"EUROPE-INBO 2015"

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13th International Conference « EUROPE-INBO 2015 »
for the implementation of the European Water Directives

Overview of mitigation options to reduce nutrient losses from rural areas and to improve surface water quality (Cost 869)

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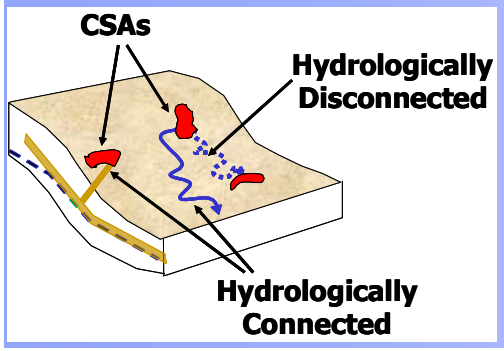
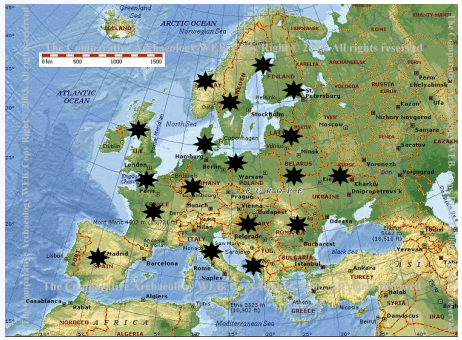
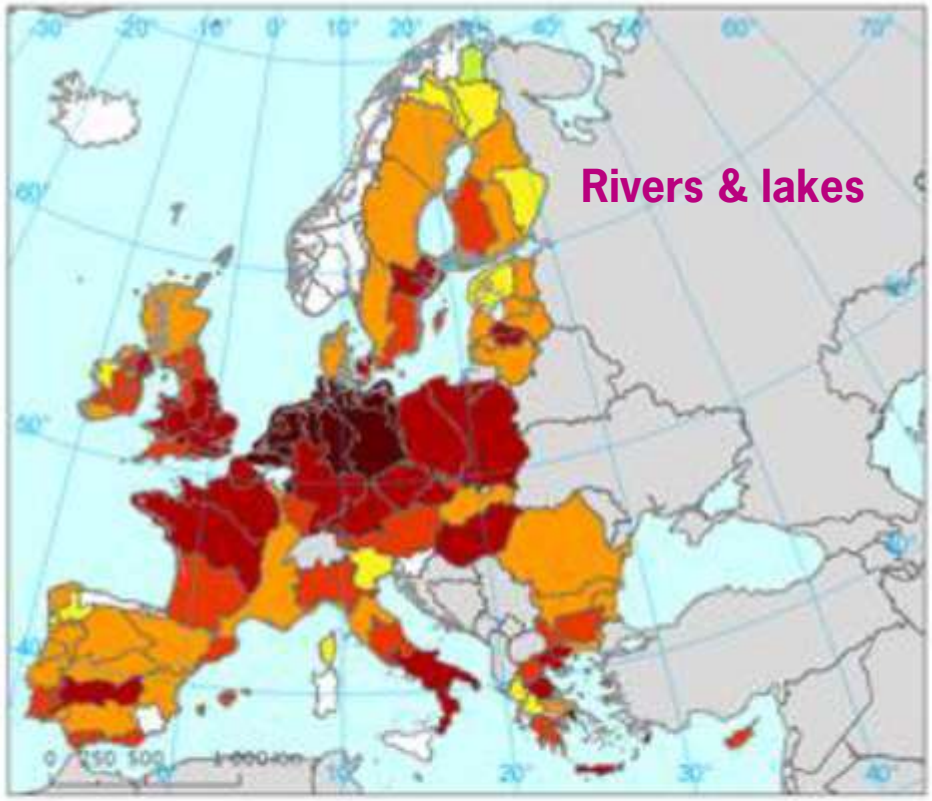
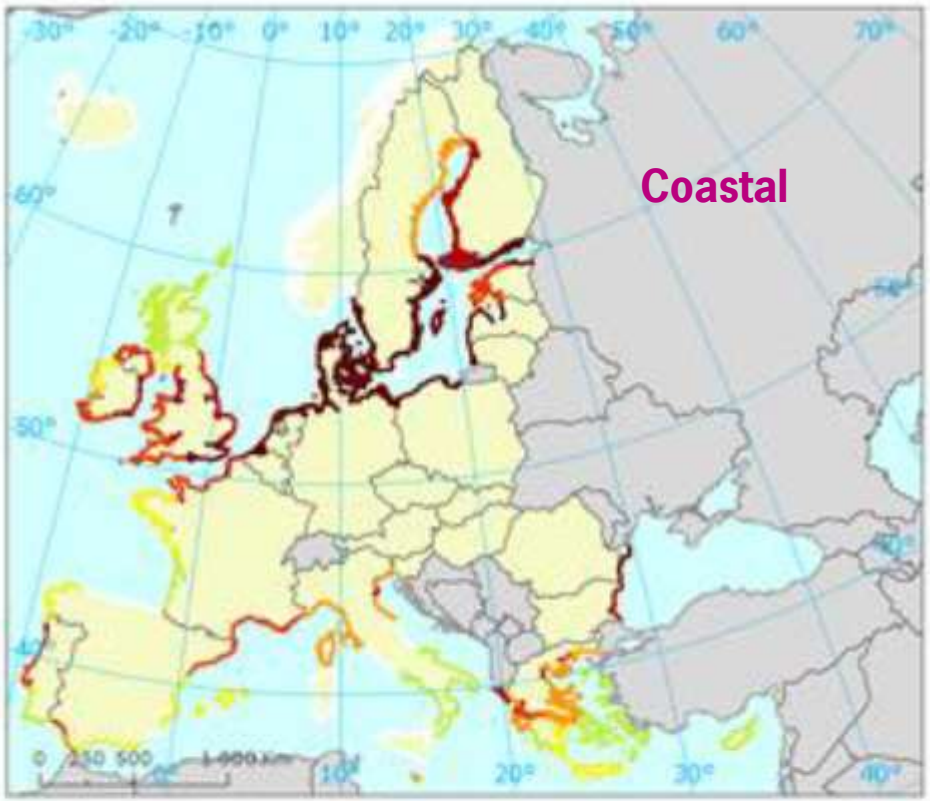




