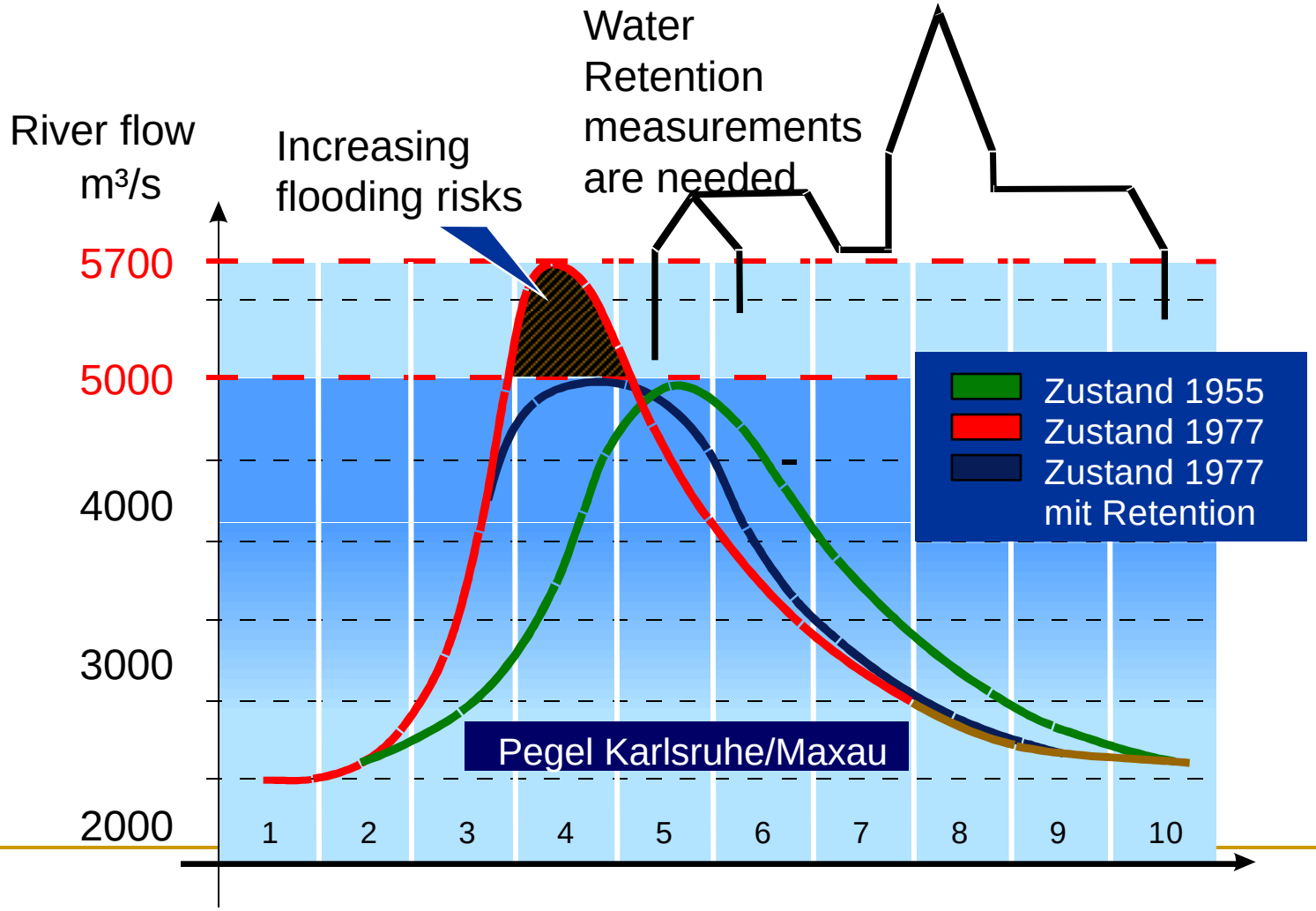
Remember: Hydrological research of the **Bellebeek** (Belgian inland brook), (Van der Beken, 1984, University Brussels)



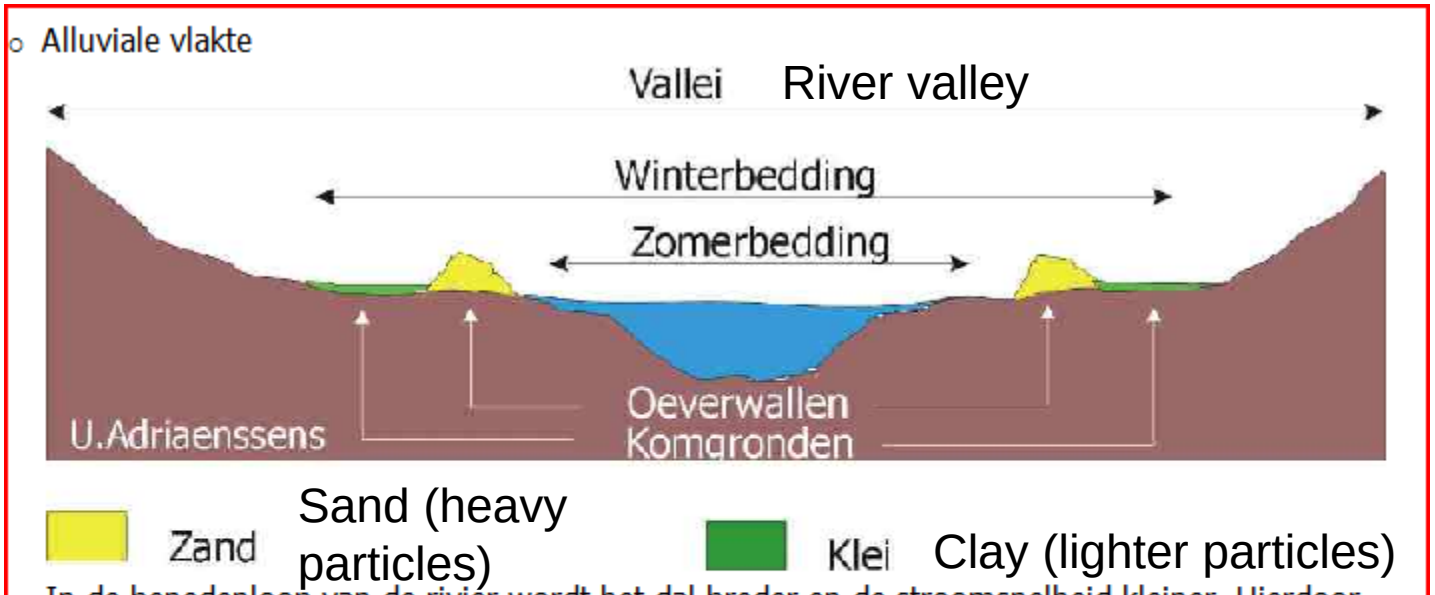
Current peak river flow rates from inland to the North Sea are **higher** and come **earlier** in the time after a rain shower, compared with the years 1950.

The same is the case all over Europe: example of the river **Rhine**, in the border region between France and Germany.

Source: Das Integrierte Rheinprogramm des Landes Baden-Württemberg (Hochwasserverschärfung)



Section of a river valley with the broader **winter** bed (komgronden, uiterwaarden) and the smaller **summer** bed.

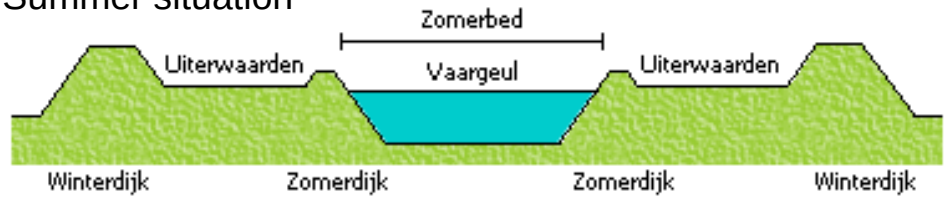


In de benedenloop van de rivier wordt het dal breder en de stroomsnelheid kleiner. Hierdoor heeft de rivier onvoldoende energie om het vervoerde materiaal verder te transporteren. De rivier vormt meanders en het materiaal zinkt selectief (afhankelijk van het gewicht) naar de bodem.

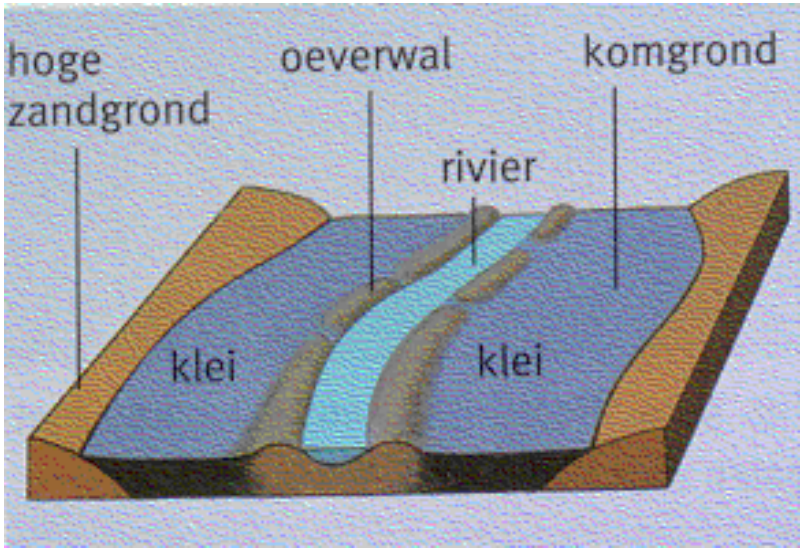
In de lente (tijdens de dooi) of na overvloedige neerslag gebeurt het dat de rivier in zijn benedenloop buiten de zomerbedding treedt en de winterbedding inneemt. Deze 'normale' overstromingen vormt een vruchtbare rivierpolder. In de overstroomde delen daalt de snelheid van het water. Het zwaardere materiaal (zand) bezinkt onmiddellijk aan de rand, het lichtere materiaal (klei) bezinkt verderaf (snelheid nog lager).

Section of a river valley with the broader **winter** bed (komgronden or uiterwaarden) and the smaller **summer** bed.

Summer situation



Winter situation



nl.wikipedia.org/wiki/Zomerbed

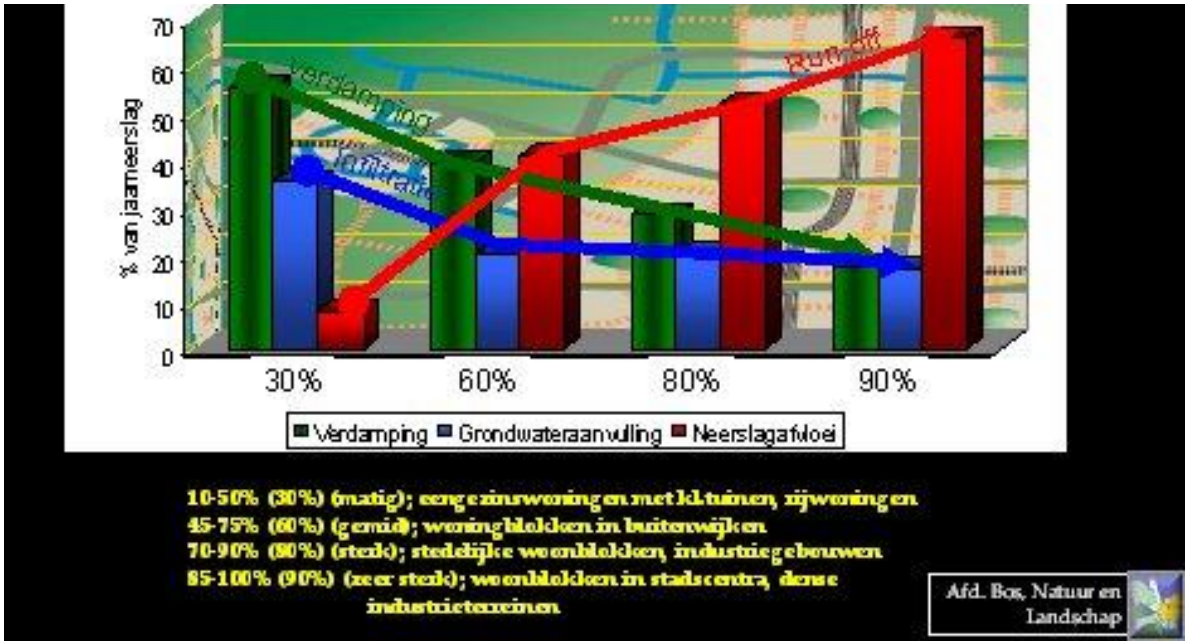
http://rivierklei.websitemaker.nl/rivierklei/1847578

www.aardkundigewaarden.nl/images/willem1.jpg

<u>Main urban causes</u>: Sealing surfaces with impermeable concrete, roofs, pavements, … causes increasing amounts of rainwater which can not infiltrate and which is mostly drained into mixed sewage systems.

Increasing RUN OFF, as more city- surface is impermeable.

Rural Urban



Sealing surfaces by urbanization exacerbates the run-off.

Each m² sealed surface is an obstacle for another **800 litres (in Flanders)** of rainwater per year.

Slovakian examples

Fig. 14 **Gigantic areas covered with impermeable materials** **in Slovakia**
On sunny days they become "hot islands" which transform most solar energy into sensible heat.

Fig. 15 **An asphalt road and a perfectly paved canal in a city environment**
Some solutions don't allow even the smallest amount of water to infiltrate the soil.

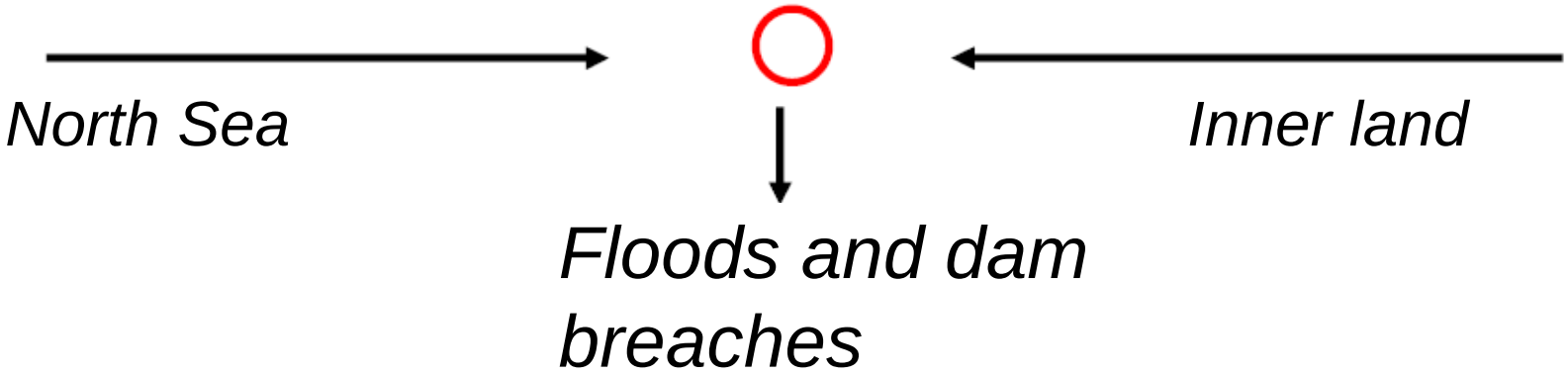
Conclusion: causes of Soil erosion and flooding (but also for LOCALLY rising temperatures, remember theme 6), all over Europe.

Main causes:

- Disappearance of the **rural** hydraulic roughness (sponge effect) of the rural areas. Deforestation, increasing agriculture
- Increasing **urban** impermeability for rain water of cities.

- As we have studied in theme 6, both causes have at the same time also serious consequences for the local temperature and heat distribution **(small water cycles !!)**

Continuous widening and straightening the rivers and brooks was dislocating the problems downstream in Europe , while the rising sea level complicates the drainage of river water from the inland to the sea



1976: B (Ruisbroek, *Rupel*)
1995: The Netherlands (*Maas* en *Rhine*)
1997: Poland, Germany, Czech republic (*Oder*, *Elbe*, *Morava*)
1998: B (lots of brooks and rivers)
2002: Austria, Germany (*Elbe*, Dresden) , CZ (*Moldau*, Praag)
2005: Romania – Alpine region.
2010: B (lots of brooks and rivers*, Dender),* Slovakia
2012/2013/**2014**: Great-Britain (all over the country)

To be continued ….

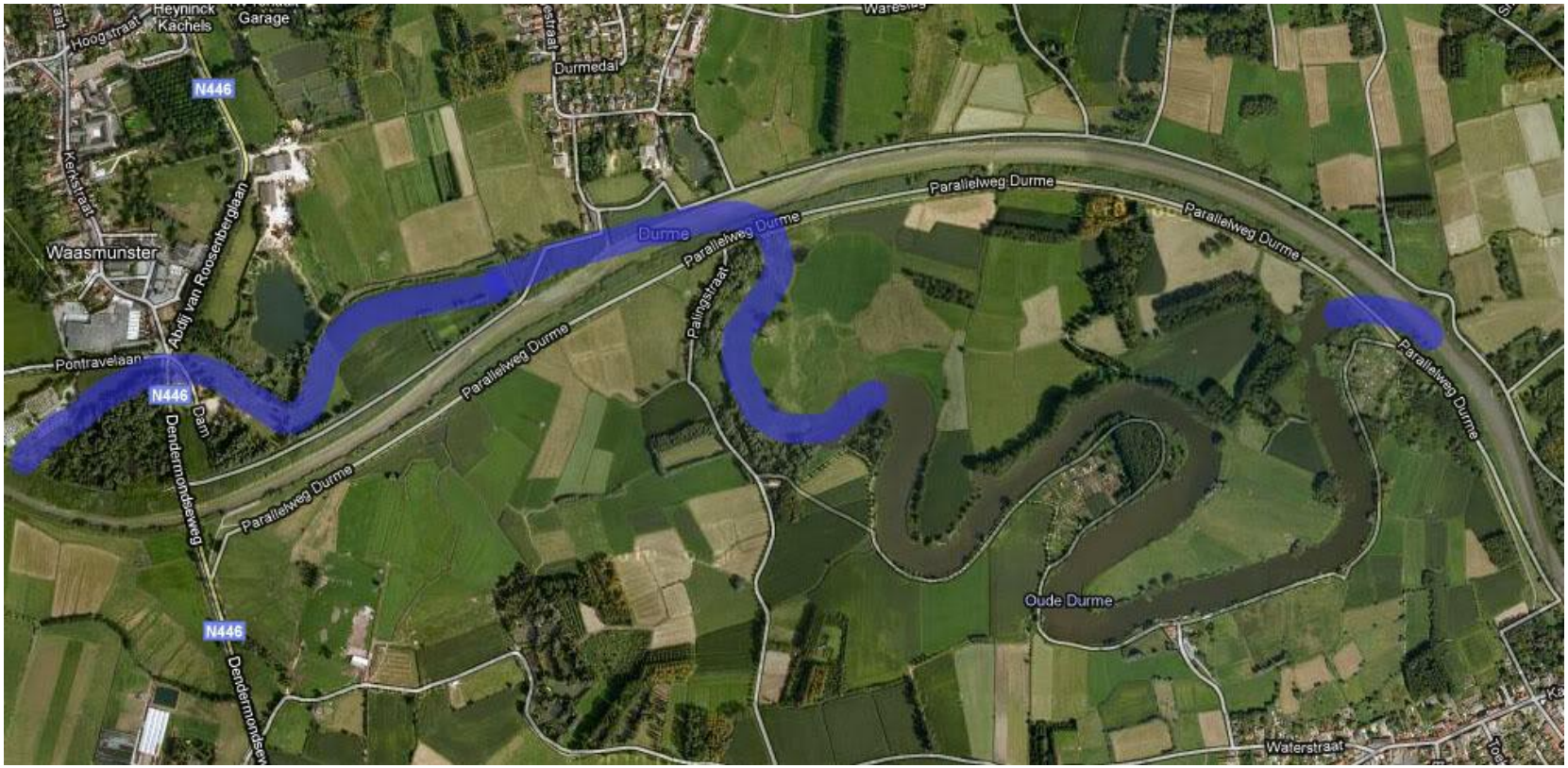
1976 (Ruisbroek, België)

Symptom Control by 'river standardization' programs: stream widening and straightening. (ecological 'law of conservation of misery'(1)).

The river Marck (B) is being '(AB)normalised'.

(1) The so-callled law of *conservation of misery* will occur every time when people try to solve the *symptoms* in stead of tackling the *causes* of the problem.

Straightened river Durme in the municipality Waasmunster (B) (in blue the former riverbed 'Old Durme')

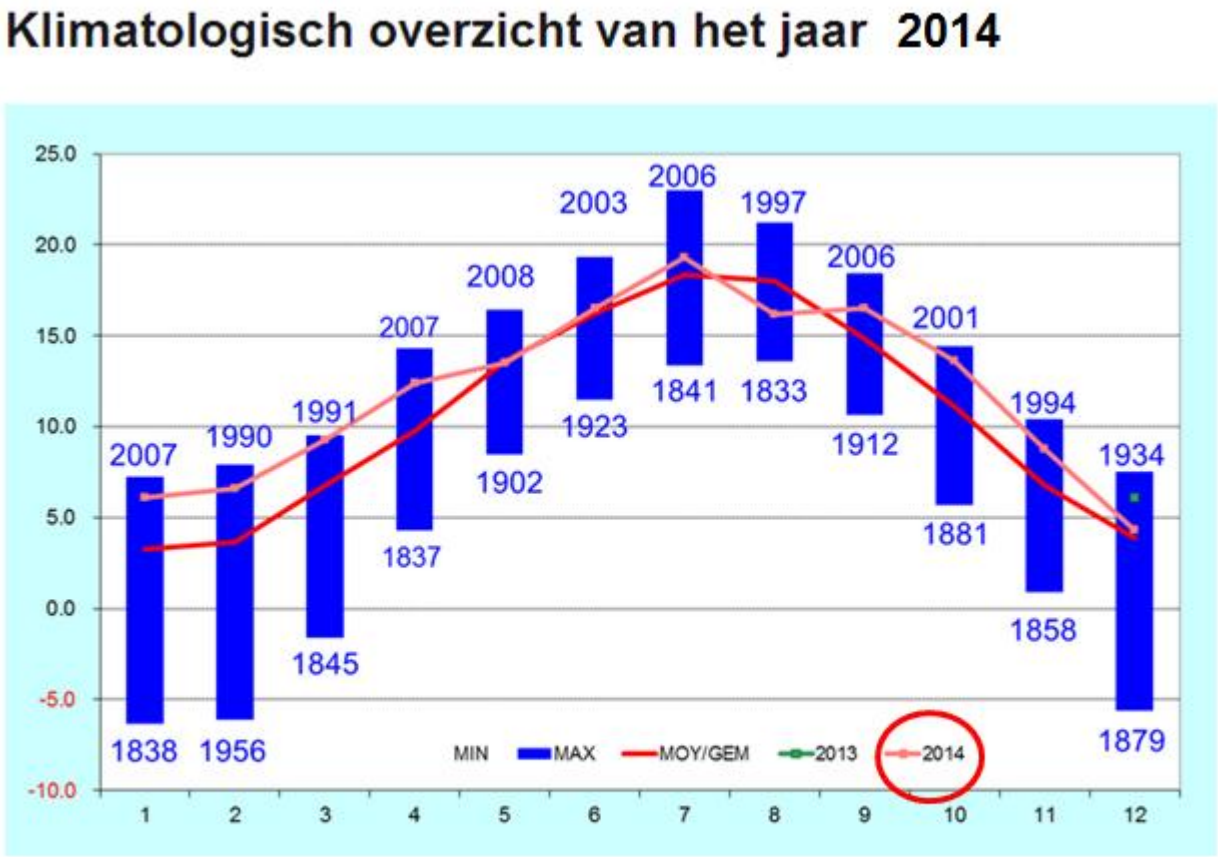


trobken.weebly.com/durme.html

The link of rural water management with local and global Climate change

- Climate change not only has its influence on global temperatures, but as a consequence also on global **precipitation** patterns.
- That is because the hotter the air, the more *absolute humidity* (water vapour) it can contain, but also because of the influence of human activities on the so-called small en large water cycles (see theme 6).

The hottest year since the observations (1833) in Belgium was 2014. (http://www.kmi.be/meteo/view/nl/1088480-Jaarlijkse+grafieken.html)



Temperatuur : Maandelijks gemiddelde van de luchttemperatuur te Ukkel (België) (°C) Normalen (1981-2010) en absolute uitersten vanaf 1833

Watch: http://www.climatecentral.org/blogs/131-years-of-global-warming-in-26-seconds/

The relation between global climate change and water management in Europe.

- See level rising (currently ca 3,5 à 4 mm/ year) is influencing the discharge of fresh river water into the see.
- Climatologists are predicting for this region in Western Europe:

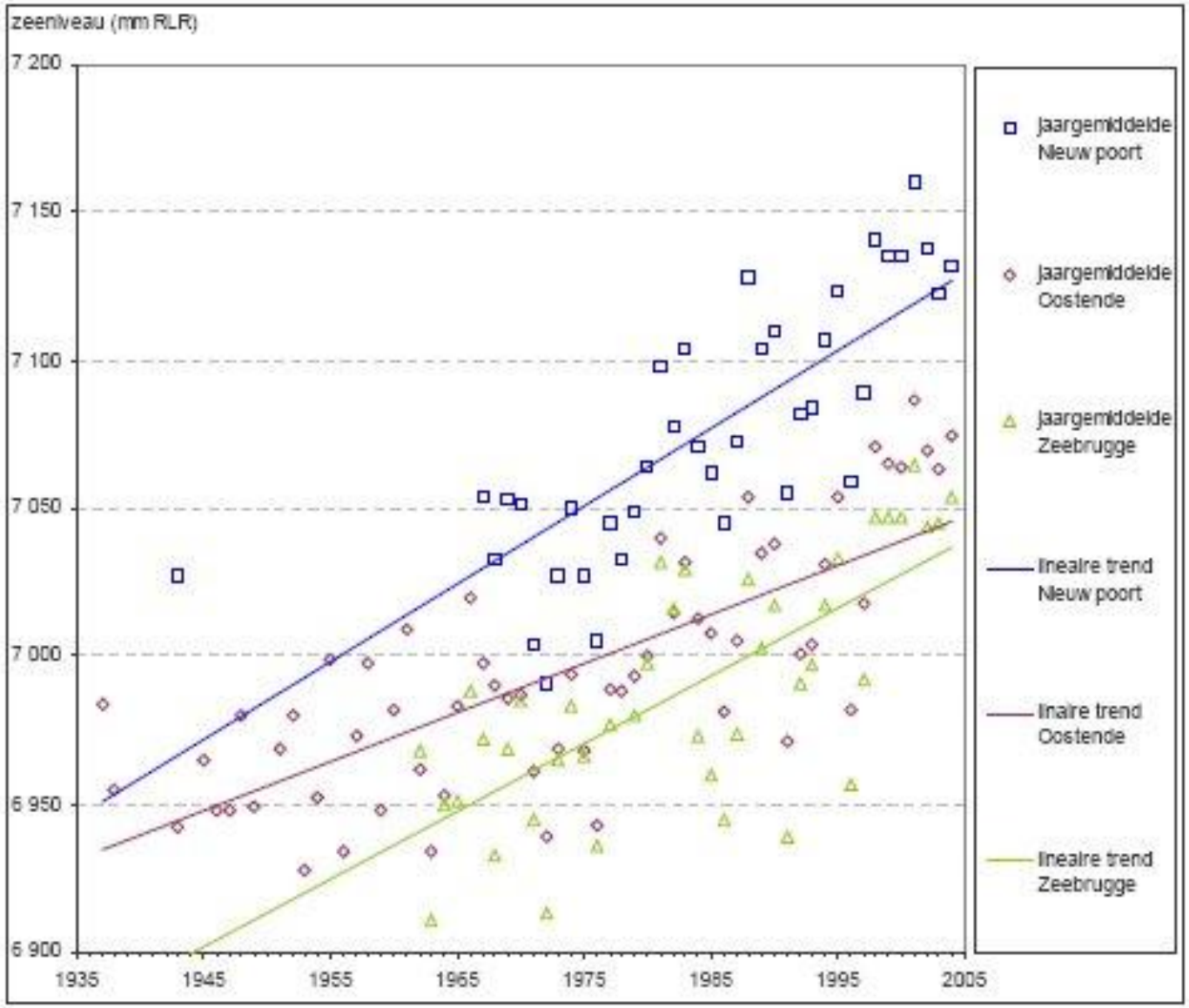
  -30 % more precipitation in winter (!)

  -the same amount of summer precipitation, but with longer periods of drought and more summer thunder storms and flooding risks.
- Desertification is expected in the Mediterranean region, and a lot more precipitation in Scandinavia.

See level rising in Belgium.

(currently
3,5 à 4 mm/year)

Figuur 63: Evolutie zeeniveau aan de Belgische kust (Oostende, 1937-2004; Nieuwpoort, 1943-2004; Zeebrugge, 1962-2004)



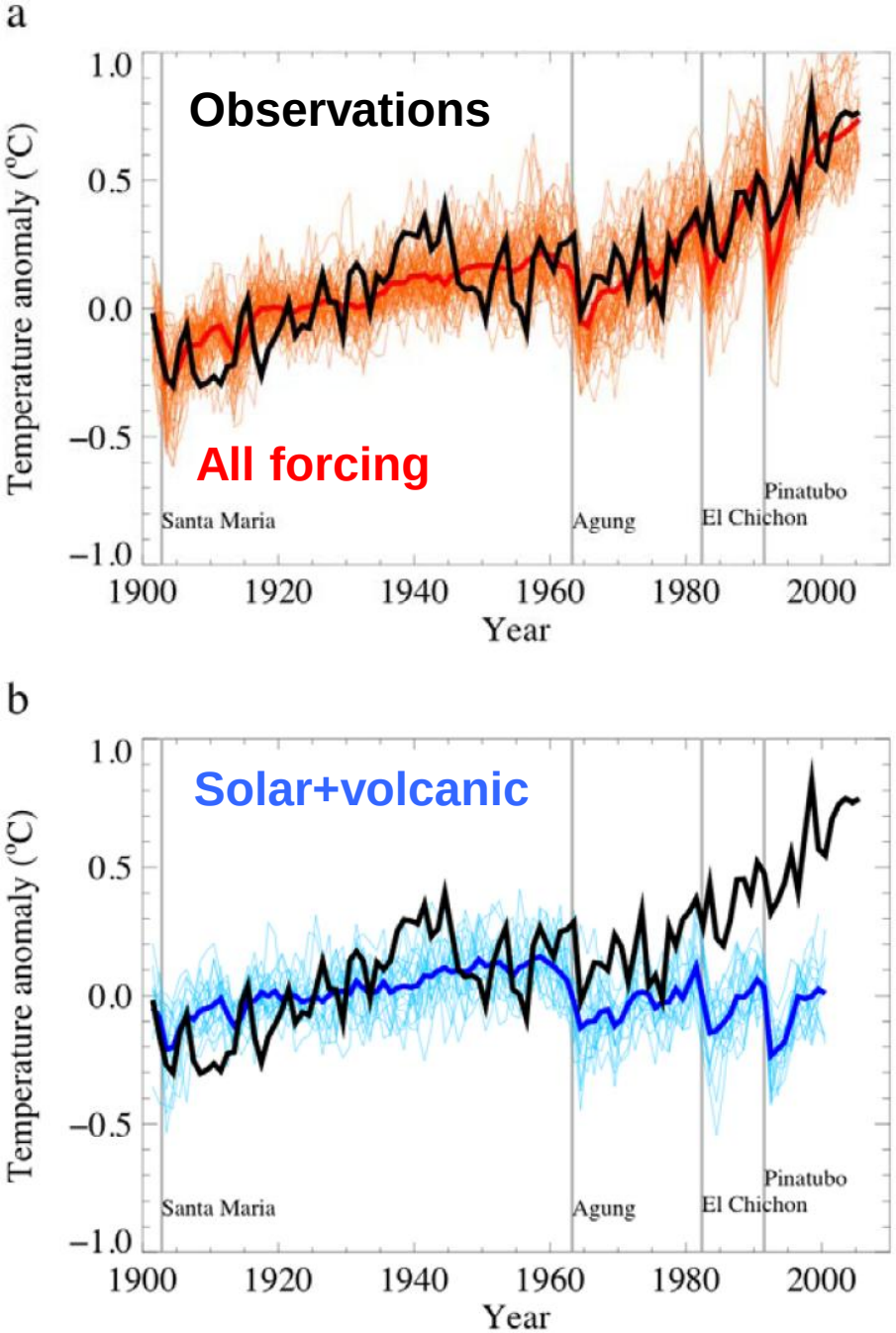
Het zeeniveau wordt uitgedrukt in mm RLR (Revised Local Reference). Daarbij zijn de data van een lokale referentie omgezet t.a.v. het internationaal refentieniveau.

Bron: VMM op basis van Afdeling Kust en PSMSL (2005).

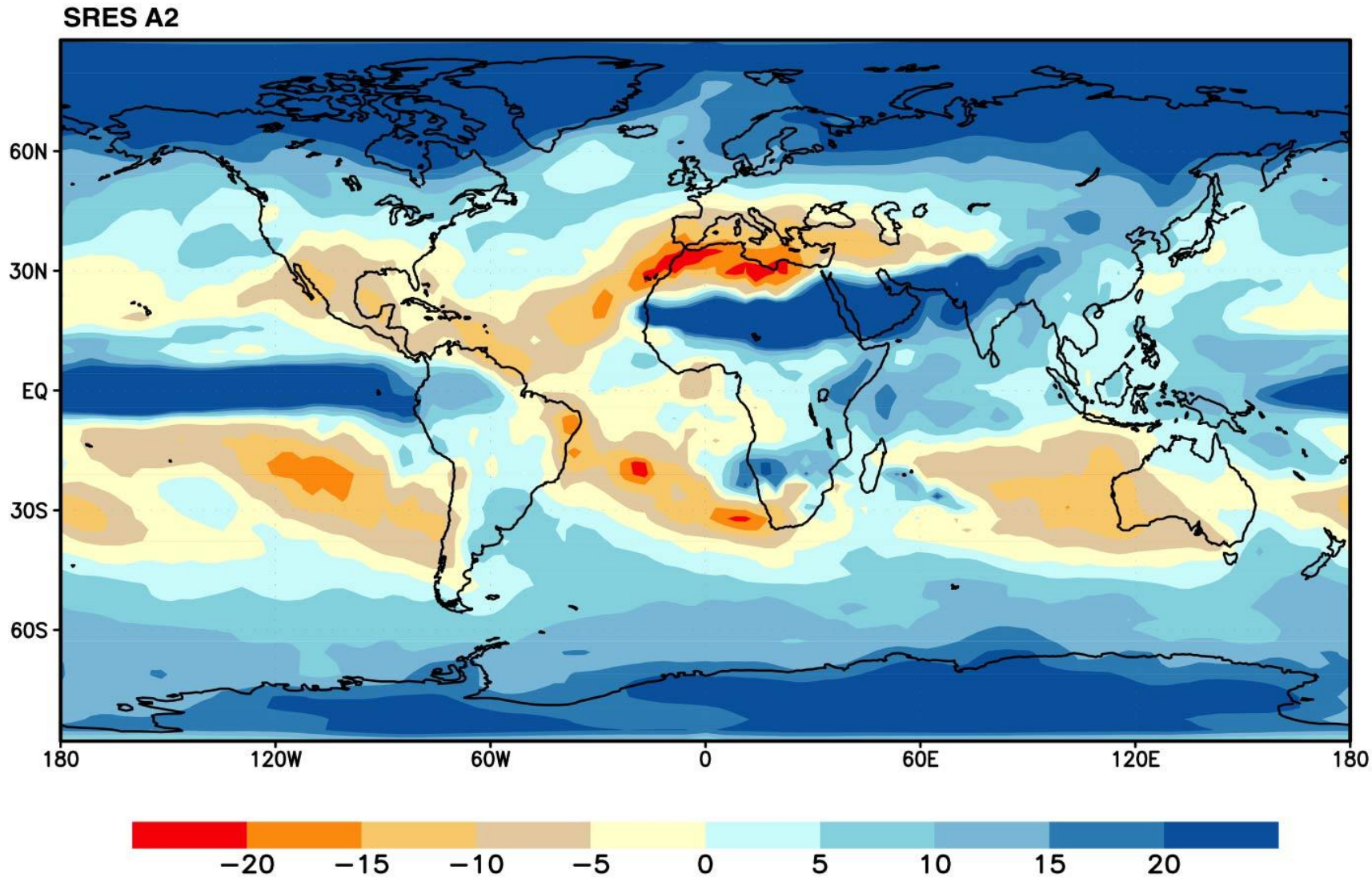
Human Attribution to global climate change

(from Van Ypersele, 2011)

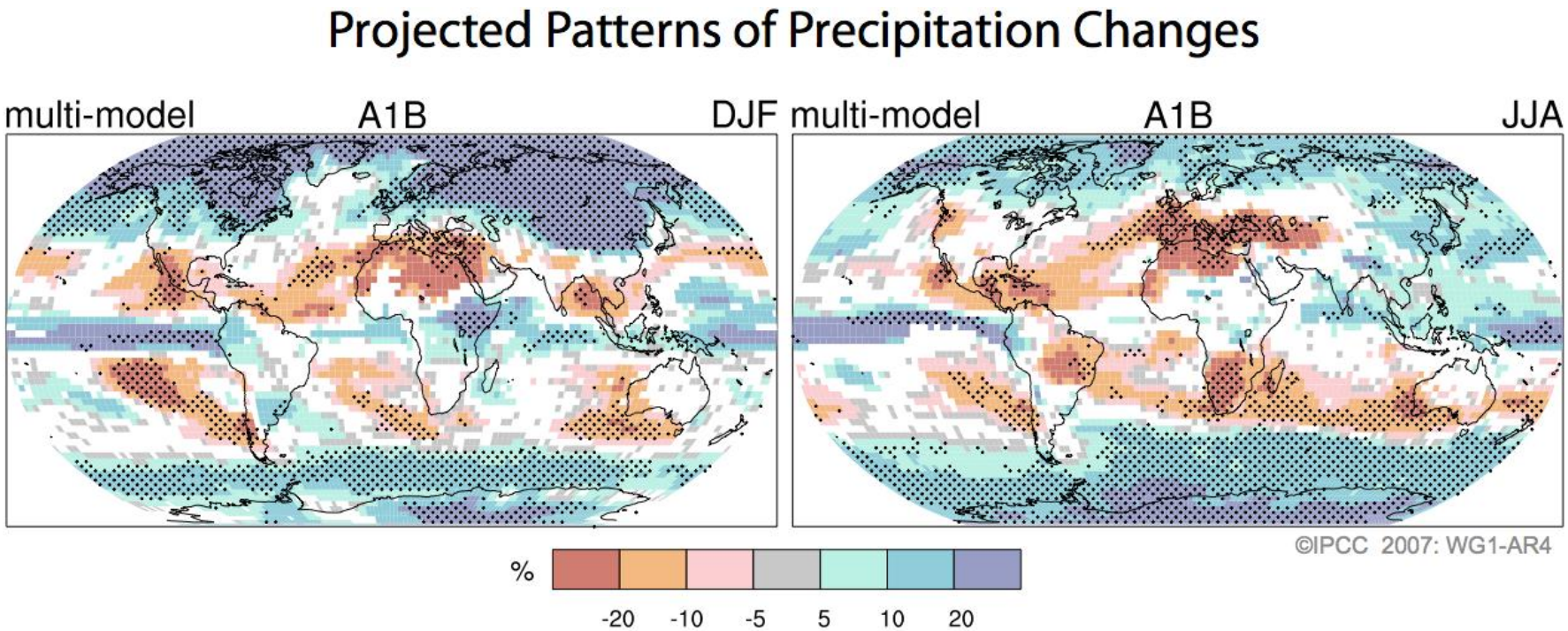
Simulations with natural factors only (blue) are unable to reproduce observed global temperature trends after 1960. When in simulations natural + human factors are taken into account, reproduction of observed data is possible (red).



(from Van Ypersele, 2011) Precipitation changes in 2080: results from one climate model for scenario A2



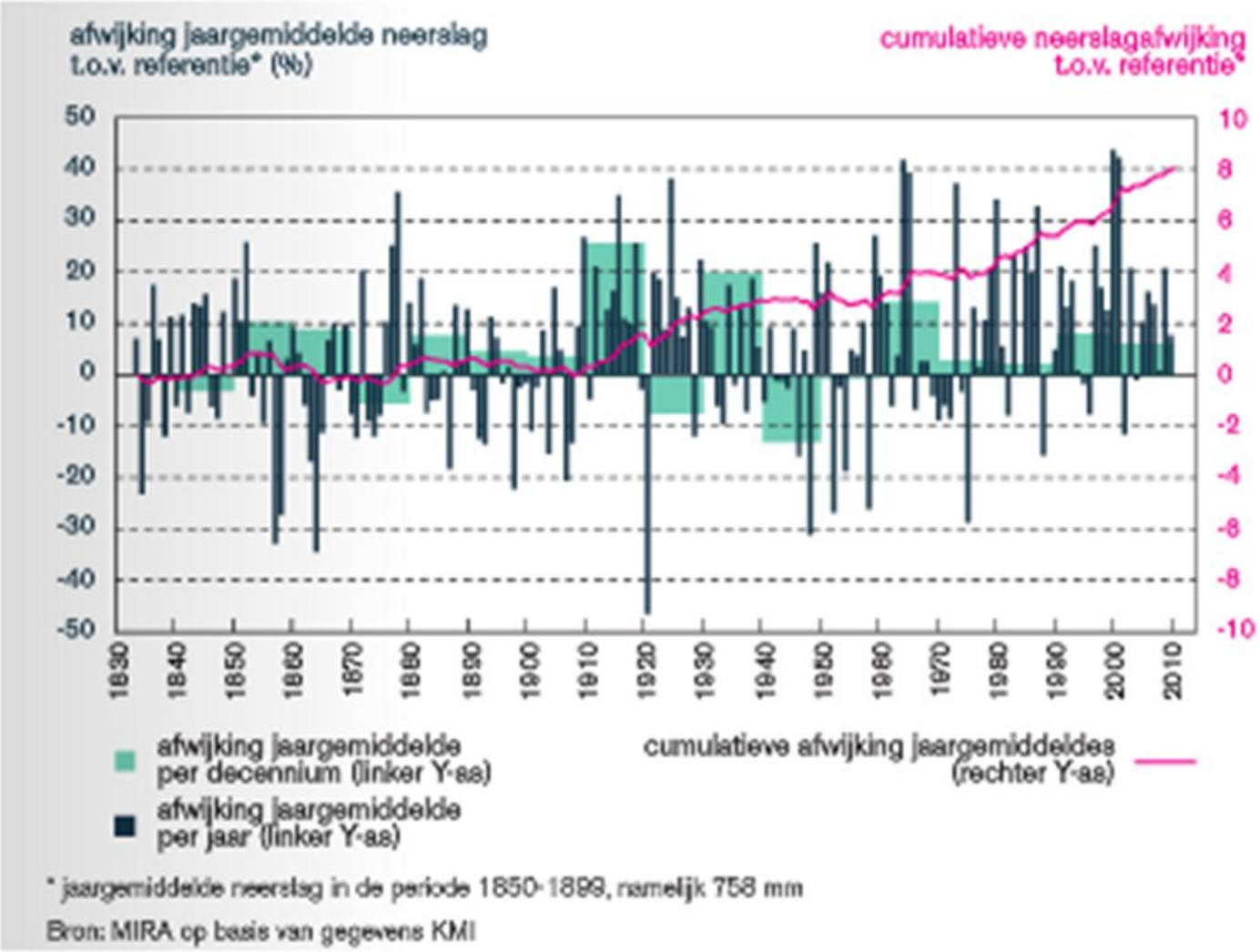
Projections of Future Changes in Climate (from Van Ypersele , 2011)



Changes are plotted only where more than 66% of the models agree on the sign of the change. The stippling indicates areas where more than 90% of the models agree on the sign of the change

Brand new in AR4: Drying in much of the subtropics, more rain in higher latitudes, continuing the broad pattern of rainfall changes already observed.