Eutrophication status of surface waters

Percentage classified as less than good in different European countries





% of classified water bodies in less than good ecological status or potential
(left map: rivers and lakes, right map: transitional and coastal waters)

no data reported | <10 % | 10-30 % | 30-50 % | 50-70 % | 70-90 % | >=90 %

Source: COM (2012) 670

•Assessment of agri-measures in draft River Basins Management Plans

- **Main pressures addressed**: diffuse pollution by nitrate (92%) or by phosphorus (90%), pesticides (74%), morphological deteriorations (50%), water abstraction for irrigation (28%).

- For 50% of the cases, agriculture is clearly mentioned as **a reason for exemptions** (recovery time of nature)

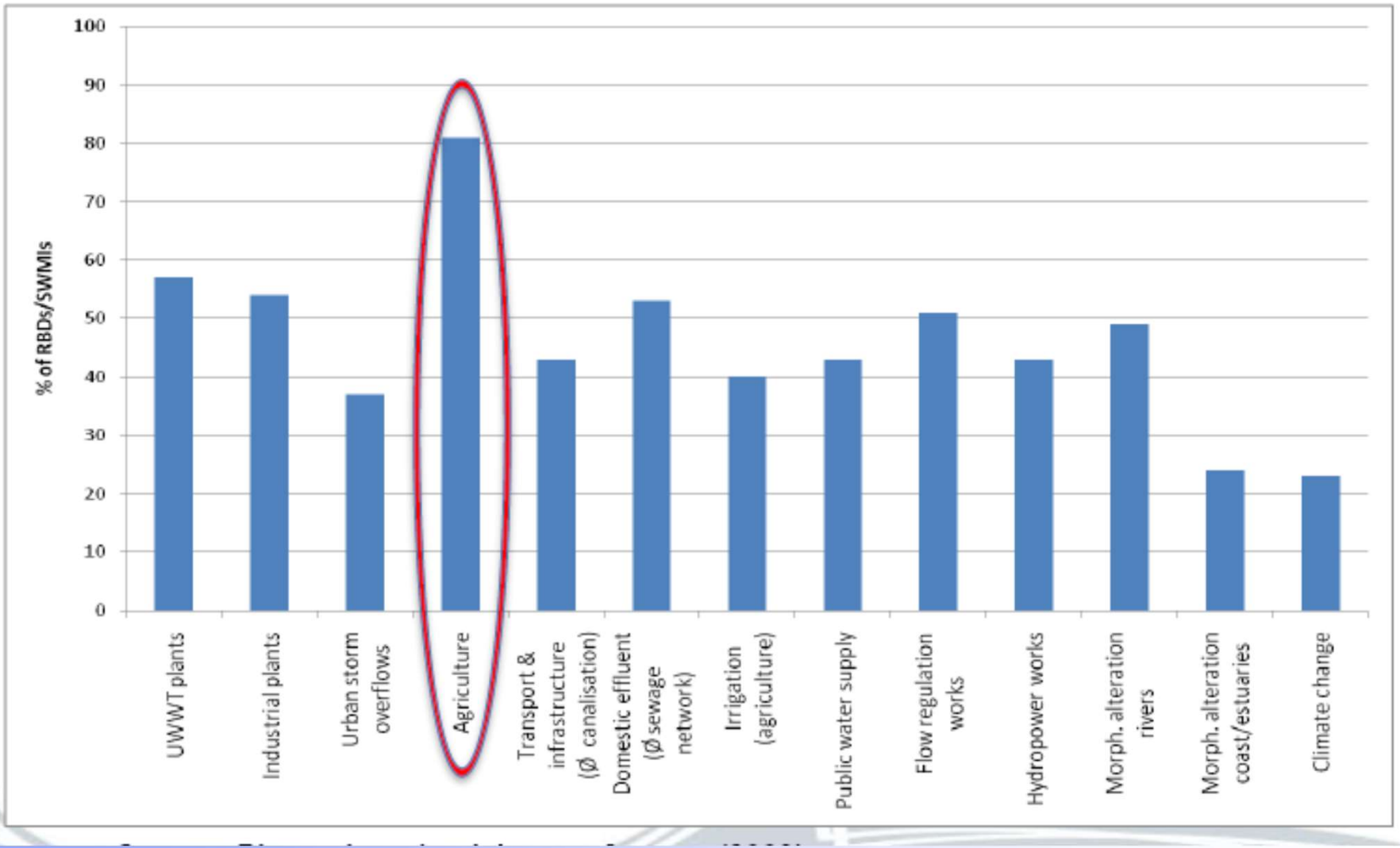
- If a statement on farmer's participation is made, **farmers have been mostly included** in identifying, selecting, and evaluating measures

- **Most commonly applied measures**: buffer strips/zones 70% (multi-objective measure), training & advisory 50% (other measures), reduction in spraying 40% (input reduction m.), storage capacity for manure 33% (input reduction m.), creation of wetlands 26% (multi-objective m.), catch crops 23% (input reduction m.), re-meandering of streams 16% (morphology m.), spraying technologies 14% (input reduction m.), water saving irrigation practices 11% (water savings m.), water storage capacity increases 10% (water savings m.), cooperative agreements 10% (economic m.)

- The selected measures **focus on input reduction**, but for most measures not covered under existing legislation it remains **unclear if they will be voluntary or mandatory**.
  No link with the Rural Development Programmes is made in most of the plans.
  The area or the length covered by a measure is not reported in most cases

- In about 2/3 of the plans, the undertaking of a cost-effectiveness analysis has been reported.
  Information on the costs of agricultural measures is mostly lacking.
  A reference to how the measure implementation is controlled is only available in a few cases.

Agriculture identified as a key issue



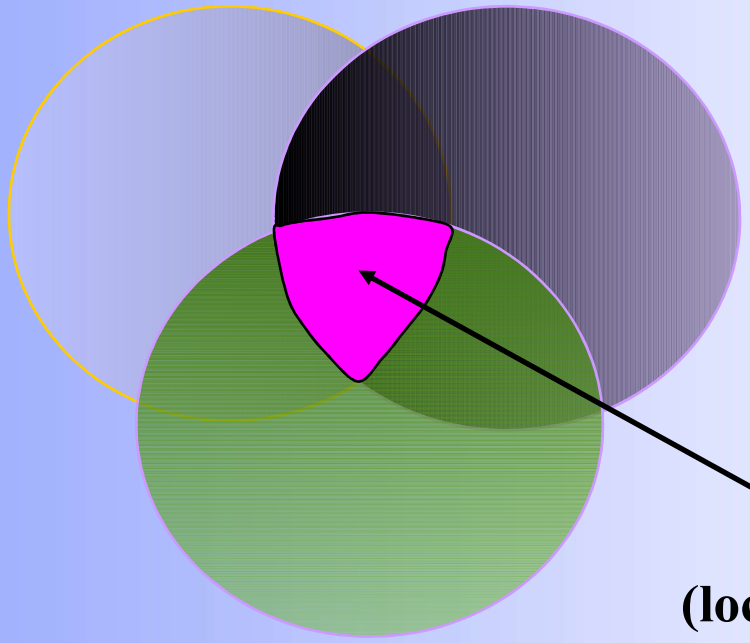
Nutrients: risk assessment

1: Field management

2: Field & landscape characteristics

Source

- Nutrients applied
- Available (mobile) nutrients in soil



Precipitation:transport

- Surface runoff
- Leaching (sub surface runoff)