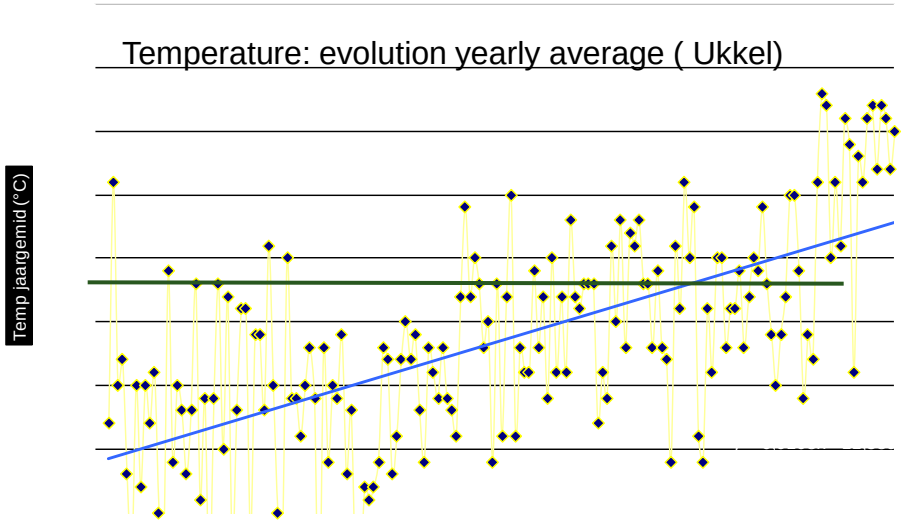
Precipitation data for Brussels 1833-2012 (Mira, 2012)



http://www.milieurapport.be/mira_mira_indicatorrapport_2012/magazine.html#/spreadview/94/

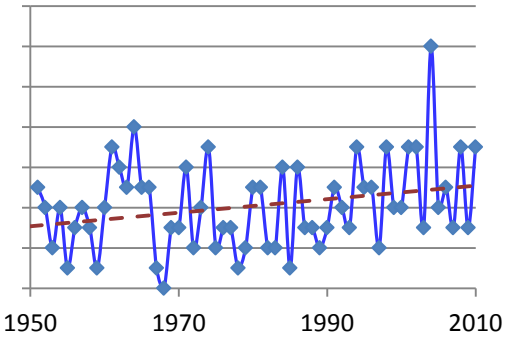
So, providing and restoring more floodable areas in river valleys is also necessary because of macro-climatological reasons (global change), in rural planning.

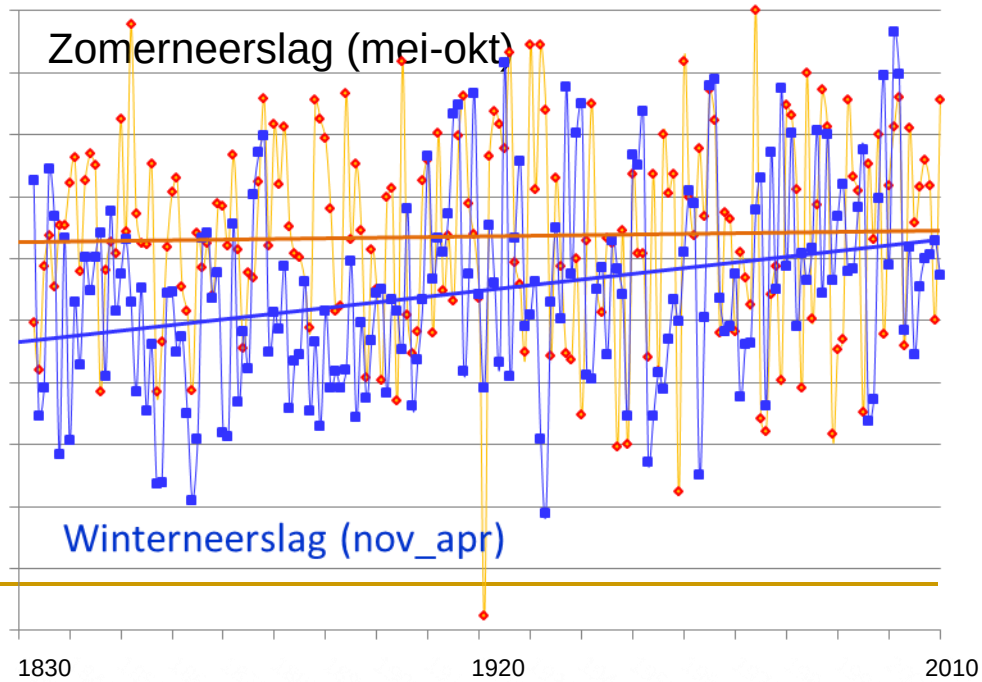
9,8°C (average: 1961-90) ⟷ 11°C (average: 2000-05)



→ temp.↑

- Precipitation softly increasing , but more extremes & intensity↑
- Consequences ?

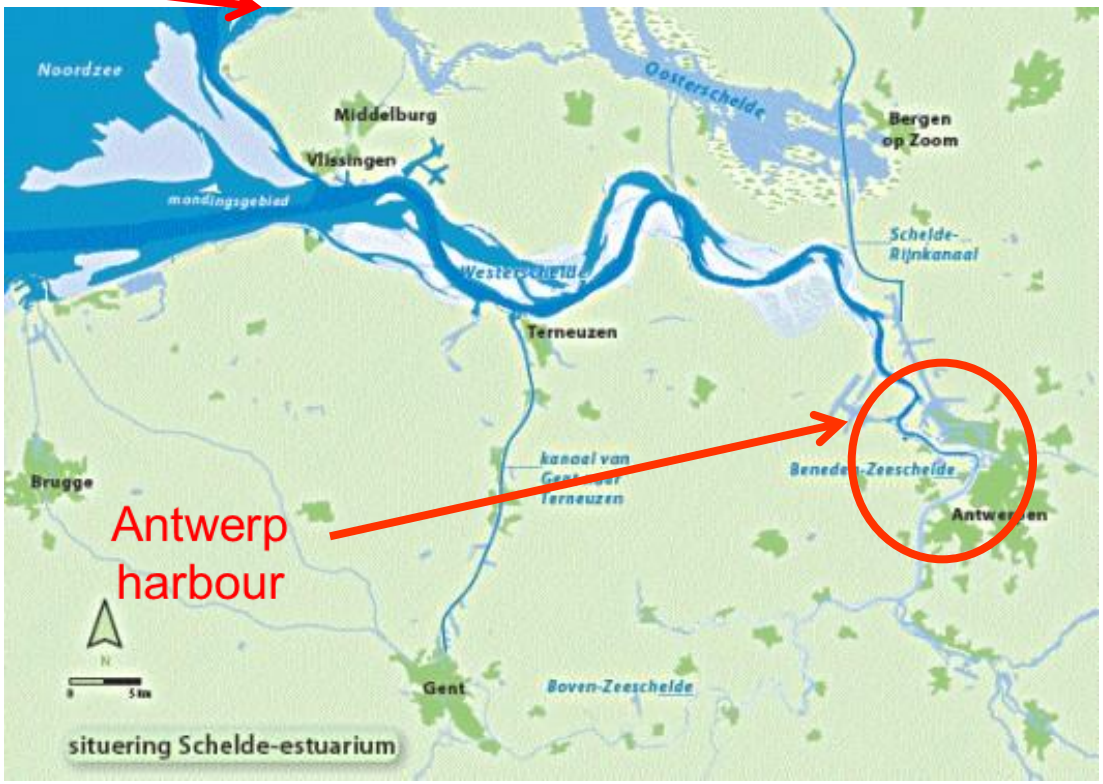




days with precipitation ≥ 20,0 mm ↑

The Belgian River ‘**Scheldt**’ as a case.

There has been a lot of dredging in the Scheldt, to make it navigable for large ships to Antwerp harbour (more than 80 km from the Northsea)



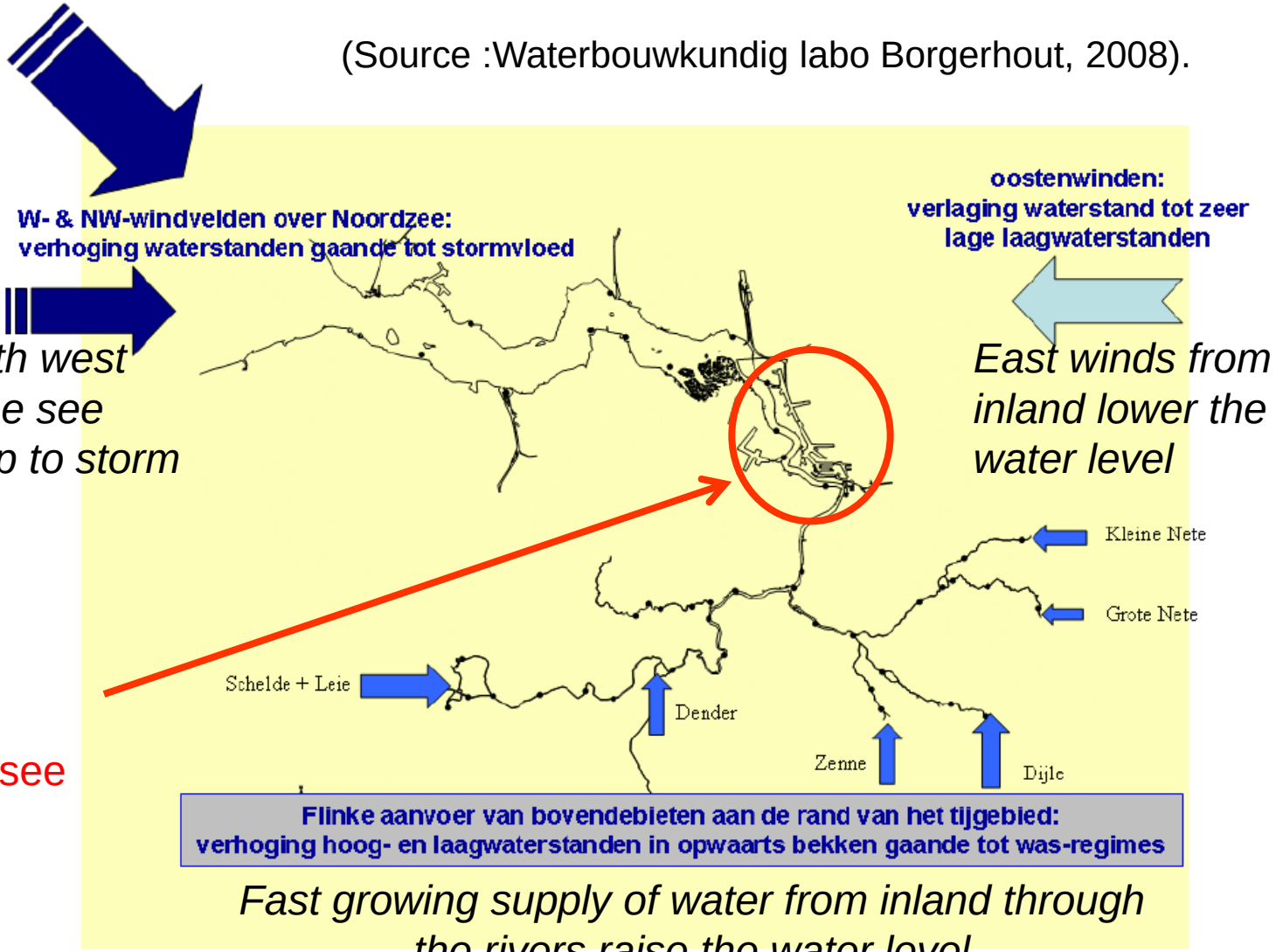
G: Gent / A: Antwerpen

http://www.psmarine.nl/nieuws/?page=overzicht&id=94

http://pro.vnsc.eu/kaarten

The Belgian River ‘**Scheldt**’ as a case.

(Source :Waterbouwkundig labo Borgerhout, 2008).



West and north west winds raise the see water level (up to storm water)

East winds from inland lower the water level

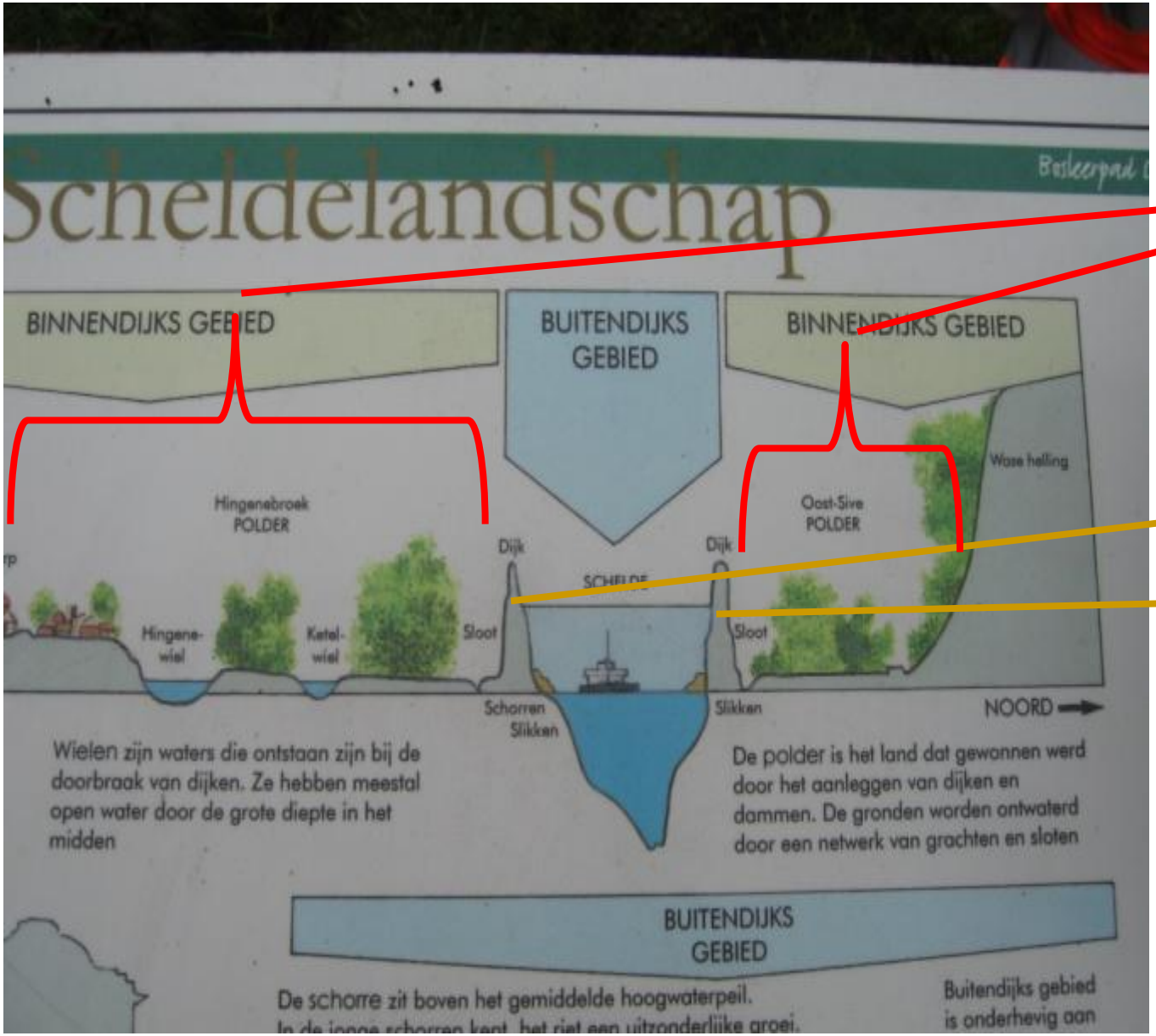
Antwerp harbour 80 km from see

Fast growing supply of water from inland through the rivers raise the water level

Figuur 1 - Zeescheldebekken:
algemeen liggingsplan met schetsmatige aanduiding van de grootste tij-beïnvloedende componenten

In the years 1980 of the 20e century: strengthening the summer dikes and making them higher (e.g. first version of the Belgian Sigma plan).

- *Principle*: see course.
- *Consequences*: increasing water levels between the summer dikes. The former winter beds of the river are occupied by all kinds of activities: dwellings, industry, recreation, ….
- Risk of breakage of the summer dikes is increasing.



Increased flood risks in the winter bed

Summer dikes are built higher

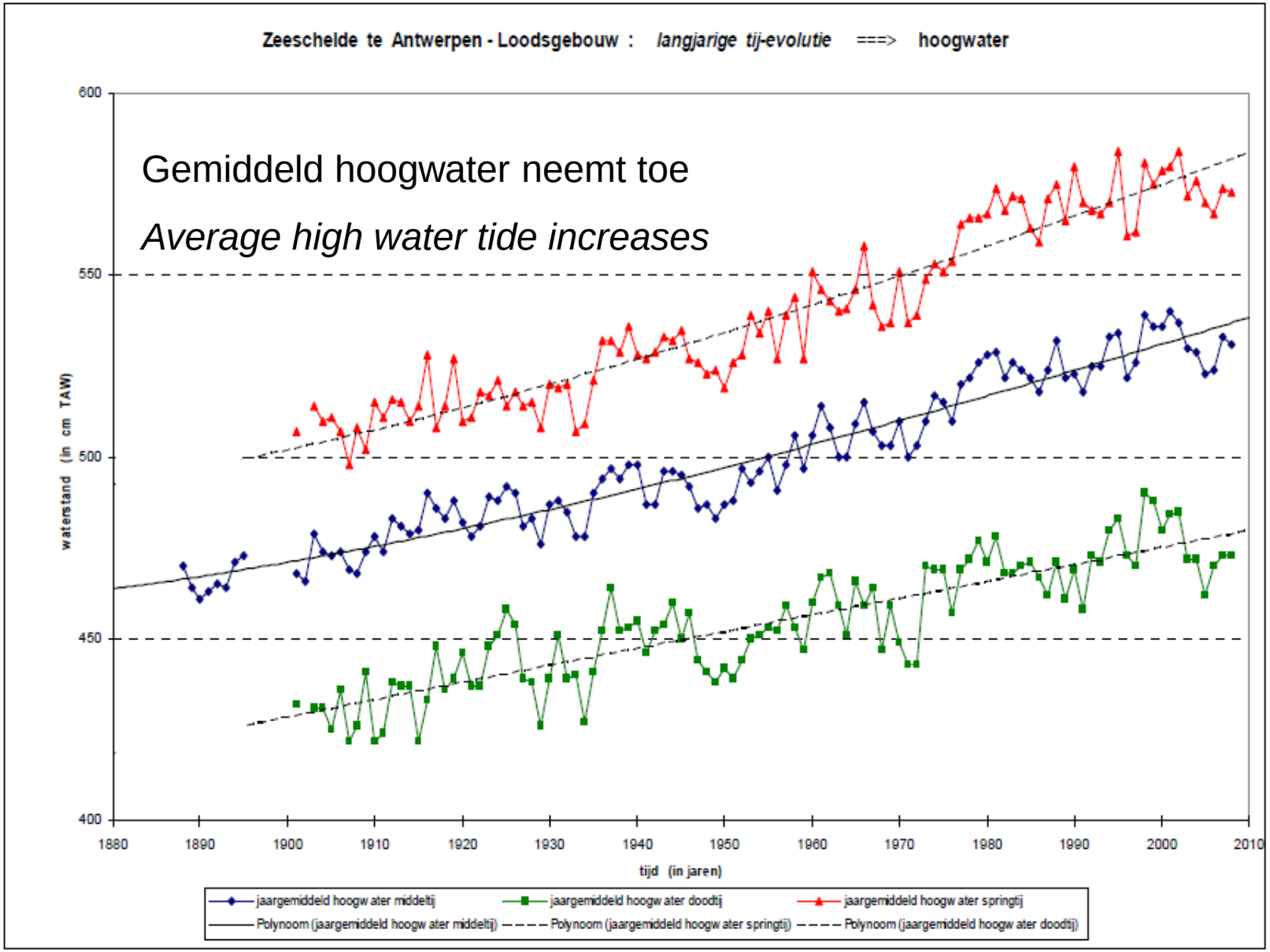
Bornem (B). Sandwiching the river Scheldt between the summer dikes, means increasing the risks of flooding in the winter bed.

Bornem (B): Summer bed of the River *Scheldt .*

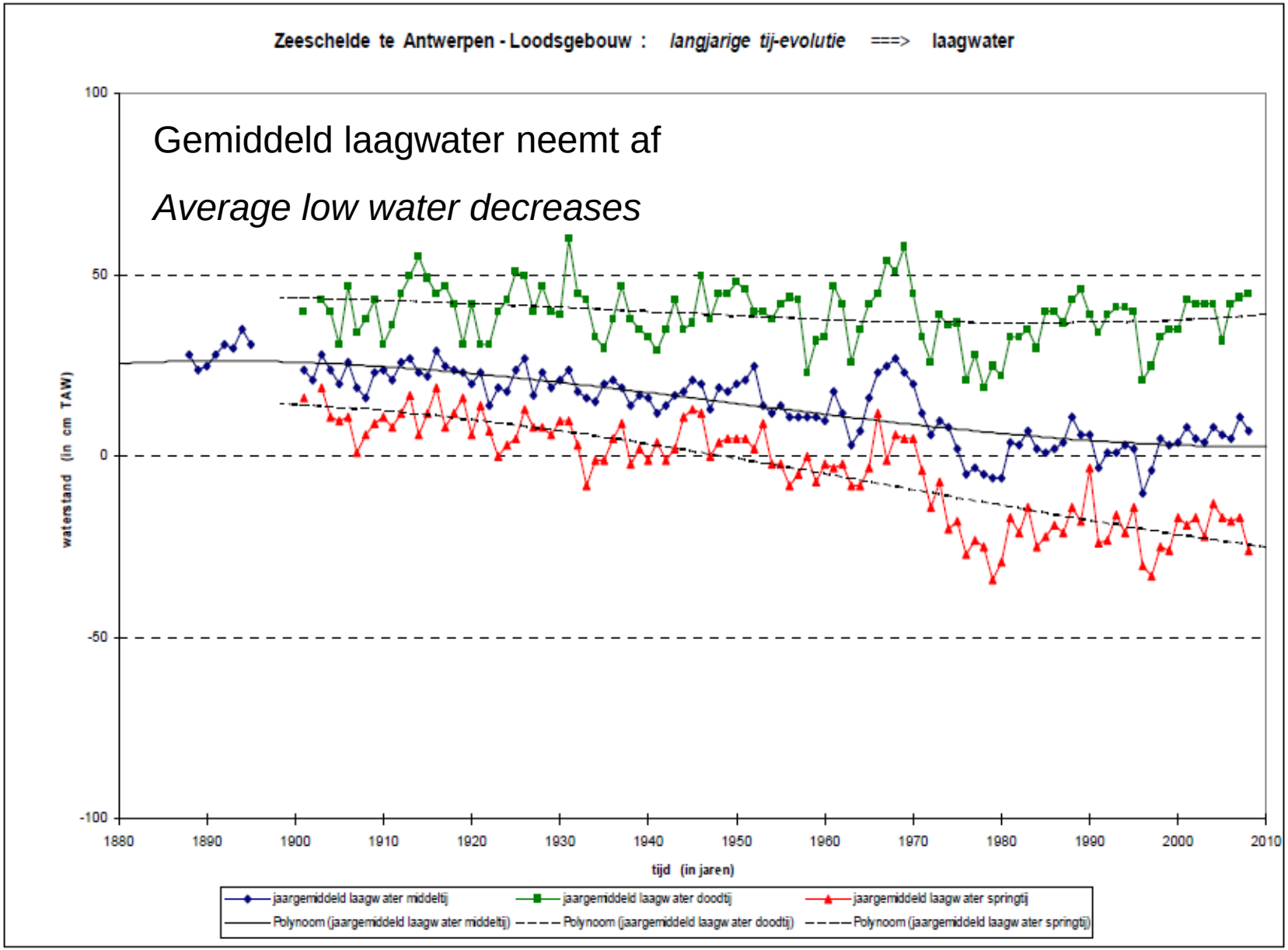
Deposition of eroded loam and sand material **reduces** the ability of **storing water volumes** in the summer bed.

Especially the lower parts of the river fill up with **sludge**, which is provoking more flooding risks.

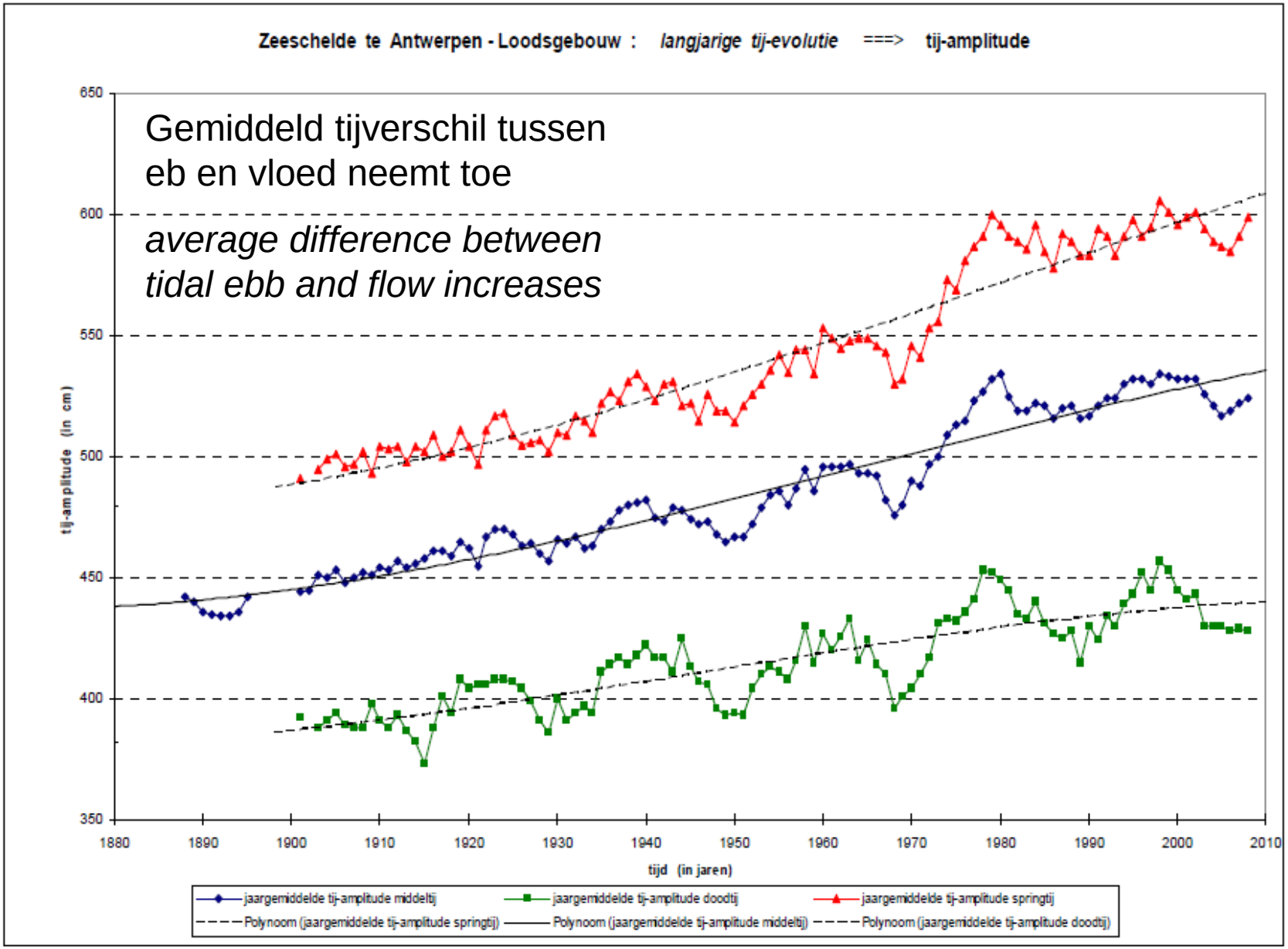
Moreover, the **flood current** is penetrating faster and deeper inland, as a consequence of the dredging (allowing not only bigger ships into the Scheldt, but more water too !)



Figuur 18 - Zeeschelde te Antwerpen-Loodsgebouw: "eeuw"-evolutie jaargemiddelden van hoogwater (1885-2008)

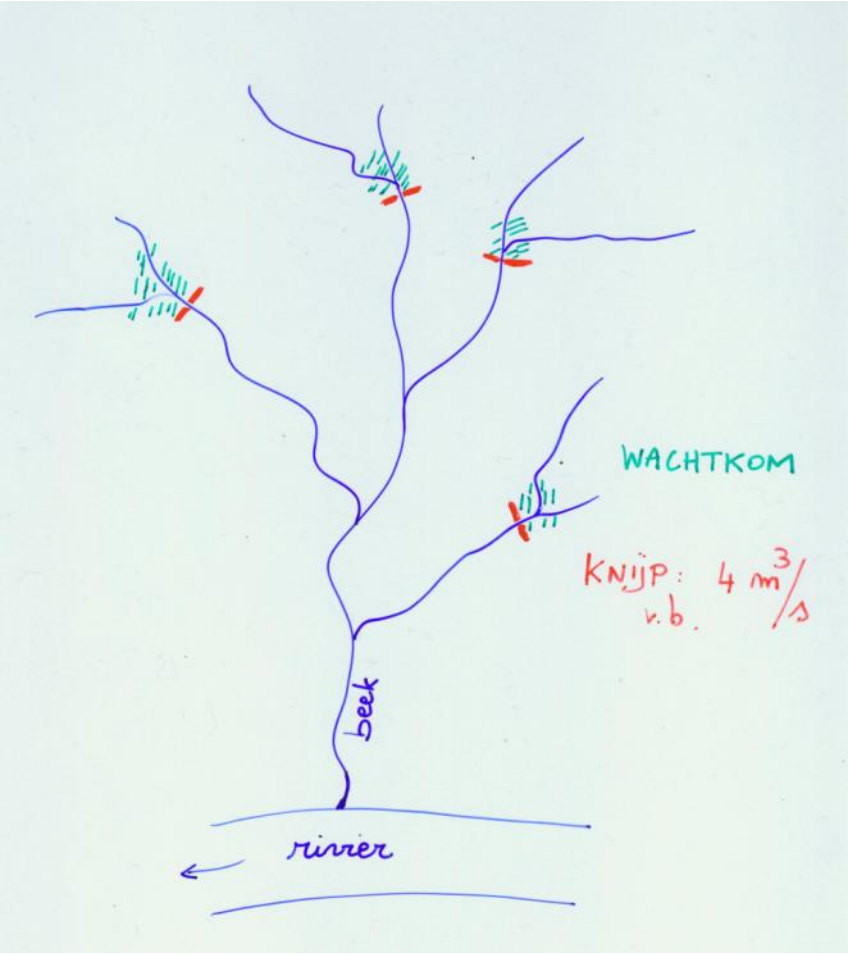


Figuur 19 - Zeeschelde te Antwerpen-Loodsgebouw: "eeuw"-evolutie jaargemiddelden van laagwater (1885-2008)



Figuur 20 - Zeeschelde te Antwerpen-Loodsgebouw: "eeuw"-evolutie jaargemiddelden van tij-verschillen (1885-2008)

In the years 1990 of the 20e century: construction of water storage reservoirs ('temporary water storing basins')



- *Principle*: see course
- *Consequences*: By decreasing the flow of riverwater within the storage reservoirs, sludge sedimentation occurs with strong concentrations of minerals (manure, eutrophication).

Hoegaarden (B). Building a dam across the stream, with a narrow passage structure is needed to create a temporary storage basin.
Remark the sludge sedimentation already after using the basin just a few times.

conclusion: once more, it is better to tackle the causes than focusing on the consequences.

Thus:

- Restoring the hydraulic roughness of landscapes again (management agreements with farmers, European agricultural policy, see theme 8).
- Restoring water permeability of urban areas, see theme 7.
- Spatial arrangements in the floodable winter beds of rivers, giving them back to the rivers where possible.

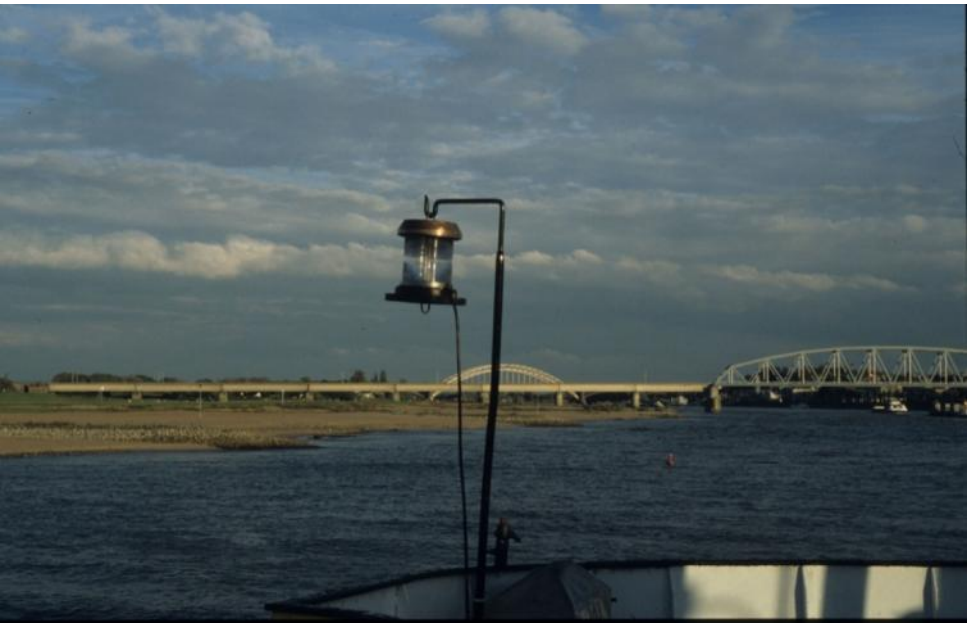
The law of conservation of misery will occur every time when people try to solve the *symptoms* in stead of tackling the *causes* of the problem.

Grants (financial support) to famers, to keep the landscape hydraulically rough:

- saves money downstream (dikes, damaging floods, …)
- is an advantage for ecology (horizontal ecological relations, theme 8)
- is an advantage for recreation

- is possible with financial support of the European union, as has been explained in theme 8 (management agreements) within the frame of the common agricultural policy, especially in **COUNCIL REGULATION (EC) No 1257/1999 of 17 May 1999 on support for rural development from the European Agricultural Guidance and Guarantee Fund (EAGGF) and amending and repealing certain Regulations** (Detailed in Regulation 1750/1999 dated. 23 July 1999) **.**

An inspiring example: The Dutch ‘plan black stork (zwarte ooievaar)’. Restoring blue green networks along the river **Rhine**.



De Millingerwaard (close by the city of Nijmegen). First phase. Strengthening the winter dikes of the **Waal (Rhine).**

Phase 2: the excavation of summer dikes, making the winter bed floodable again.

The patterns in the winter bed are constructed in combination with small-scale extraction of sand, gravel and clay.

Kleiwinning

Door het afgraven van de klei verandert de Millingerwaard in een plassengebied met bossen, moerassen en natte graslanden. De steenovens in de waard zelf zijn inmiddels gesloten, maar de afgravingen gaan nog steeds door. De klei gaat nu naar fabrieken elders in het rivierengebied en u zult regelmatig vrachtwagens het gebied uit zien rijden. Iedere vrachtwagen, die het gebied verlaat, betekent in feite dat er weer een stukje natuur bijkomt. Rond het jaar 2000 zal zo het totale natuurgebied zijn ingericht.

In the abandoned clay pits, the process of natural succession (see theme 8) to marsh vegetation starting from open water, begins.

Millingerwaard (Millingen,Nijmegen, NL): Why there has been digging ?.

For bricks, for nature, for recreation, for water and safety against flooding

There has been chosen for '*extensive grazing*' and '*restoring natural flooding*' as processes, in order to restore a nature rich wetland. (because **process** dominates **pattern** (see Van Leeuwen, theme 4).

Patterns are the result of natural processes. The landscape values and biodiversity are high again: river dunes and floodplain forests are restored along the river Waal (Rhine).

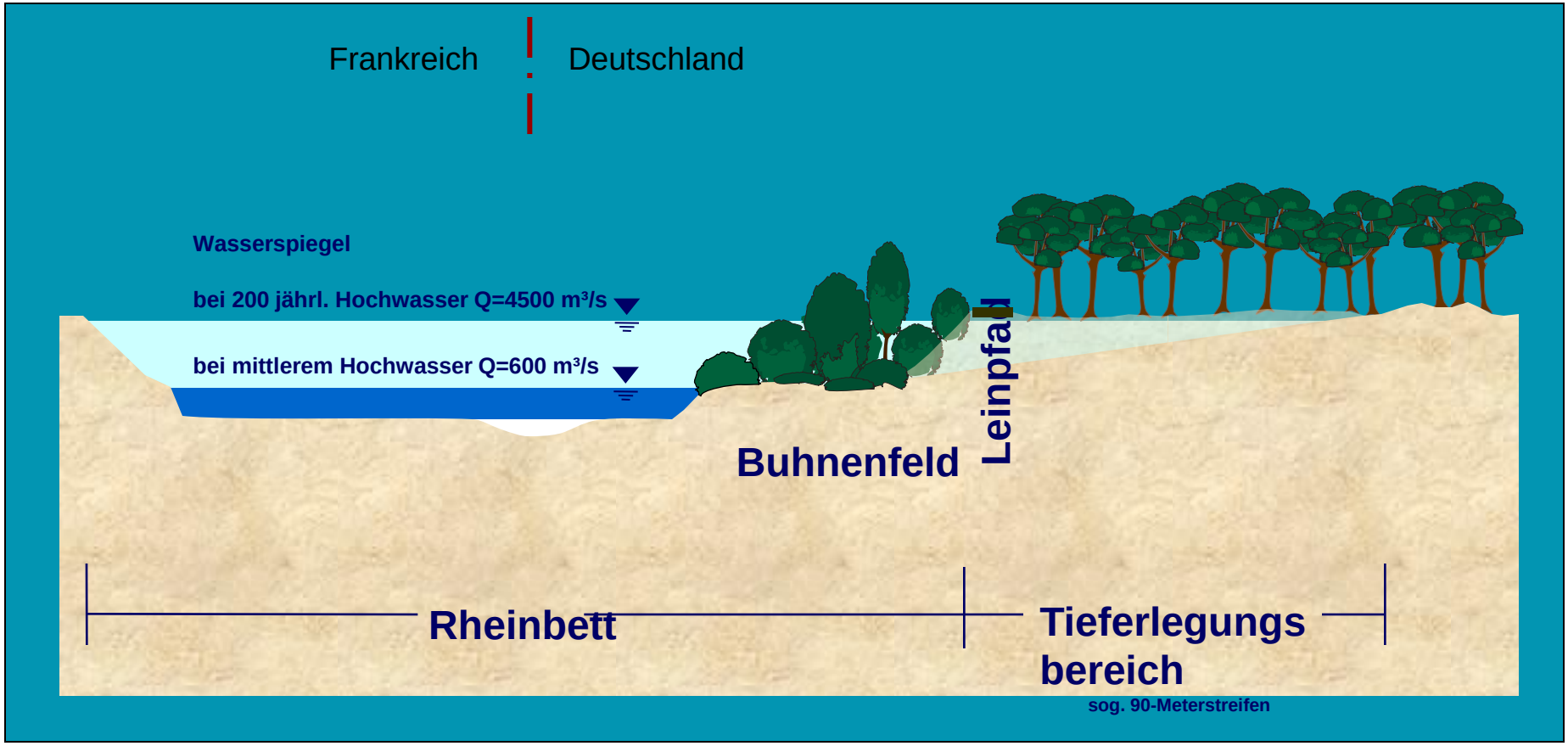
Ooibossen en rivierduinen

De Millingerwaard was eeuwenlang een vrijwel boomloze polder. Door de afgraving van klei en zand is deze uiterwaard inmiddels veranderd in een waterrijk natuurgebied. Het oorspronkelijke ooibos keerde terug en bedekt nu al grote delen van de Millingerwaard.

Langs de rivieroevers stuift het zand vanaf de brede stranden op tot metershoge duinen, de hoogste levende rivierduinen van Nederland.

Tijdens hoog water verandert de Millingerwaard in een binnenzee, met nog slechts enkele eilandjes. Het verschil tussen de hoogste en laagste rivierwaterstanden bedraagt bijna tien meter! Een goede afvoer van het hoogwater ontstaat door het graven van een lengtegeul tussen bos en rivierduin.