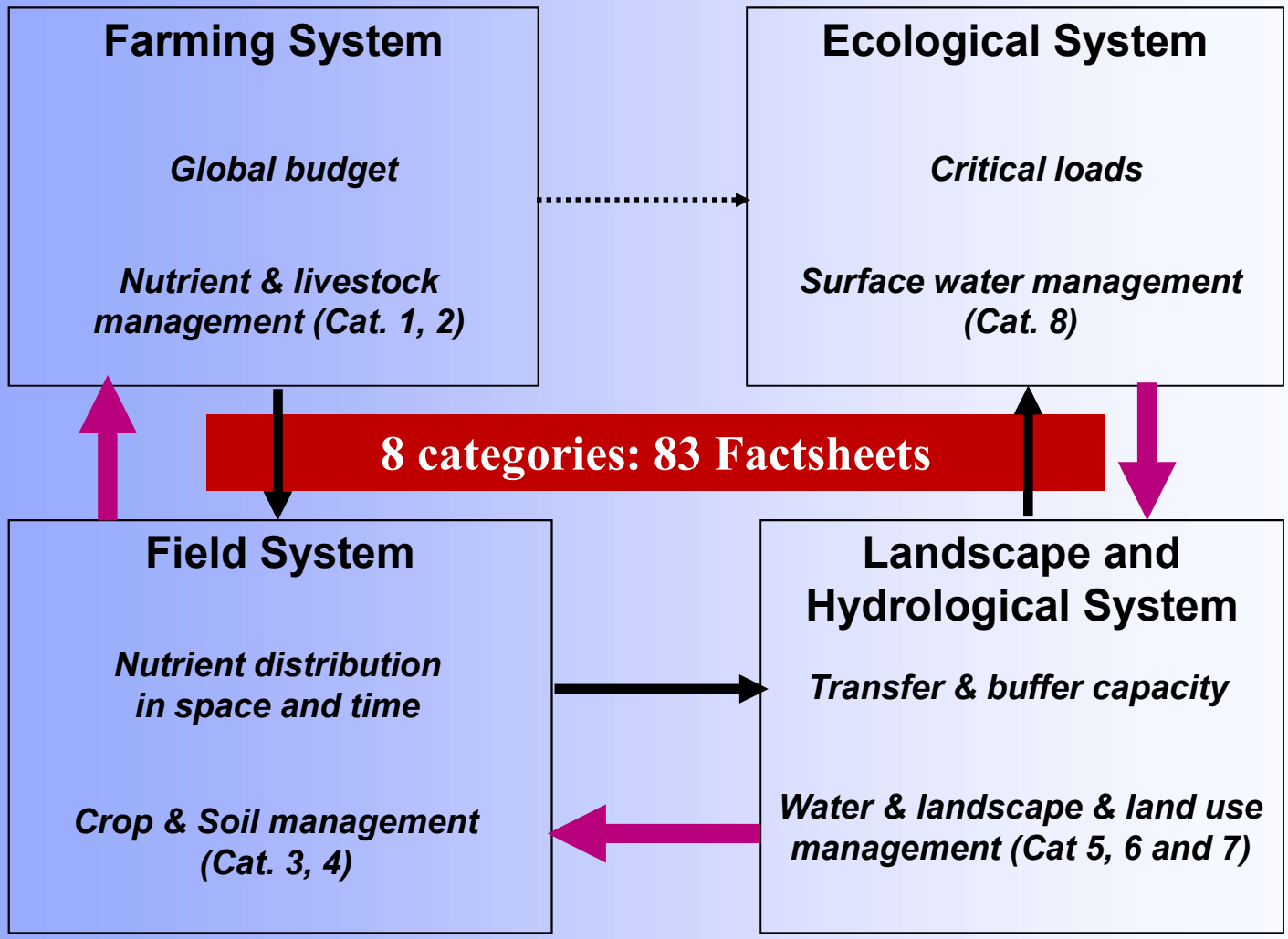
•**Hot spots**

(locally very high nutrient losses)

Connectivity

3: Interaction between field and surface water

Evaluation of mitigation options
(conceptual framework)



83 Factsheets: headings

- Description, incl. if effect is aimed at N or P
- Rationale, mechanism of action
- Relevance, applicability & potential for targeting
- Effectiveness, including uncertainty
- Time frame
- Environmental side-effects / pollution swapping
- Administrative handling, control
- Costs (investment, labor)
- References

General descritpion

Evaluation

Implementation

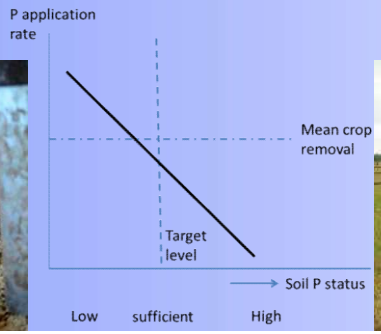
83 Factsheets
(http://www.cost869.alterra.nl)

Main results
I. Nutrient & Livestock management (Farm system)

Balance approach & agro-environmental approach:

- Reduce P (and/or N) content of animal feed to meet animal requirements
- Take into account the soil P status !!! Yet, no European P legislation
- Take into account the N mineralisation
- Manure separation in liquid (N, K) & solid (P, OM) fraction
- Number of animals/ha or export of mineral surplus (manure processing)
- Reduces farmyard losses (feed & manure stores, septic tanks, ...)