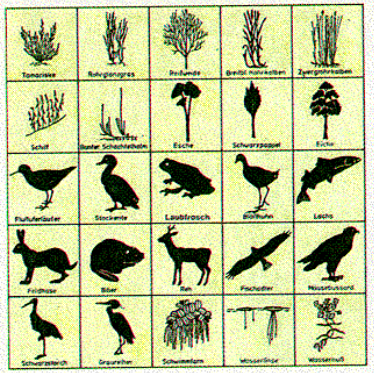
Similar initiatives are taken along the **Rhine** in the border region between France and Germany (region of Freiburg im Breisgau).



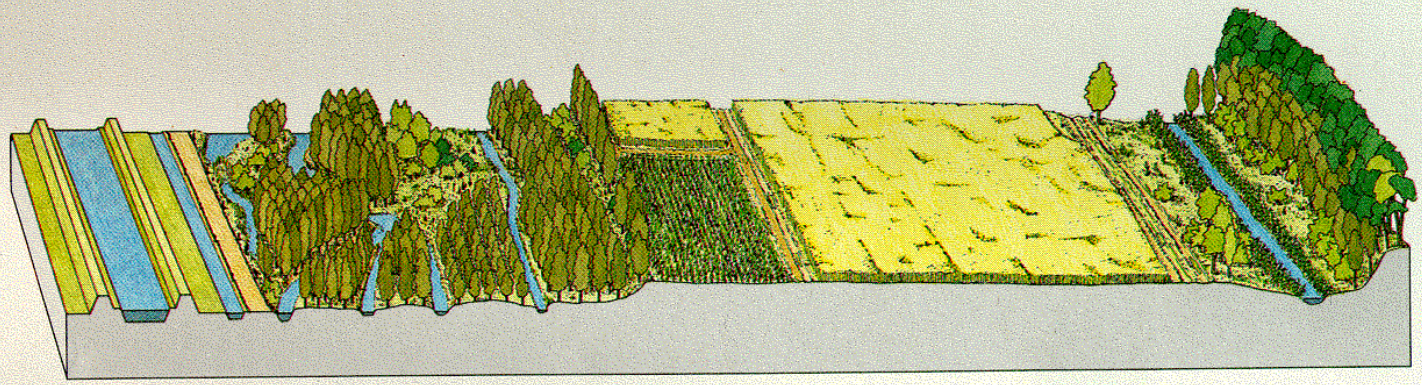
Former flood plain areas of the **Rhine** are now occupied by intensive agriculture and other functions, losing biodiversity and losing floodable areas. (Veränderung des Lebensraumes Aue)

Ursprünglicher Zustand Original situation

©Gerken 1988

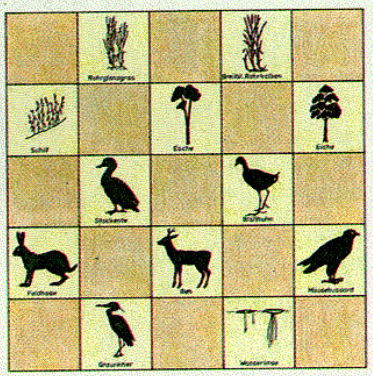


©LfU 1992



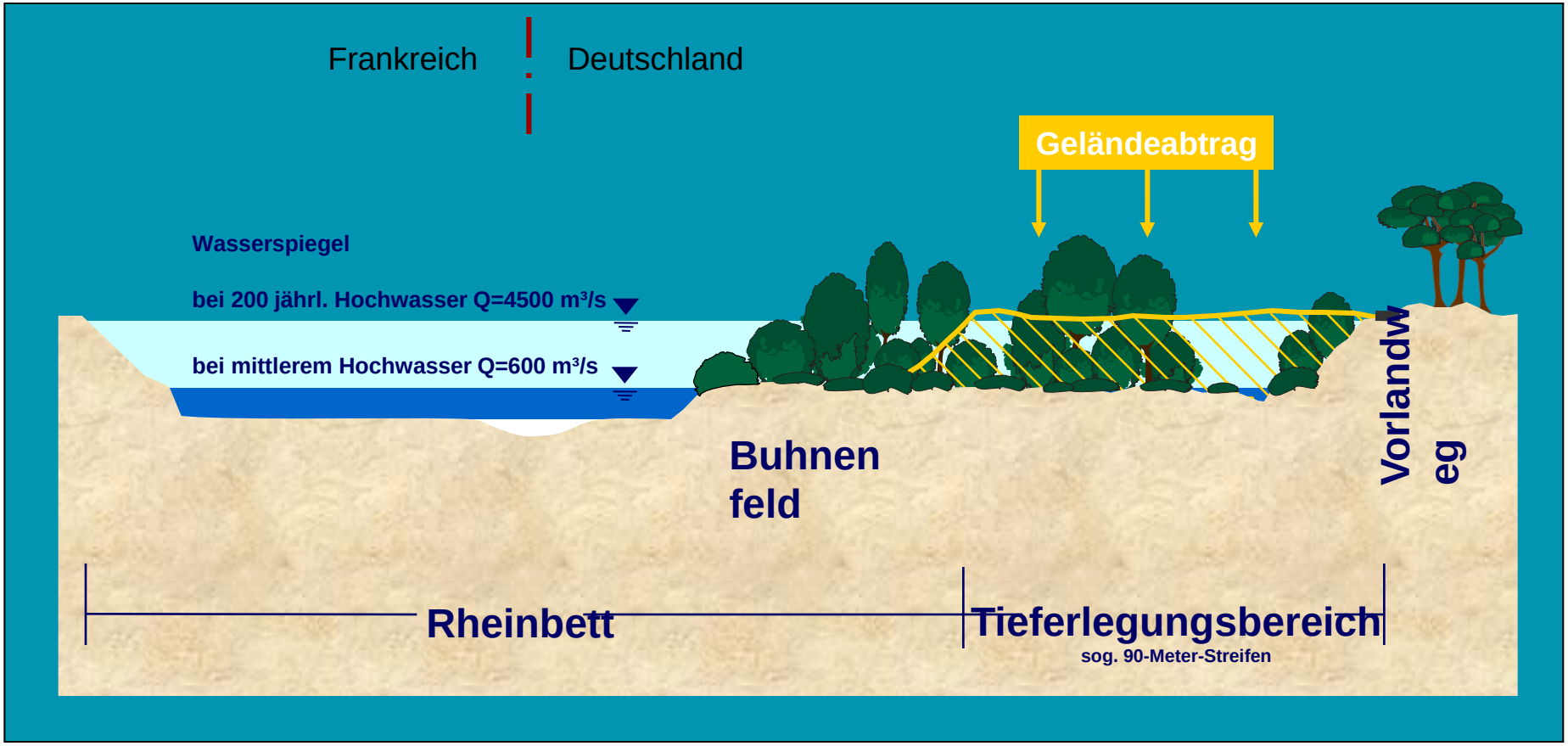
Heutiger Zustand am ausgebauten Rhein Situation today

©Gerken 1988

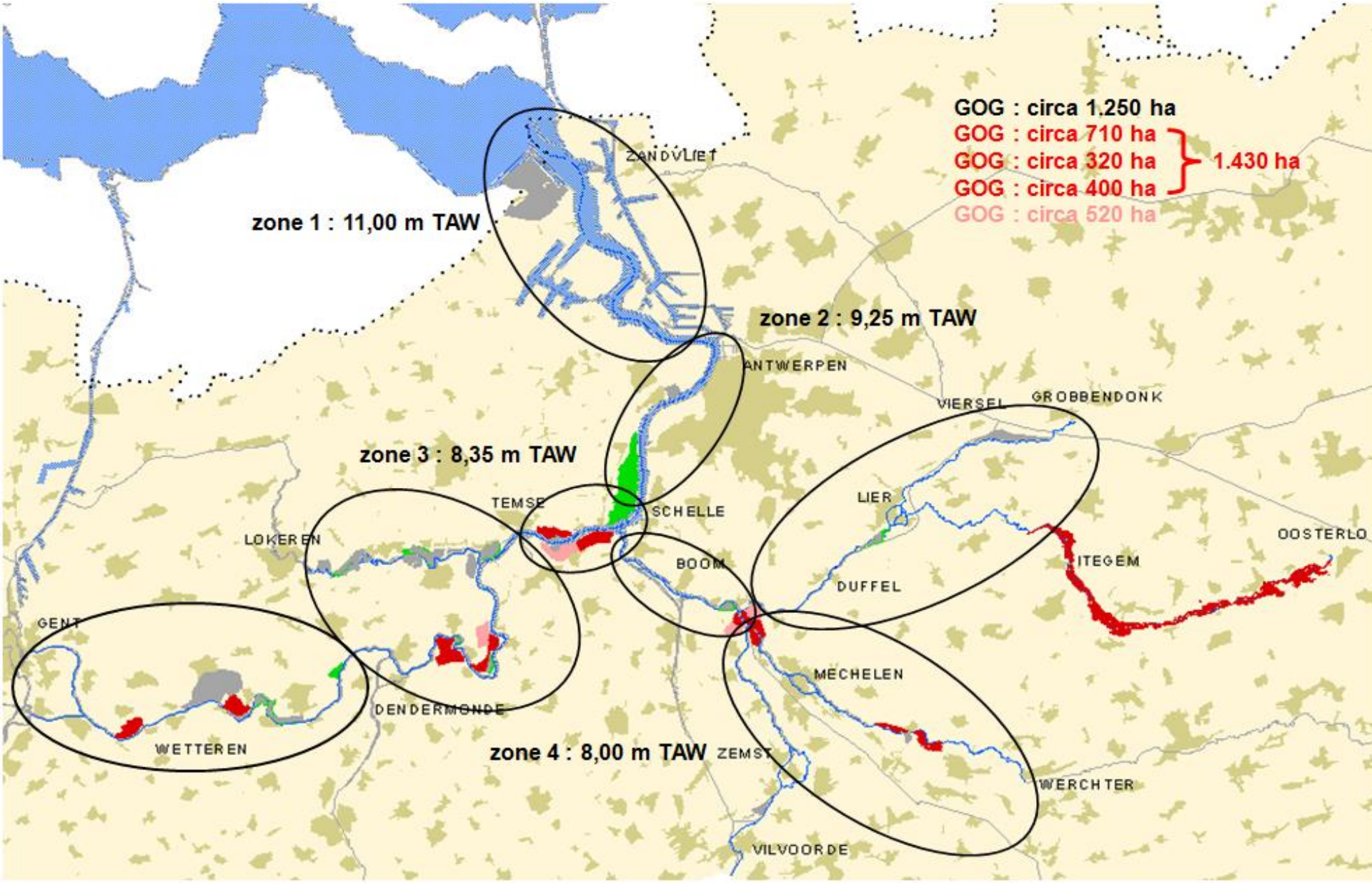


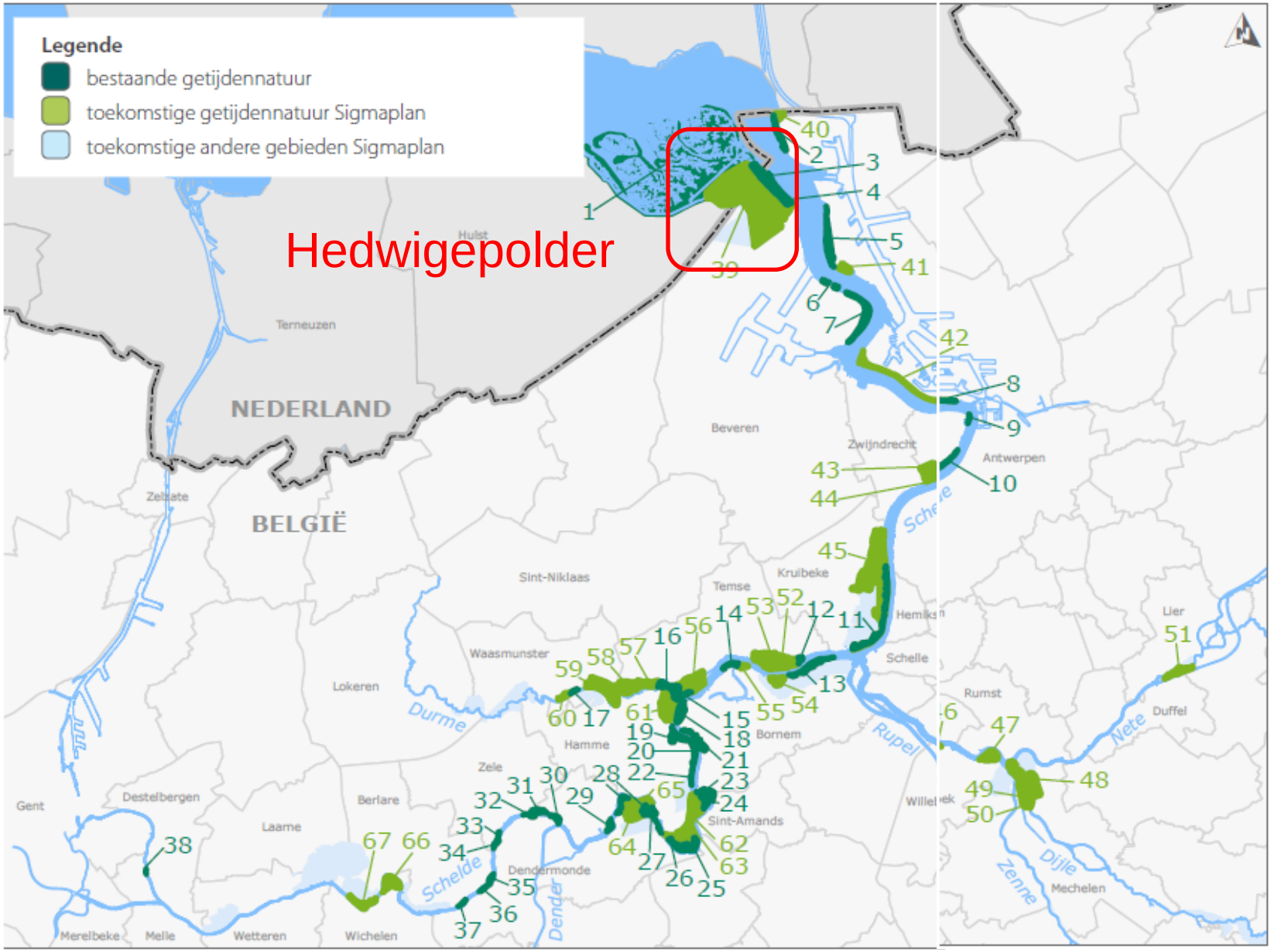
©LfU 1992

PLAN: Lowering of elevated portions of the winter bed and restoring the natural function.



This approach is now being conducted in Belgium: Location of the planned Flood control areas= FCA's in the basin of the river **Scheldt.**





http://www.natuurenbos.be/nl-BE/Over-ons/Projecten/~/media/Files/Publications/2011/SIGMA-brochuregetijdennatuur_oktober2011.ashx

Example: Location Hedwigepolder (NL) Prosperpolder (B)

JAAR

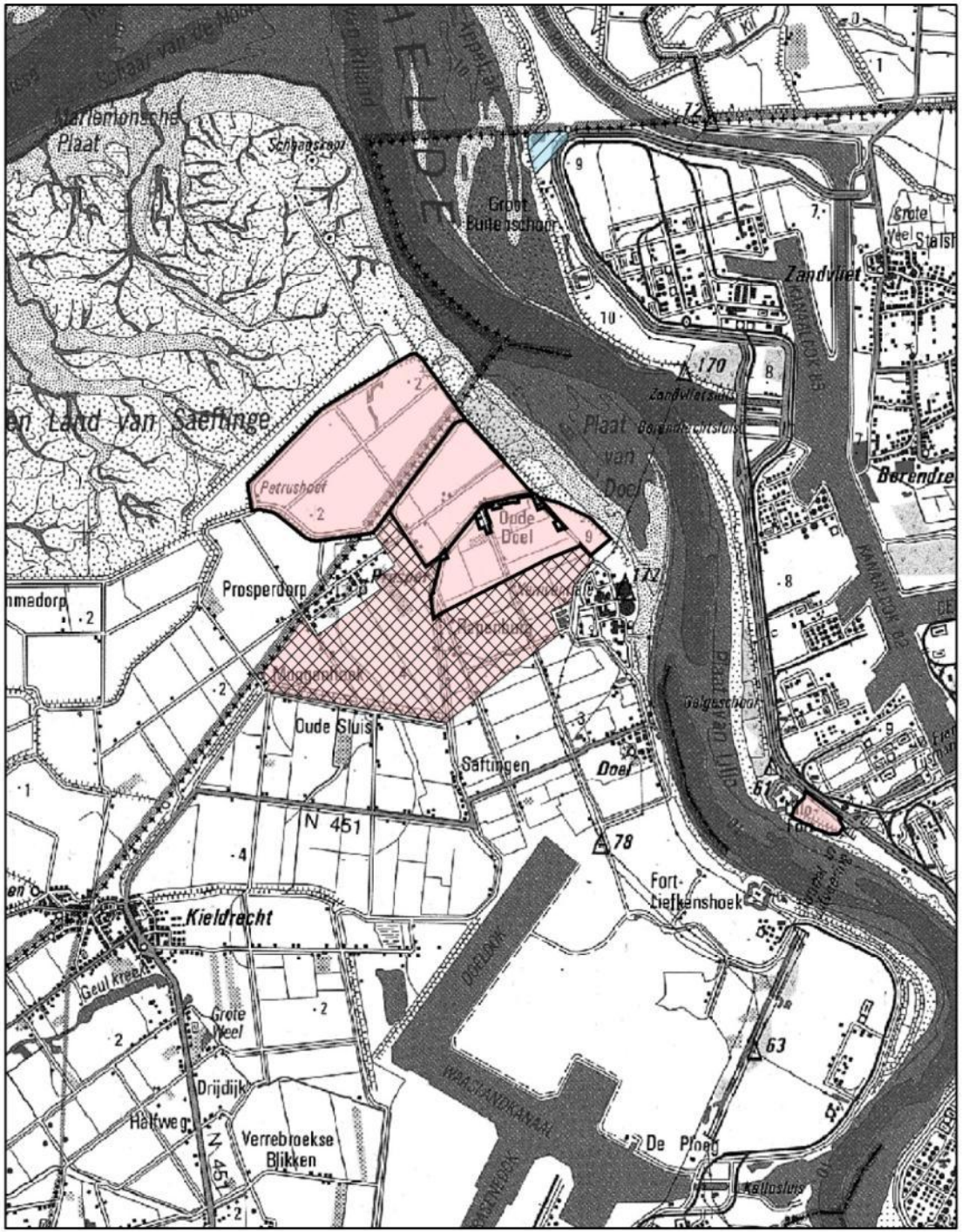
- 2010
- 2015
- 2020
- 2025
- 2030

BESLISSING

- -
- Beslist, fase 1
- Beslist, fase 1 en eerder proces
- Beslist, in eerder proces

B_NATUUR

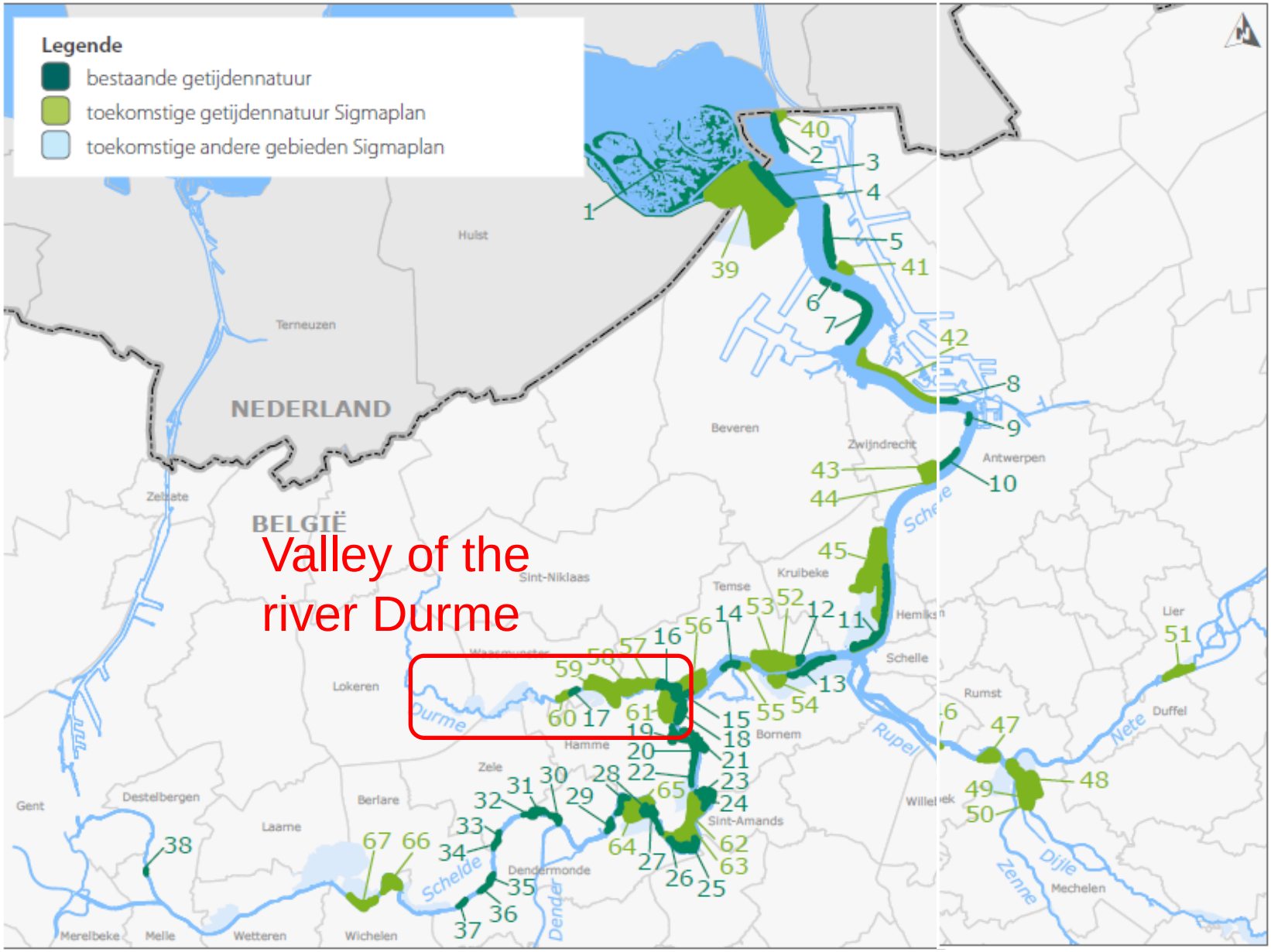
- -
- Aantakking
- Estuariene natuur
- Verweving
- Wetland
- Winterbed



Nature establishment plan (pattern). Hedwigepolder (NL) Prosperpolder (B)

In rural areas it is important to give back former winterbeds to the rivers, The example of the river Scheldt in Belgium: situation 2009

Situation 2019



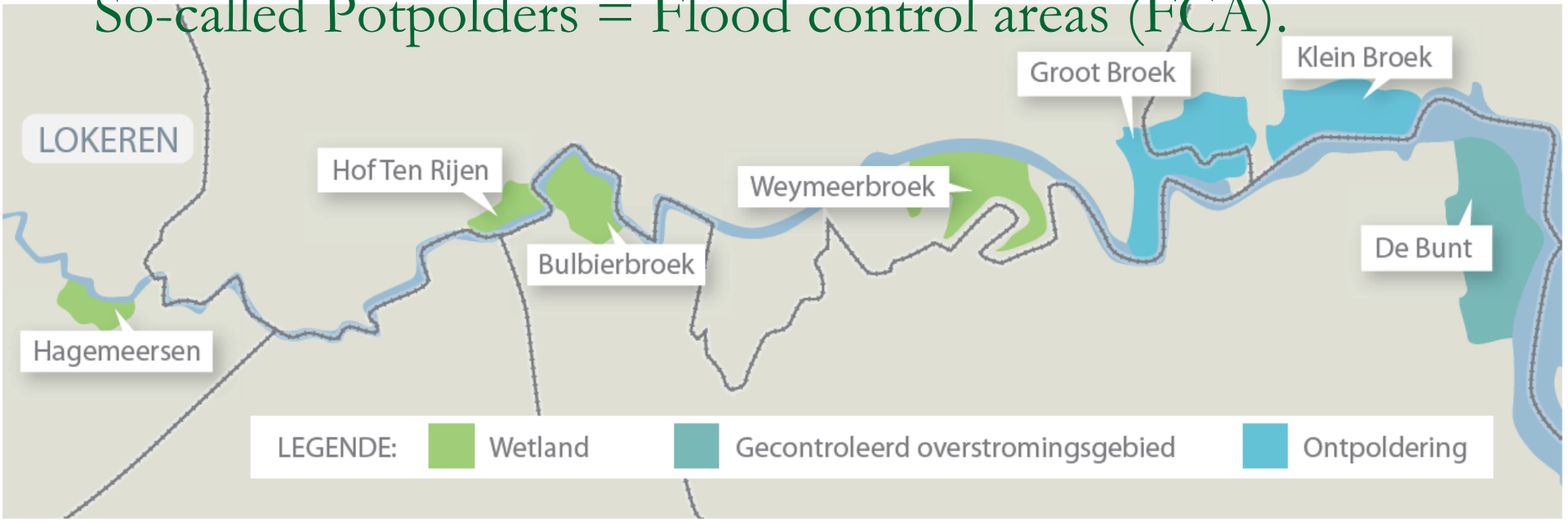
http://www.natuurenbos.be/nl-BE/Over-ons/Projecten/~/media/Files/Publications/2011/SIGMA-brochuregetijdennatuur_oktober2011.ashx

Example: Valley of the 'river **Durme'**
So-called Potpolders = Flood control areas (FCA)
see dvd during lecture

The summer bed of the river Durme.

'Potpolders' are situated in the winter bed. Extensive co-use by humans and agriculture is possible if the water quality permits this.

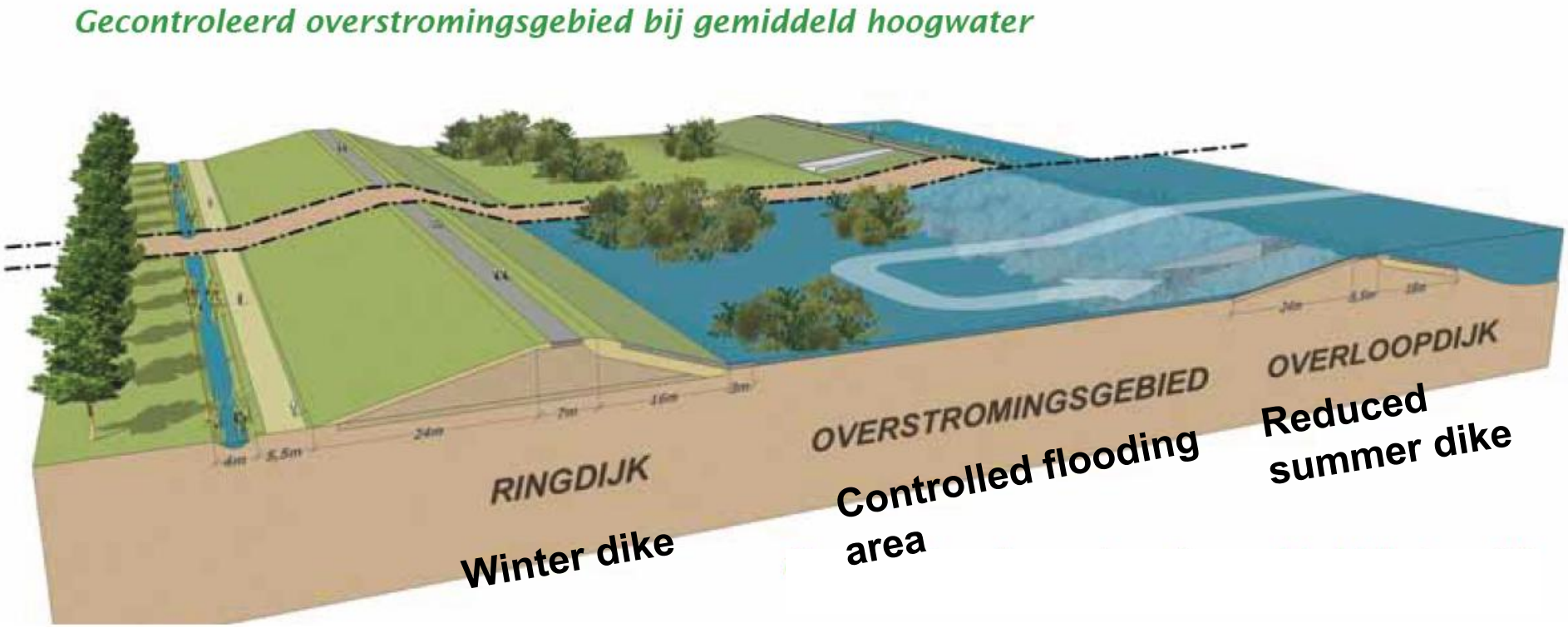
Example: Valley of the 'river **Durme'**
So-called Potpolders = Flood control areas (FCA).

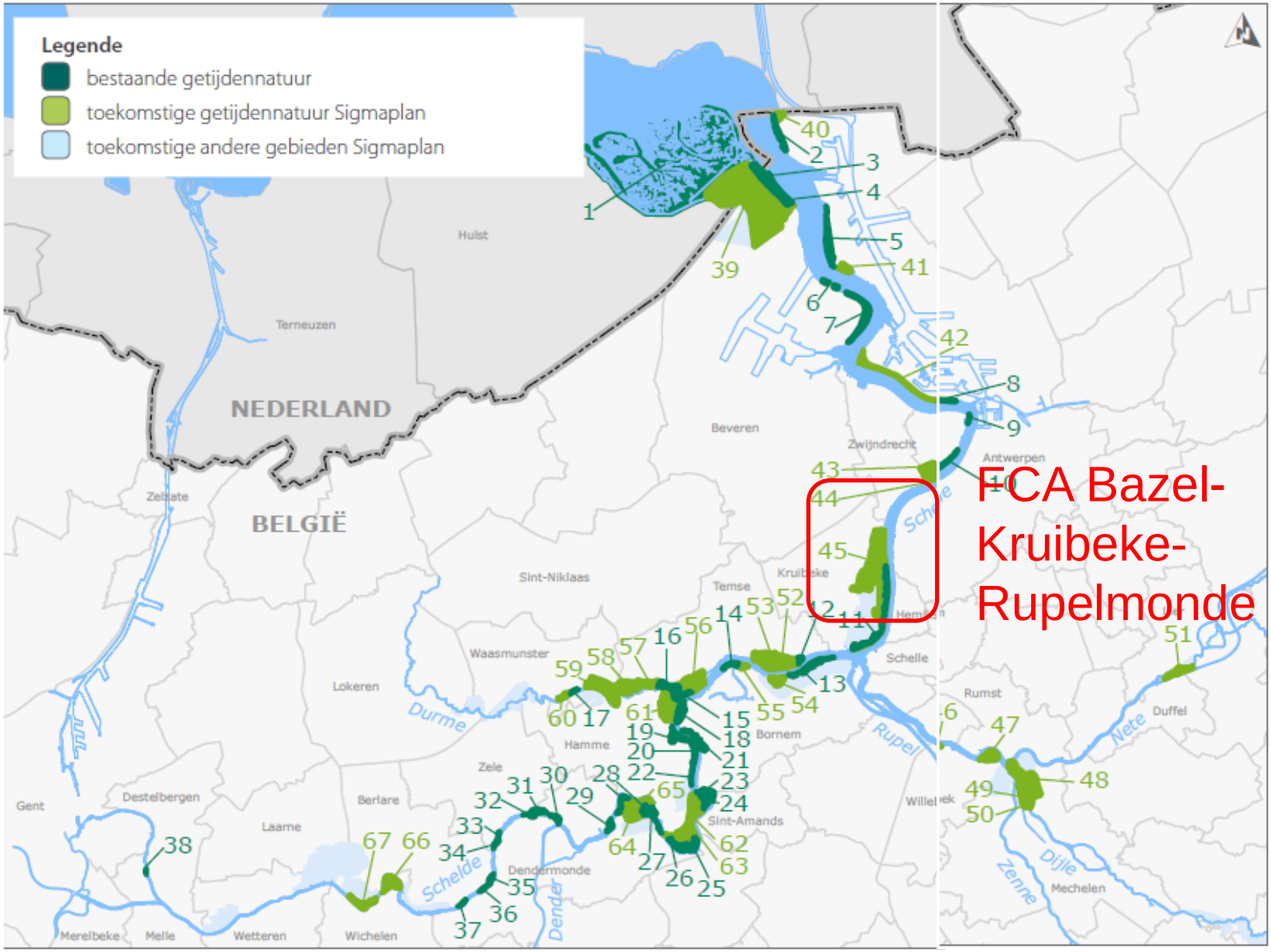


•*Gecontroleerde overstromingsgebieden* als De Bunt treden enkel in werking als een hevige noordwestenstorm samenvalt met een springtij: ongeveer 1 à 2 maal per jaar.
•Door de *ontpoldering* van Groot Broek en Klein Broek in het mondingsgebied, krijgt de Durme straks meer ruimte. Stroomafwaarts neemt het waterpeil af en de opslibbing van de Durme vermindert dankzij deze ontpoldering.
•In Bulbierbroek, Weymeerbroek, Hof ten Rijen en de Hagemeersen worden *'wetlands'*, natuurgebieden met rietlanden, stukjes moerasbos en open water (vergelijkbaar met het Molsbroek en omgeving).

http://www.sigmaplan.be/uploads/Publicaties/Nieuwsbrief%20juni%202009%20durmevallei%20LR.pdf

Principle of a Flood control area (FCA)





http://www.natuurenbos.be/nl-BE/Over-ons/Projecten/~/media/Files/Publications/2011/SIGMA-brochuregetijdennatuur_oktober2011.ashx

Casus 'valley of the river Scheldt': FCA Bazel-Kruibeke-Rupelmonde

- See DVD during lecture.

Case study: Slovakia

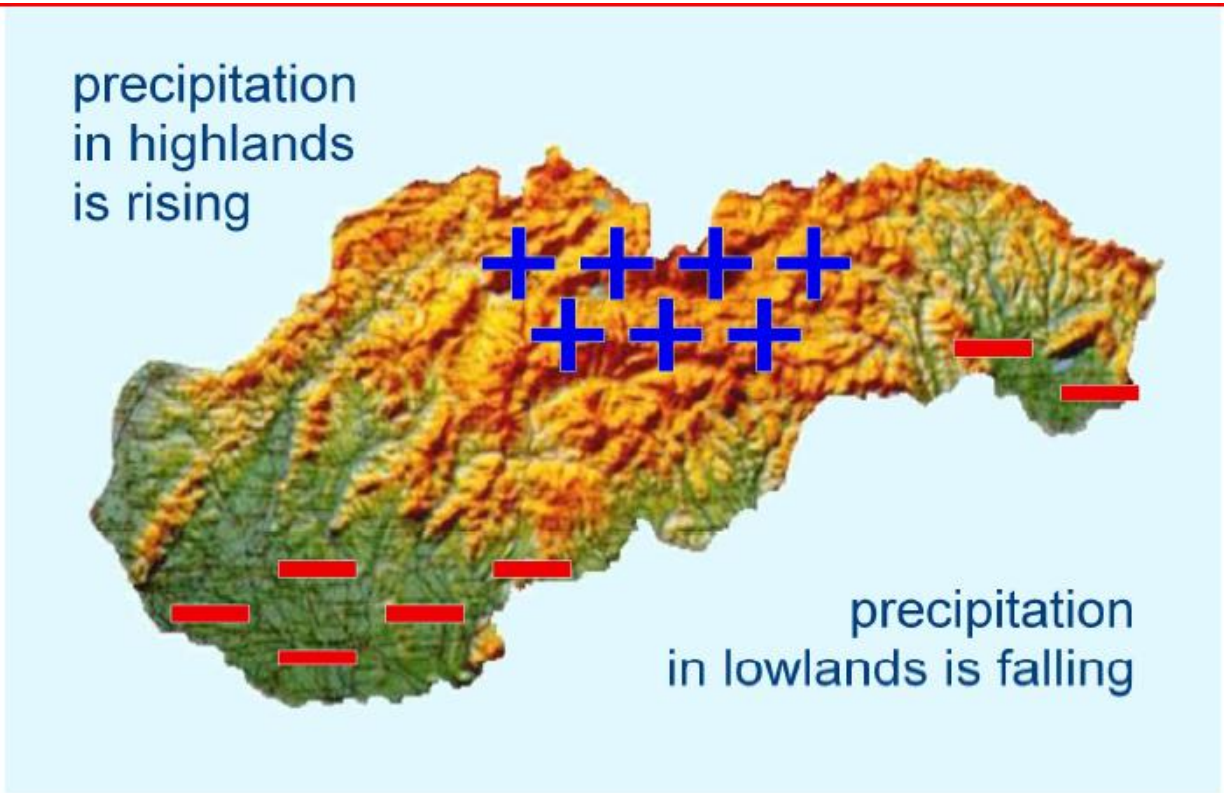


Fig. 20 **The growth of precipitation in mountainous northern regions and the decrease of precipitation in southern lowlands – Slovakia used as an example**

Kravčík, M. et al., 2008. Water for the recovery of the climate. A new water paradigm. Košice (Slowakia), Typopress-publishing house, ISBN 978-80-89089-71-0. 122 pp. ill.

Case study: Slovakia. Changes during 20th century :

- Average temperature: + 1,1 °C (even more in winter)
- Precipitation in the southern plains: - 10 % , in the mountains: + 3 %
- Relative air humidity: - 5 %
- Drought periods are lengthening, rain periods are shorter (and heavier).

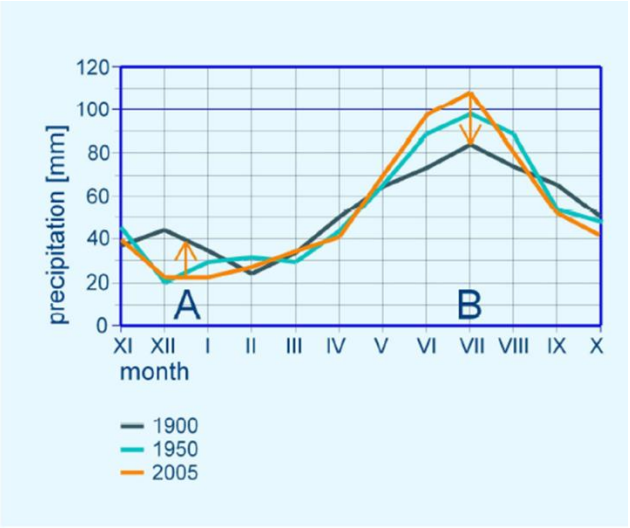


Fig. 23 **Average annual precipitation totals in Prešov**
Resembles the average trend throughout Slovakia.

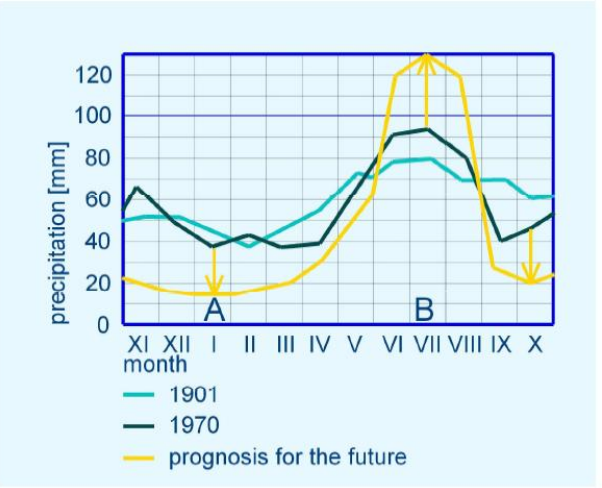


Fig. 22 **Precipitation trends in Slovakia**
Periods of "drought" are lengthening (A) and the time period in which most precipitation falls is getting shorter (B).

[46] "Fourth National Report of the SR on climate change and the Report on achieving progress for fulfilling of the Kyoto Protocol." Slovak Republic, Ministry of the Environment of the SR, Slovak Hydrometeorological Institute, Bratislava, 2005

Het Donau-bekken in Europa – The Danube river basin in Europe.

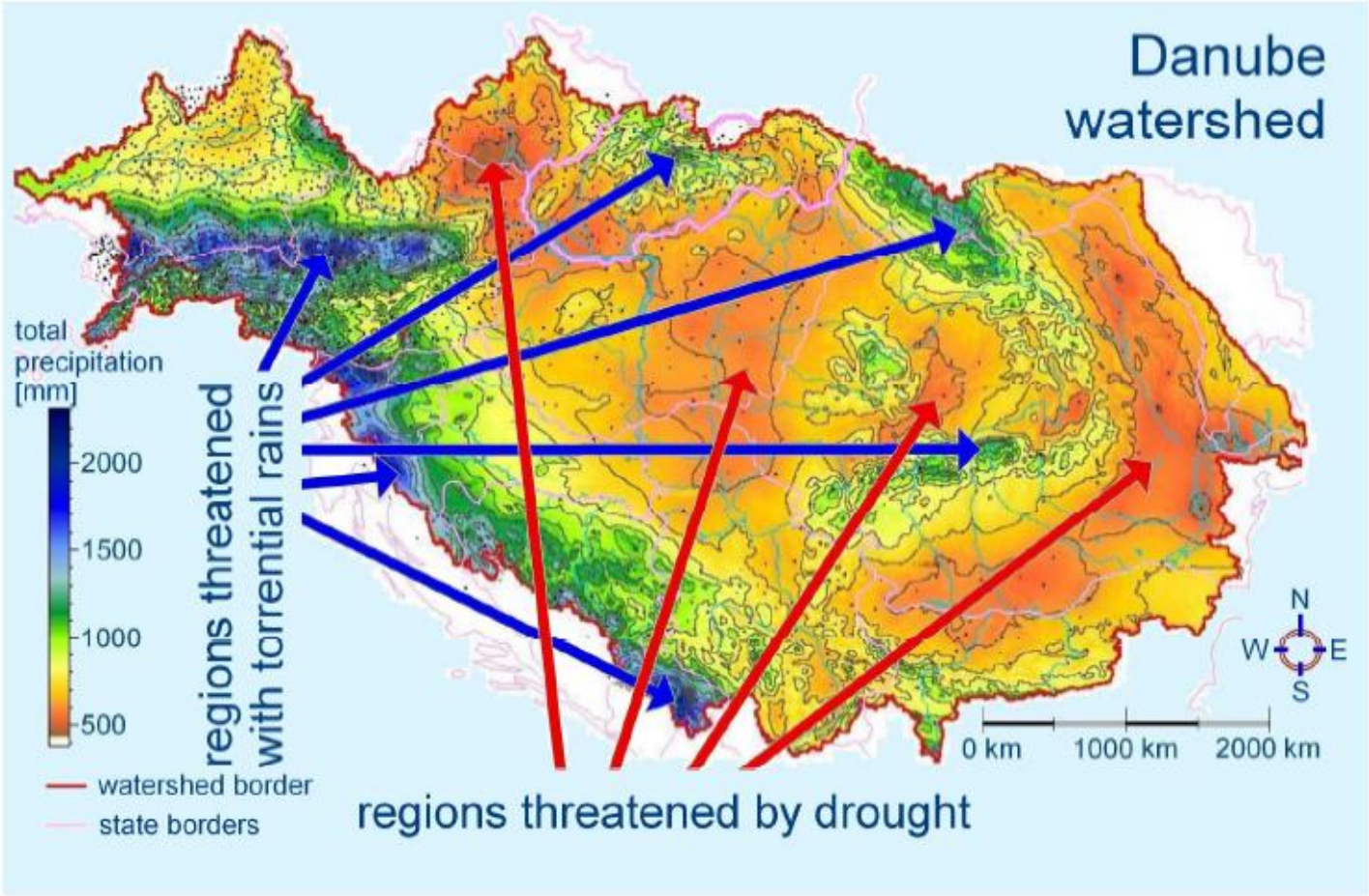


Fig. 21 **The rise in precipitation in mountainous regions and the decrease of precipitation lowlands – Danube watershed**

How to explain these changes in central Europe ? Remember : The concept of the **large and small watercycles (theme 6)**.