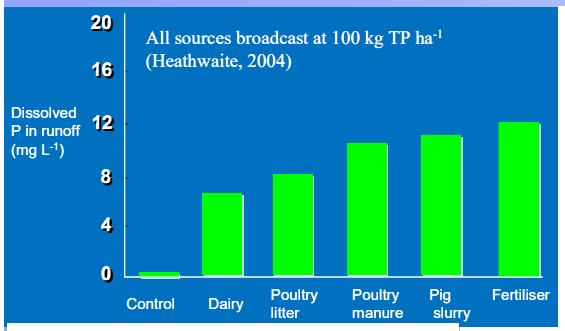
P content feed
20 -25% ↓

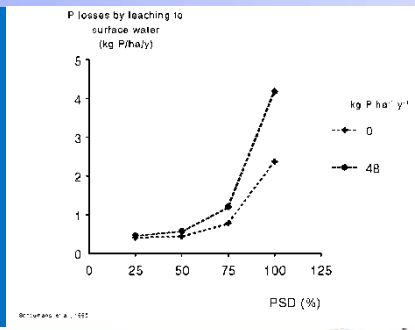


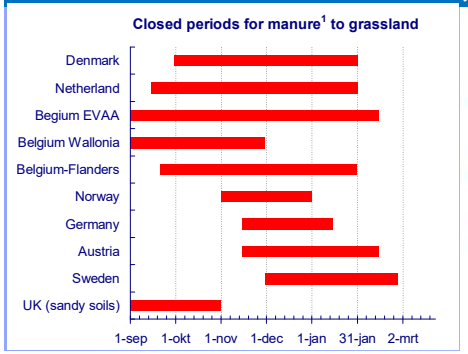
Main results
(II) Crop & Soil Management (Field system)

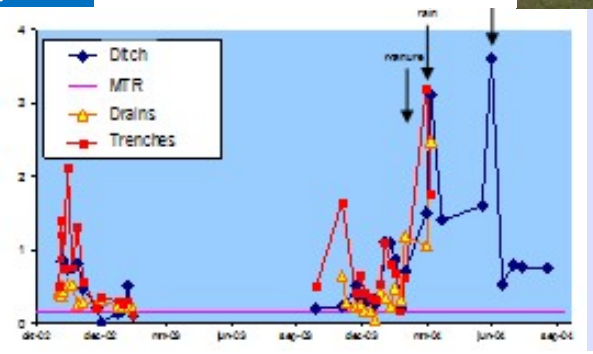
Crop: Stewardship (Increase efficiency & Reduce losses)

- Right source (manure type, fertilizer type)
- Right amount (application rate)
- Right place (patches, wide spreading, row / injection, direct ploughing)
- Right time (period of the year, just before a rain event)









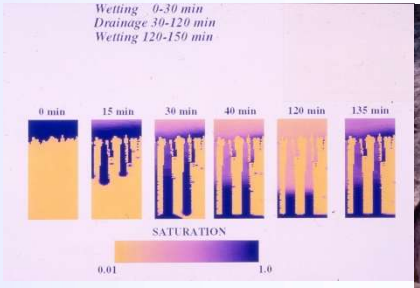
Main results
(II) Crop & Soil Management (Field system)

Soil

- Management of the field: restore uniformity!!
  - Trampled areas / tramlines
  - Preferential flow (cracked soils; fingered flow)
- Direct drilling/shallow cultivation and mulching/cover crops reduce erosion losses from high risk areas more than ploughing.
- Compared to autumn ploughing, on average a spring tillage reduces erosion risk and nutrient losses during winter.