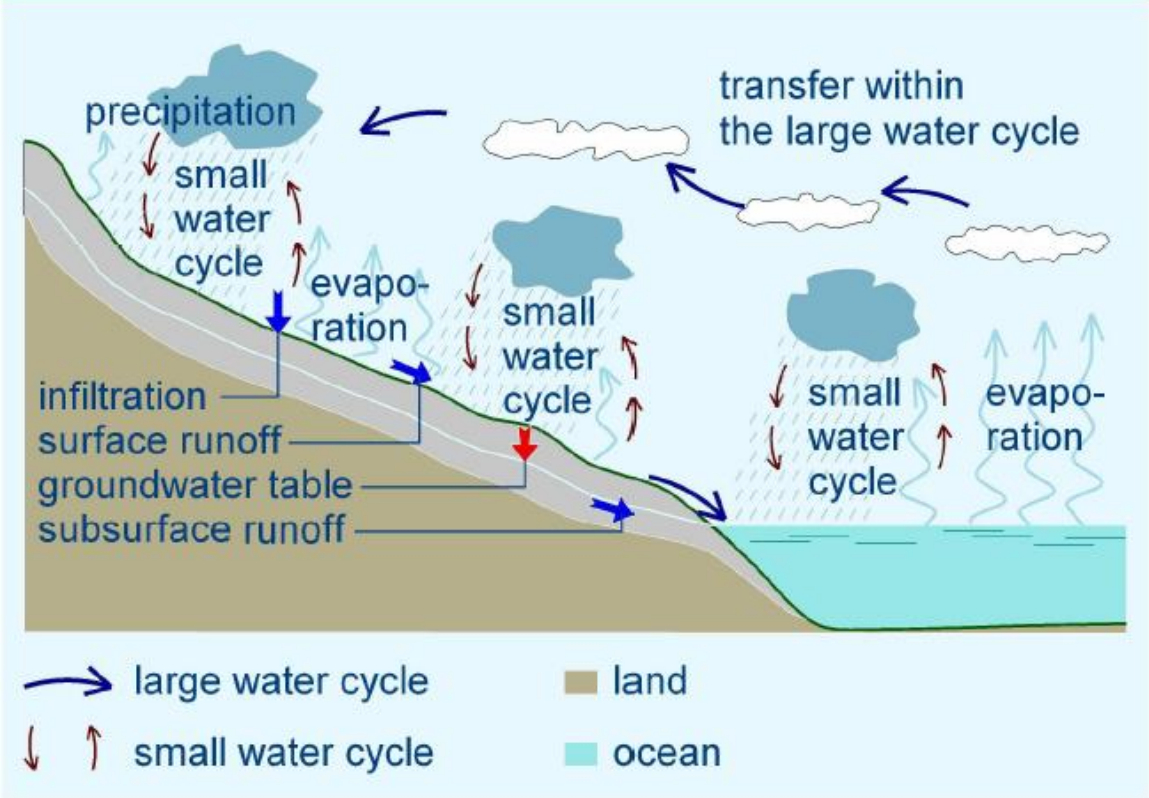


Fig. 1 **The large and small water cycles on land**

Consequences of decreasing the small water cycle.

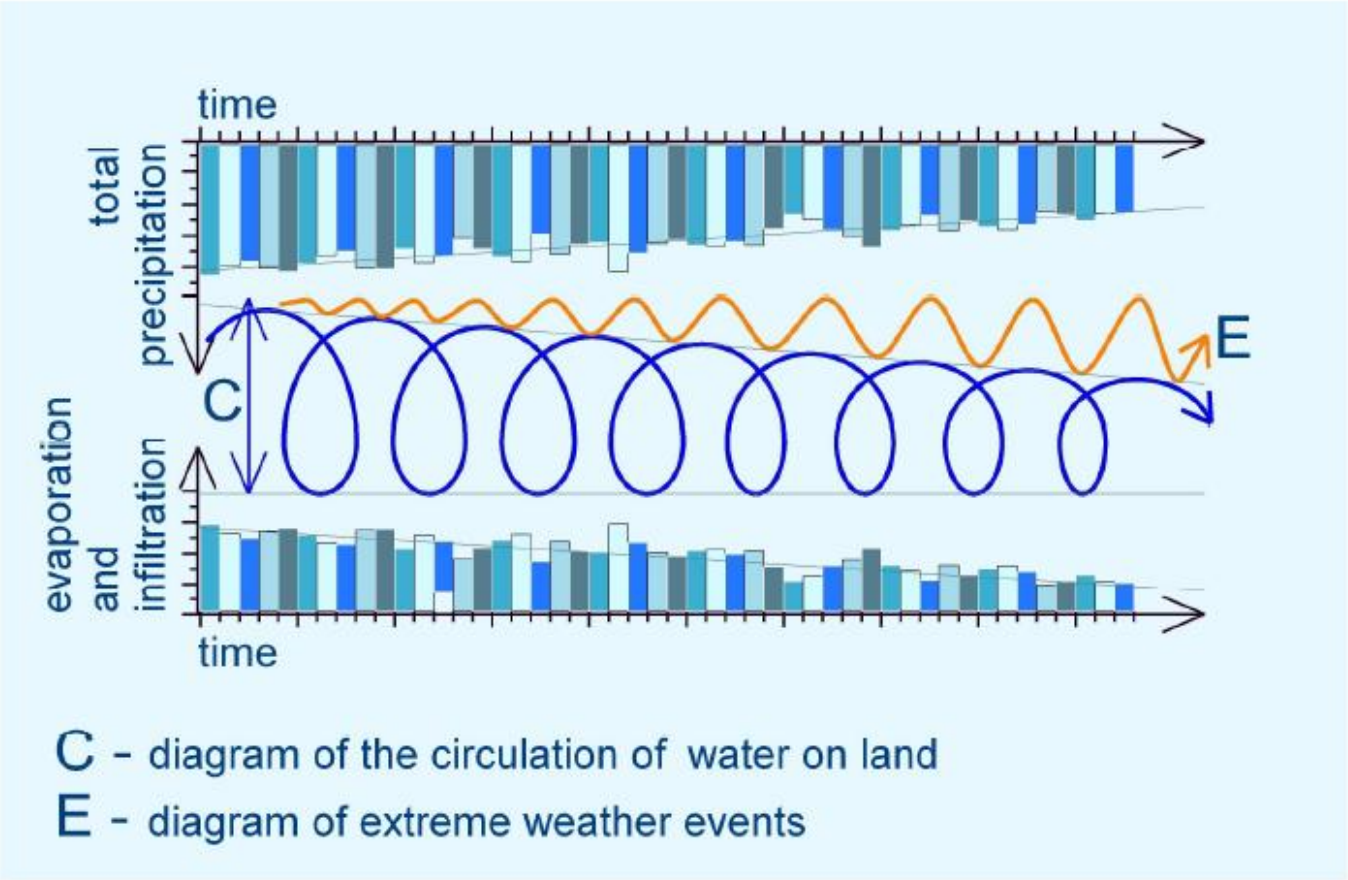


Fig. 17 **The growth of extreme weather with the decrease of water in the small water cycle**

Less evapotranspiration leads to decreasing locally generated rainfall and increasing risks for extreme weather events

Slovakia, Tatra mountains. Situation 2004.
Increasing risks for extreme weather events
See also flooding in **Balkan countries**
Spring 2014

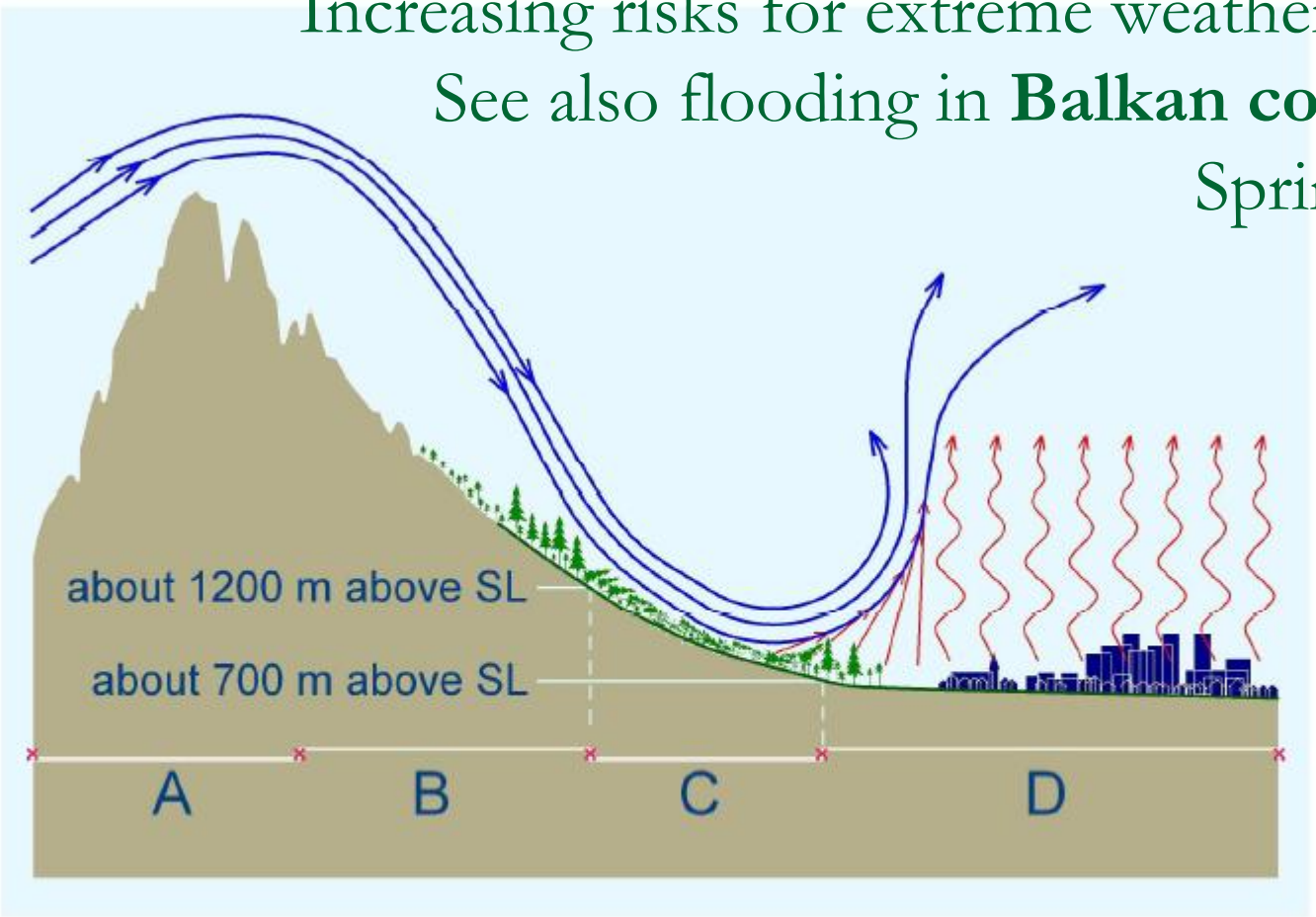


Fig. 25 **Wind storm in the High Tatra mountains, Slovakia, November 19, 2004**
Radiant flows of warmed currents from agricultural-urban areas (zone D) accelerated air currents with the rapidly falling cold front through the ridge of the High Tatra mountains: v(A) 150 – 200 km/h, v(B) < 100 km/h; v(C) 200 – 250 km/h, v(D) < 150 km/h.

Small water conservation measurements, such as here in the Tatra mountains (Slovakia) do matter, for *local climate* but are also *preventing flooding* downstream

***Fig. 35* A Water Forest in the High Tatras – building water conservation measures on territory destroyed by a natural disaster**

An example of the renewal of vegetation and hydrological stabilization of a territory through the conservation of water on land.

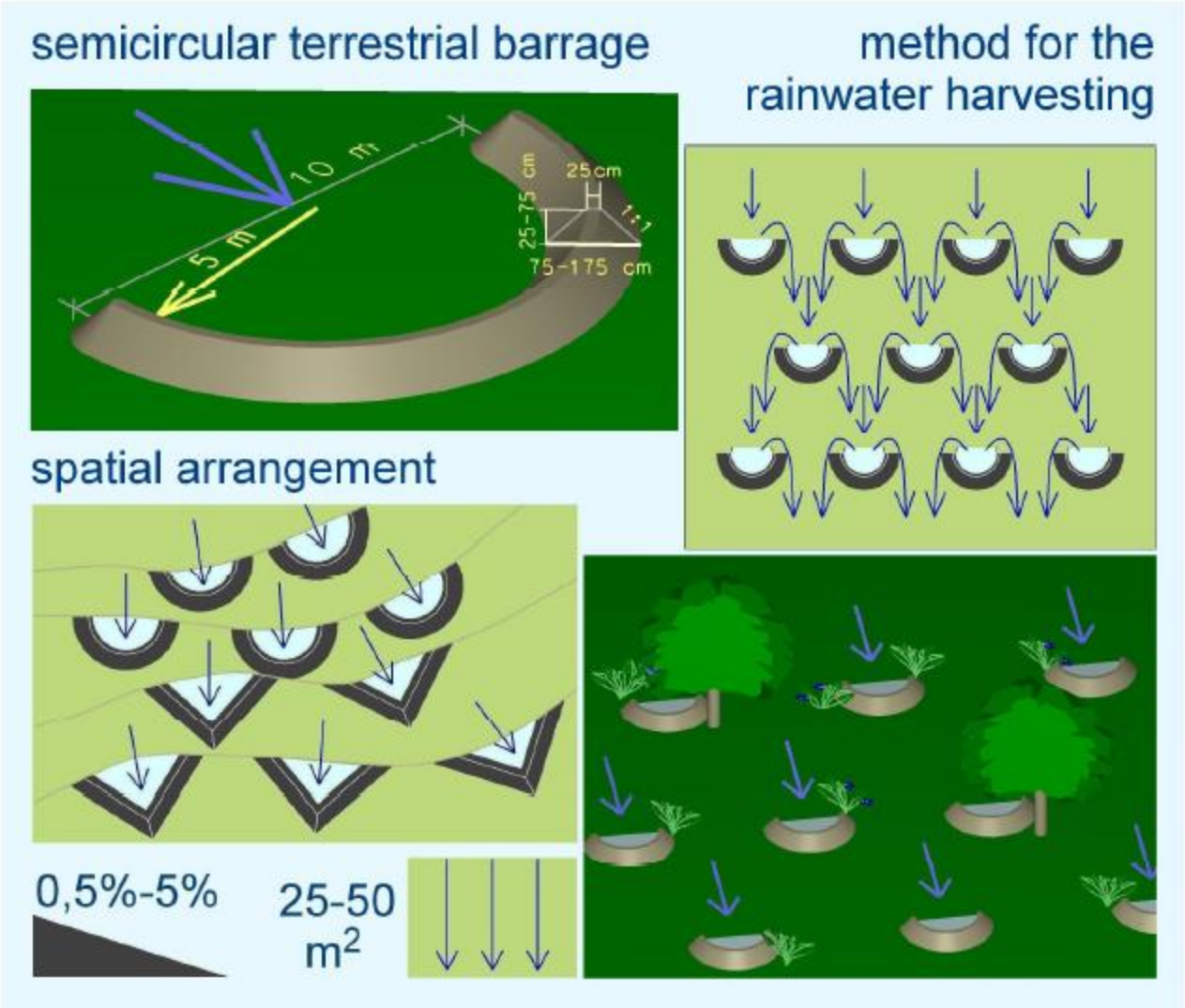


Fig. 32 **An example of cascade ground tanks for rainwater harvesting on slopes**

Different measurements aiming to tackle soil erosion and water problems. (See dvd during lecture)

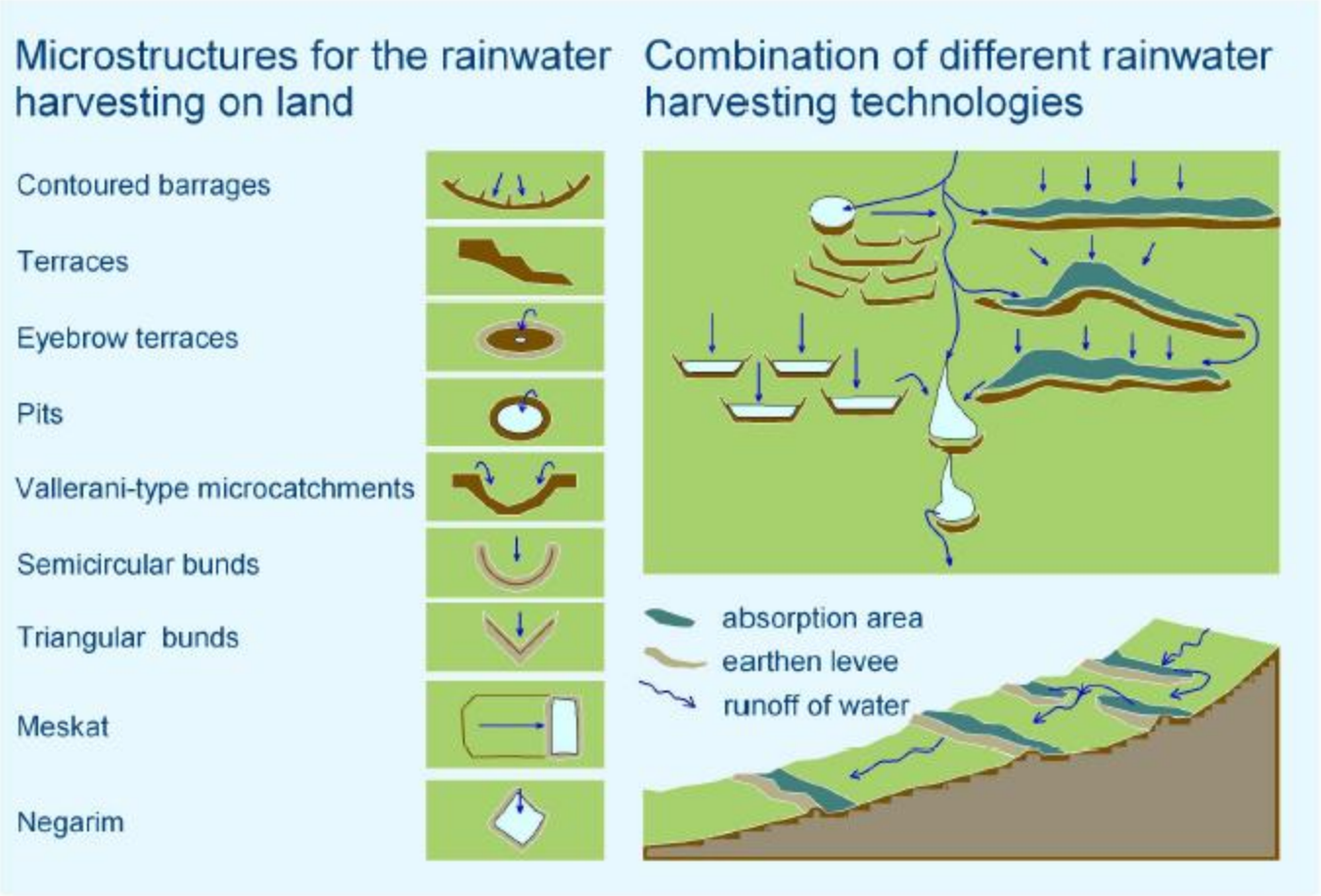


Fig. 33 **A diagram of technological measures for the protection of land against erosion and for rainwater harvesting and conservation on land**

Restoring the *small urban and rural water cycles* leads to local climate recovery and decreases extreme weather events.