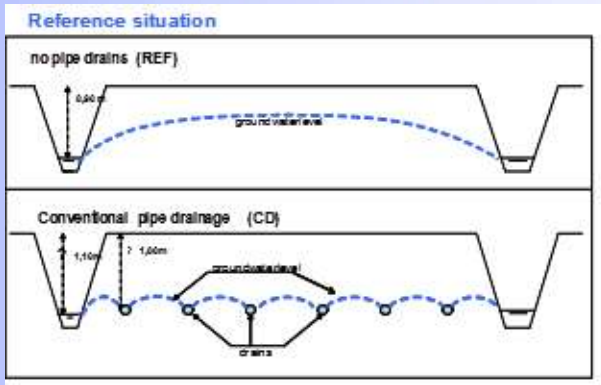


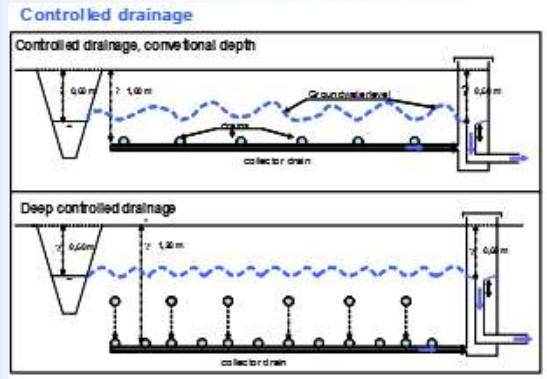


Main results
(III) Water, land use & landscape management

Controlling water flow

- Reduce nutrient concentration of overland water flow (grassed waterways).
- Reduce surface nutrient losses by buffer strips (store nutrients & sediments; uptake of dissolved nutrients by vegetation and biota, transformation such as sorption and denitrification).
- Reduce subsurface (leaching) nutrient losses by changing the drainage system (trenches, ditches and tile drains). E.g. Controlled tile drainage systems → change of the depth of the water discharge to surface waters.





Main results
(III) Water, land use & landscape management

Land use & landscape

- Reallocating the land use or change of crop type (high – low lands)
- Agro-forestry, nature development
- Physical barriers between grazing animals and surface water
- Catchment infrastructure: increase the water flow pathway and reduce water flow rate → increase the net buffer capacity e.g.
  - Ponding systems
  - Grassed waterways
  - Drop structures / sediment boxes
  - Field boundaries, like line elements (hedges, trees, etc)




Main results
(IV) Surface water management (ecological system)

- Surface water management to increase nutrient removal and storage processes is often applied in River Basin Management Plans because it is cost-effective for both N and P.
- River restoration and maintenance can assist in increasing nutrient retention and improving stream ecology.
- Wetlands: positive effect for N and sometimes negative for P (iron reduction)

Strategy for closing agricultural nutrient cycles

1. **Reuse** nutrients from organic residues
2. **Reduce** nutrients losses (increase nutrient efficiencies)
3. **Recover** nutrients from waste (and manure if needed)
4. **Redefine** systems, where needed

Report (144 pp)

Artikel: Science of the Total Environment 468–469:1255-1266.

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Mitigation options for reducing nutrient emissions from agriculture

A study amongst European member states of Cost action 869

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Mitigation options to reduce phosphorus losses from the agricultural sector and improve surface water quality: A review

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HIGHLIGHTS

- Various mitigation options to reduce phosphorus losses from agricultural land were described in terms of factsheets.
- Global budget systems and agro-environmental recommendations systems are useful tools for setting up a more sustainable agricultural management practice.
- At field scale different crop and soil management techniques are available to increase the P efficiency and reduce loss of P from the fields by erosion and runoff.
- At catchment scale the landscape and the hydrological system determines the buffer capacity, transfer and delivery of nutrients to the surface water systems and several options are available to reduce P losses.
- Finally, with surface water management measures the impact of nutrient loads on surface water quality can be reduced.

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ABSTRACT

The EU Water Framework Directive (WFD) obliges Member States to improve the quality of surface water and groundwater. The measures implemented to date have reduced the contribution of point sources of pollution, and hence diffuse pollution from agriculture has become more important. In many catchments the water quality remains poor. COST Action 869 was an EU initiative to improve surface water quality that ran from 2006 to 2011, in which 30 countries participated. Its main aim was a scientific evaluation of the suitability and cost-effectiveness of options for reducing nutrient loss from rural areas to surface waters at catchment scale, including the feasibility of the options under different climatic and geographical conditions. This paper gives an overview of various categories of mitigation options in relation to phosphorus (P). The individual measures are described in terms of their mode of action, applicability, effectiveness, time frame, environmental side-effects (Recycling) and cost. In total, 83 measures were evaluated in COST Action 869.

1. Introduction

The role of an excess of nutrients phosphorus (P) and nitrogen (N) in the eutrophication of surface water was recognised in the mid-20th century (Redfield, 1958; Vollenweider, 1968). Among the negative environmental effects of eutrophication are reduced functioning and biodiversity of aquatic ecosystems and decline in surface water quality (Scheffer, 1998; Smith et al., 1999). The Harmful Algal Blooms (HABs) associated with eutrophication produce toxic algal substances that kill fish (Carpenter et al., 1998; Jaworski, 1981) and cause disease in animals (Kotak et al., 1994; Main et al., 1977) and humans (Falconer, 1989; Lawrence et al., 1994). Nutrient loads to waters must be reduced to control eutrophication.