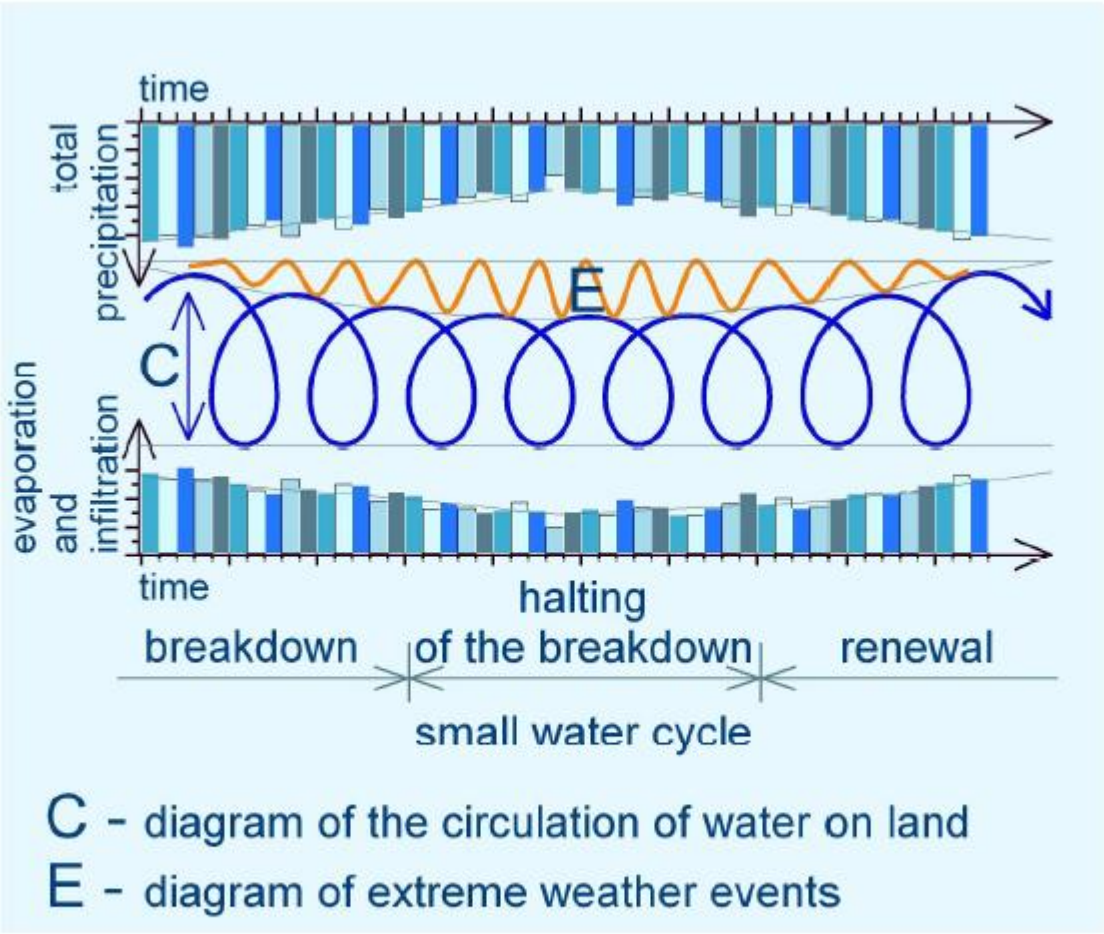


Fig. 27 **The course of destruction of the small water cycle over land until it is halted and then renewed to its original state**

Tackling desertification by restoring small water cycles (1)

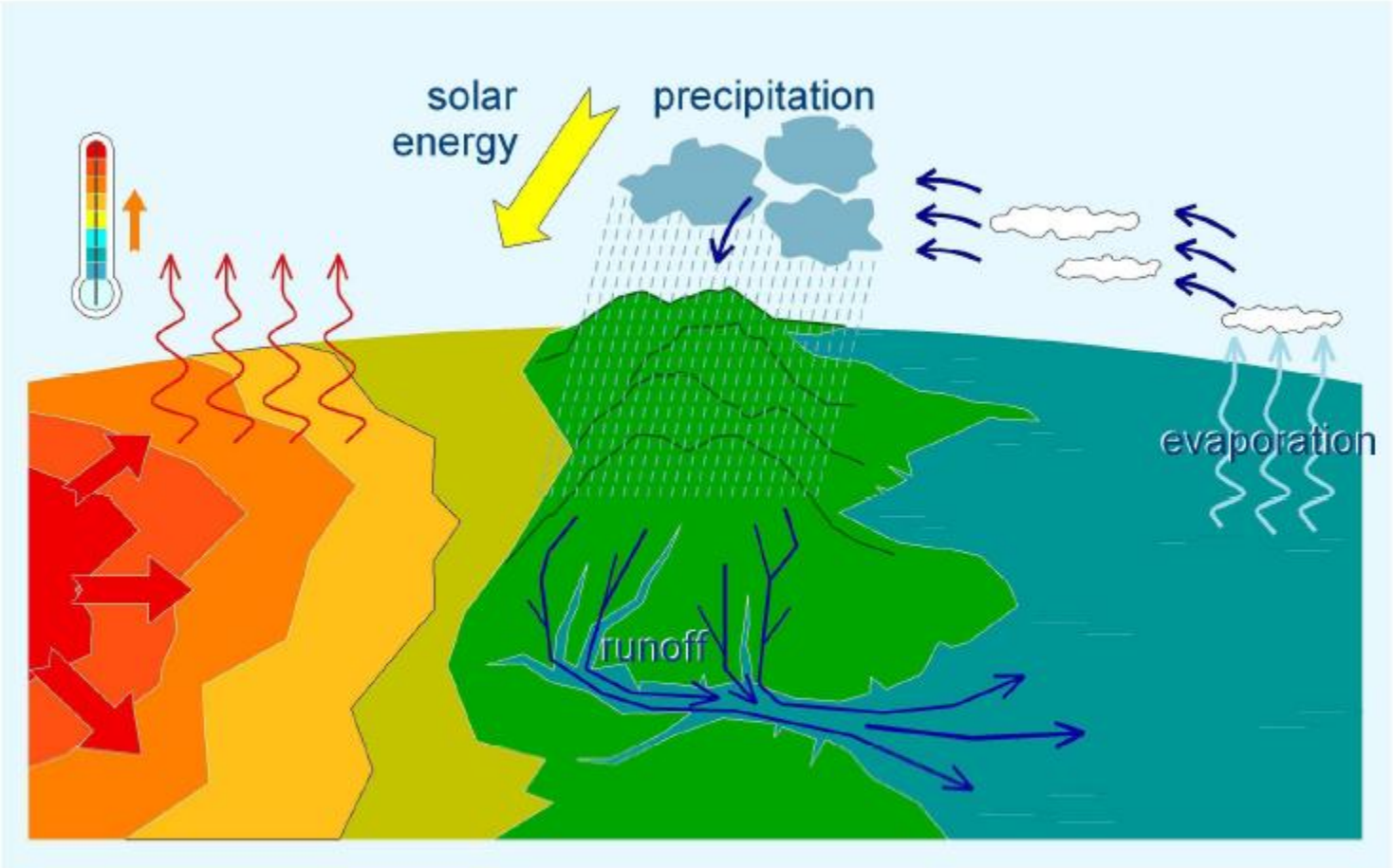


Fig. 28 Diagram of the expansion of deserts or semideserts with the breakdown of the small water cycle

Tackling desertification by restoring small water cycles (2)

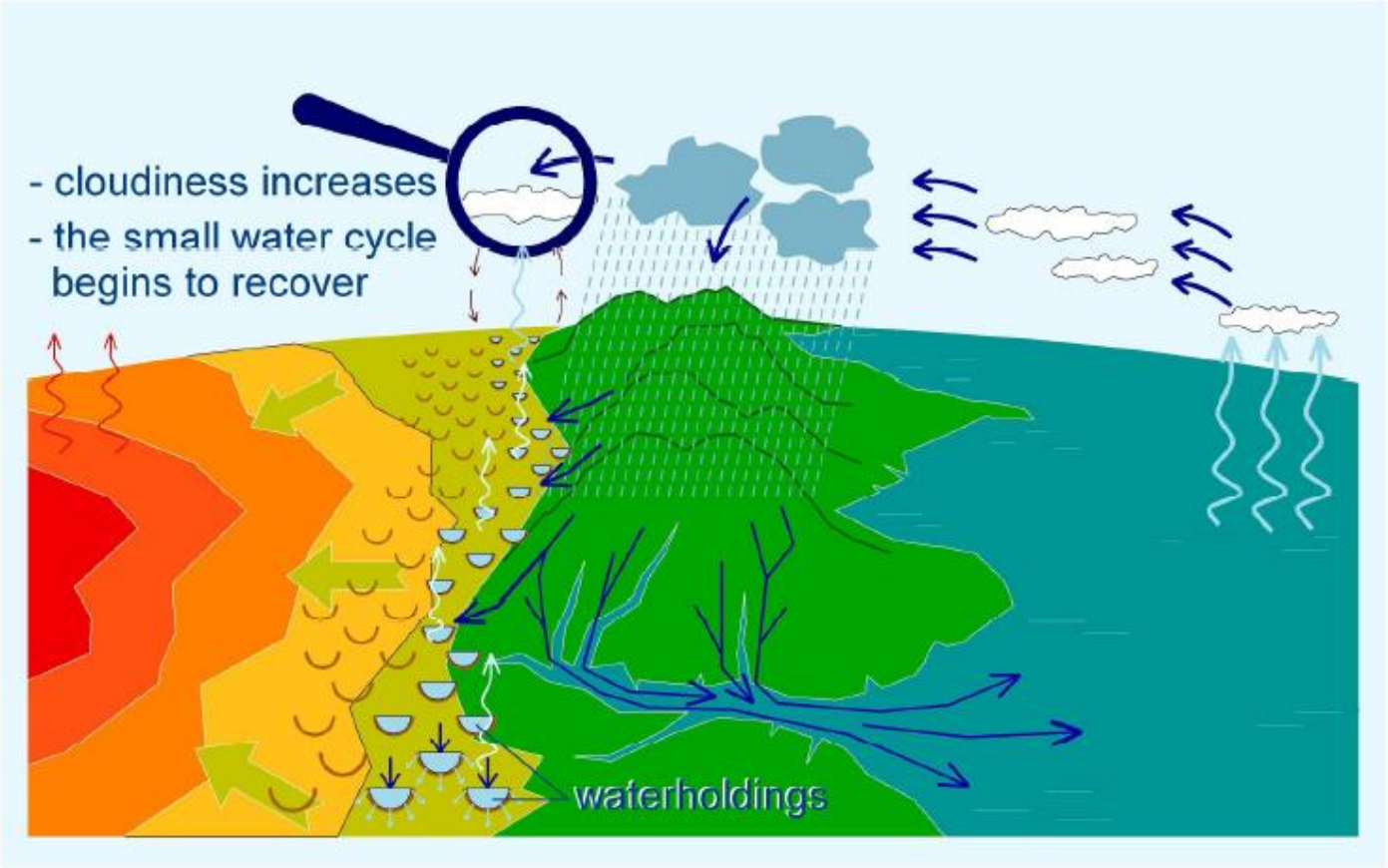


Fig. 29 Waterholding measures on the edge of critical areas
Their role is to harvest and hold water from the small water cycle from adjacent lands, or water from the large water cycle (even in deserts it rains occasionally). The period in which the water cycle is renewed depends on circumstances (the hydrological and pedological conditions, success of the growth of protective vegetation, etc.).

Tackling desertification by restoring small water cycles (3)

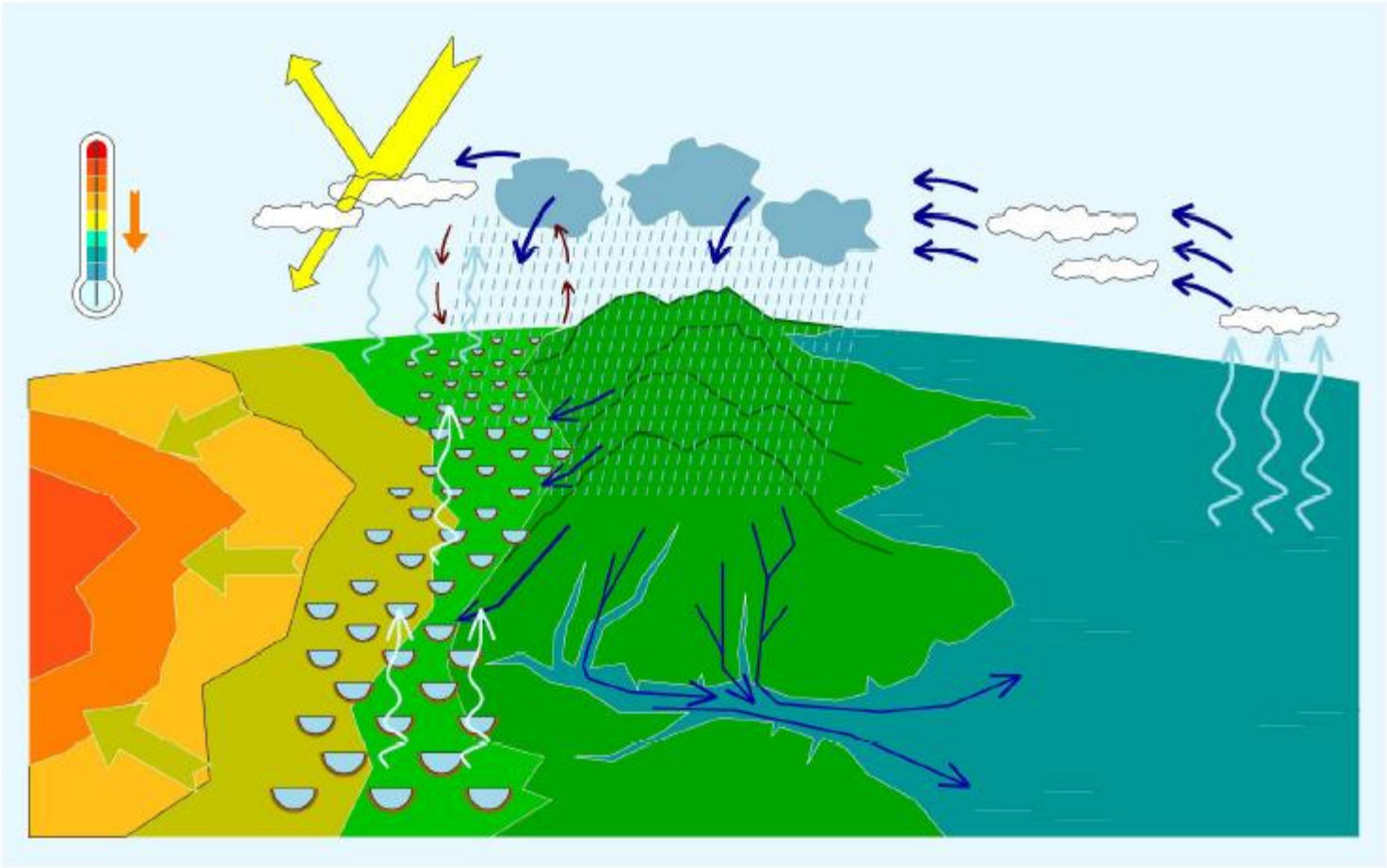


***Fig. 30* Decreasing areas of desert**

The climate recovers in an area with a renewed small water cycle and it can possibly be used as a forefront for further expansion of the hydrological recovery of land.

Case study: Tamera ecovillage (Portugal): restoring water landscapes in Alentejo, a region in the southern part of Portugal, threatened by desertification.

Decentralized Water Landscapes are capable of extensively regenerating our water's natural cycle and saving Southern Europe and other regions worldwide from desertification.

In Tamera a permaculture and water landscape is being built as a model for the re-naturalization of damaged landscapes. For this, we cooperate with the Permaculture expert Sepp Holzer from Austria.

In 2007, Lake I was built as the first big retention space for rainwater. Where there used to be a dusty valley, water, animals and plants are now building a diverse biotope which supports the healing of the landscape. All year round fruits and vegetables prosper in a mixed culture on the shore terrace gardens. The rainwater stays on site and has time to seep into the soil. The growing Water Landscape of Tamera consists of various connected water retention spaces. This way the body of the earth can extensively saturate with water and on large stretches of land forests can flourish again; the groundwater level will stabilize; people, animals and plants come alive.

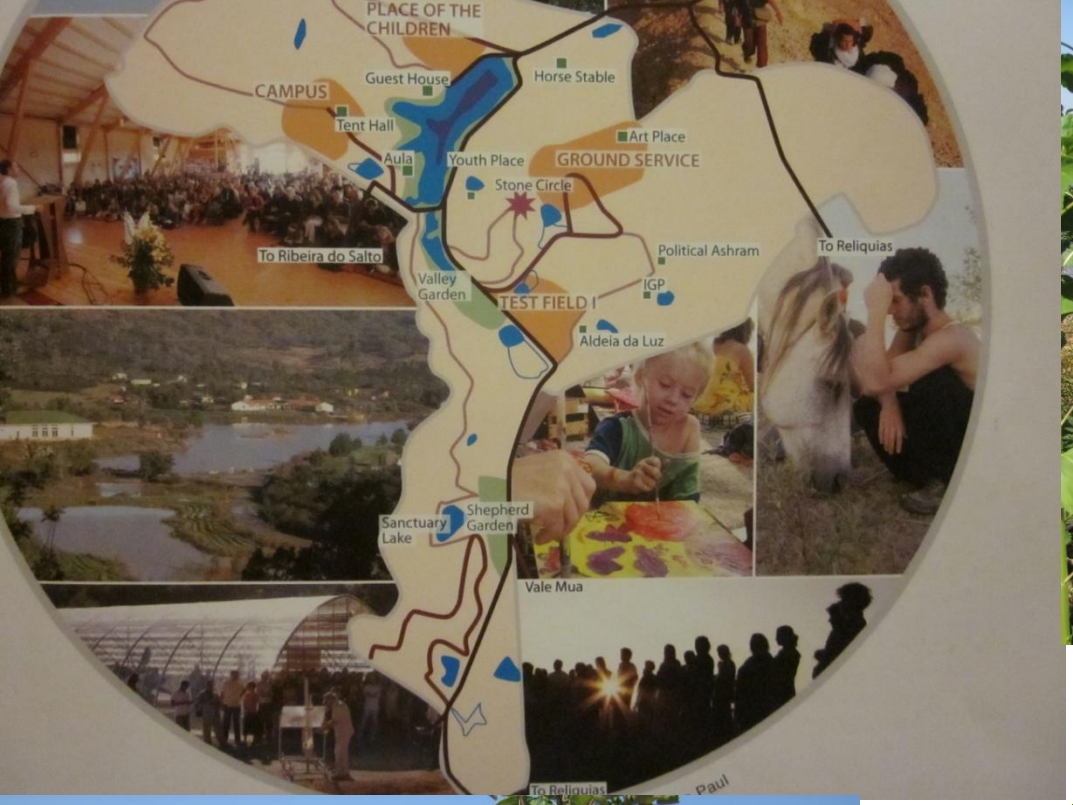
About the Construction of Water Retention Spaces: Behind the dam, which is built from natural material (loam), the rainwater is withheld. Foil, concrete or any other artificial sealing is unnecessary. The meandering shore design and the installation of shallow and deep-water zones (here up to 13 metres = 40 feet) enable a constant movement of water resulting in its vitalization, oxygenation and self-cleansing.

Tackling desertification in Portugal
Construction of a new dam, to create more water landscapes in the ecovillage of Tamera (the 'New South Lake')

(http://www.tamera.org/index.php?id=50)

Tackling desertification in Portugal. Construction of a new dam, to create more waterlandscapes in the ecovillage of Tamera (the ‘ New South Lake’)

(http://www.tamera.org/index.php?id=50)



The result: water landscapes in ecovillage Tamera (www.tamera.org)

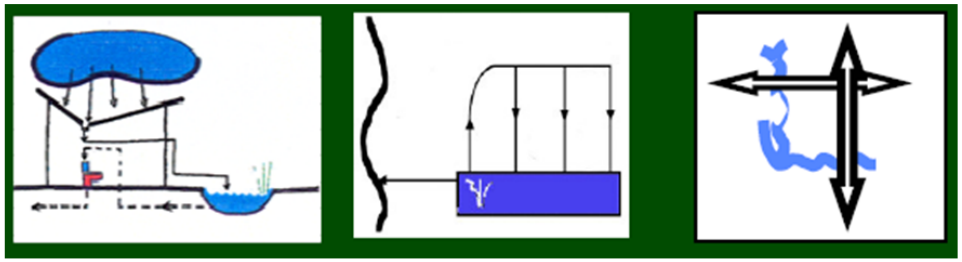
More information: http://www.tamera.org/fileadmin/PDF/WasserSymposium_en.pdf
Watch and study the following video 'water is life' very carefully:
http://www.youtube.com/watch?v=4hF2QL0D5ww&feature=player_detailpage

Integral water management: Conclusion.

- All over Europe the same problems are occurring: of increasing flooding, of soil erosion, of rapid urbanisation with a drying and a warming impact on the local climate because of the destruction of the small water cycles, followed by desertification (especially in the Mediterranean region)
- The situation will become worse due to global climate change, that will enlarge the local problems.

So once again: **Think globally and act locally**. Local measurements have to be taken in both rural and urban areas. In this theme 9 a lot of these possible measurements in rural areas are described, in complement with the urban measurements, described in theme 6.

The use of **water as an organizing principle** at different levels *in urban and rural environment is urgently needed.*



Building level **District level** **City level and rural areas**

= INTEGRAL WATER MANAGEMENT