The relative concentrations of total N and P together with bioassays have been used to estimate which of these nutrients is limiting the growth of algae in aquatic systems (Atkinson and Smith, 1983; Healy et al., 1993; Redfield, 1958; Smith, 1983). For freshwater systems the indicative N:P weight ratios are ≤4.5 for N-limitation, 4.5–6 for intermediate conditions and ≥6 for P-limitation; the equivalent

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Conclusions

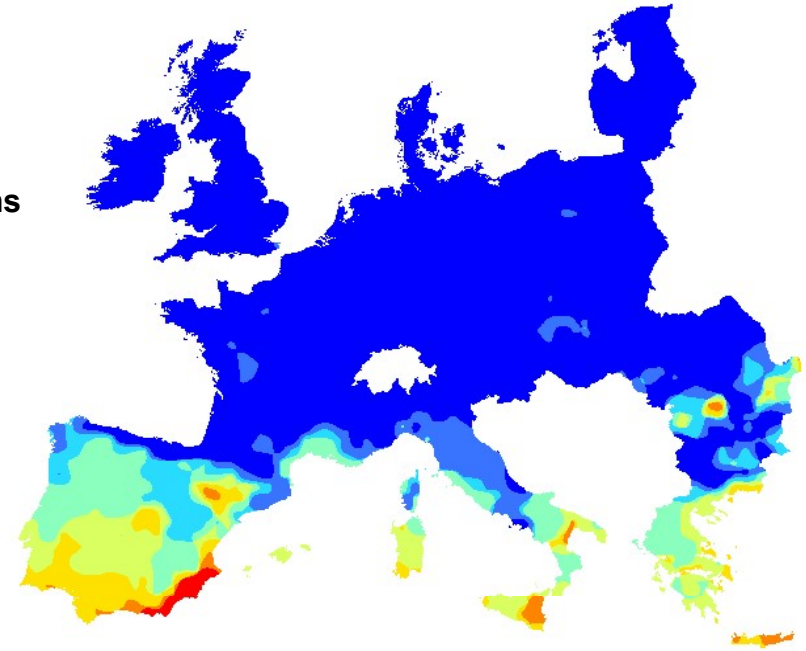
1. Causes of environmental losses are quite well known, however often more qualitatively than quantitatively and more often at local scale than catchment scale.
2. Many measures (farm, field and crop management) are no-regret measures: They should be part of Good Agricultural Practice (GAP)
3. Factsheets http://www.cost869.alterra.nl will help intermediaries, watershed managers & policy makers to implement the right measure at the right place to optimize the costs-benefits
4. Close open-minded interaction between policy makers and scientist in quite similar (macro) regional areas is important to develop effective and feasible strategies (e.g. CIS science-policy- working group)

Regionalization and current relevance

•Kirkby et al. 200

•Number of dry months
• (Rf/PE < 0.3)

•0
•1
•2
•3
•4
•5
•6
•7



•Actual climate

•2030, Hadley

(Rf/PE < 0.3)

0
1
2
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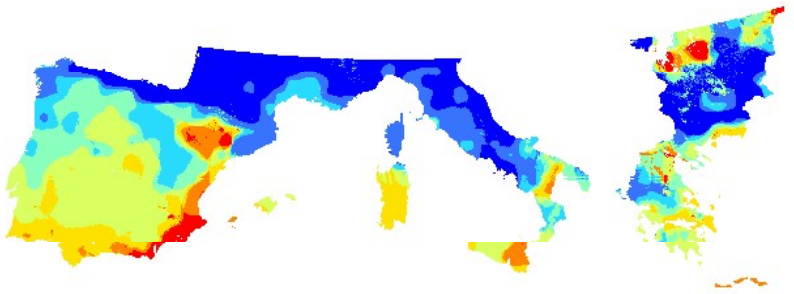


•Relevance of the flashy / intermittent rivers

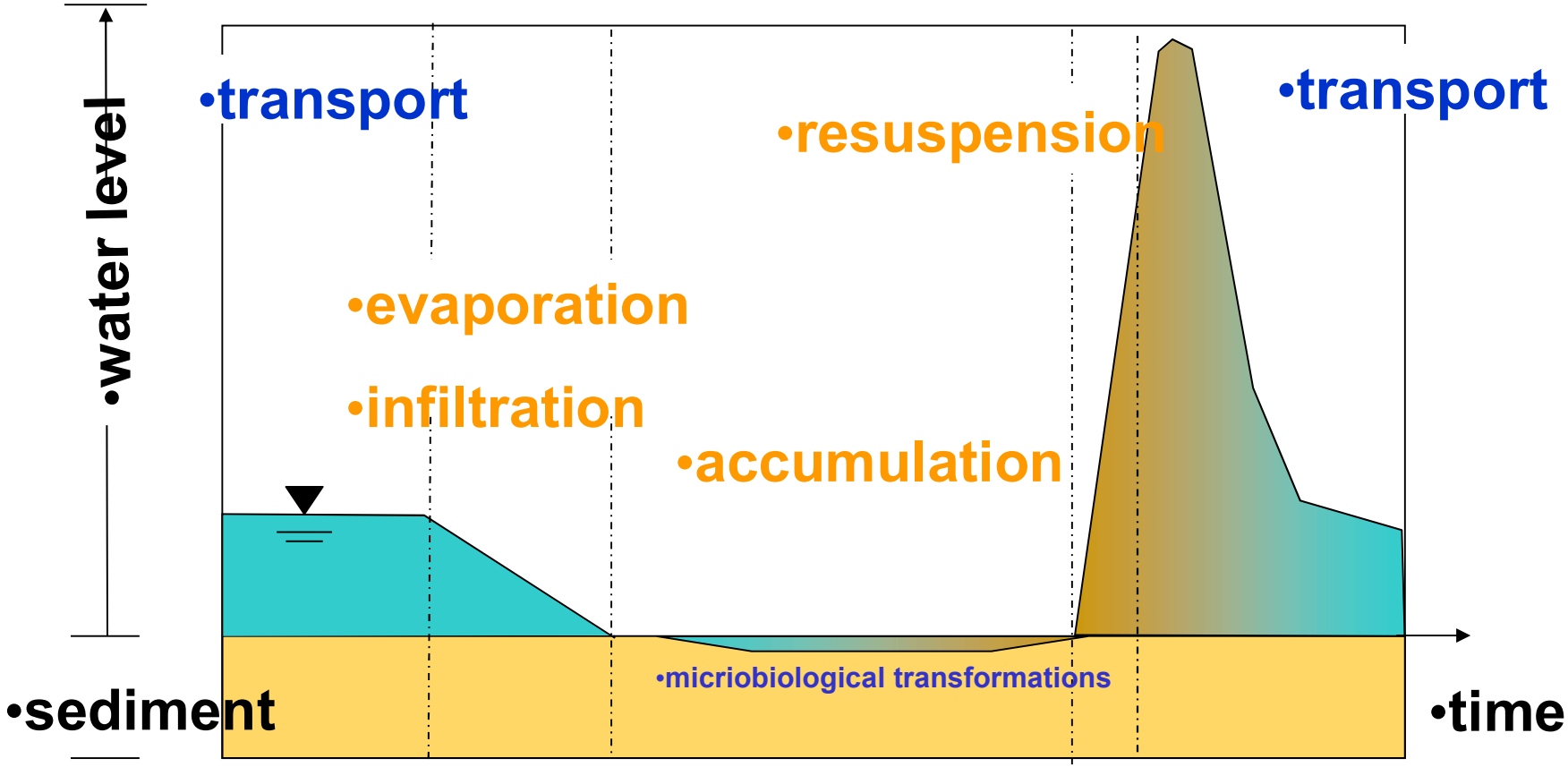
•Streamflow affects numerous processes, including sediment regime, channel formation, floodplain and flood processes, groundwater and surface water interactions, nutrient delivery, and water quality.

•In this region intermittent and ephemeral streams are very common fluvial systems.

•These rivers show a high rate of change in streamflow, high peak discharges, and low baseflow.

•A large part of their annual volume flows in a few days, delivering a great part of their sediment and nutrient loads

•water quality dynamics



•first flush effect

•first flood event

•Seasonal sequence

Considerations in Arid and Semi-Arid Watersheds

- Aquatic resources and management objectives are fundamentally different.
- Rainfall depths are much lower.
- Evaporation rates are much higher.
- Pollutant concentrations in stormwater are much greater.
- Vegetative cover is sparse in the watershed.
- Sediment movement is great.
- Dry weather flow is rare, unless return flows are present

To counteract the adverse effects of flash floods

- ✓ Increase travel time of runoff.
- ✓ Increase evapotranspiration.
- ✓ Increase infiltration.
- ✓ Provide overbank accumulation areas to allow controlled flooding to flatten flow peaks.
- ✓ Decrease erosion.
- ✓ Decrease nutrient and pesticide pools in upstream soils.

A list of potential BMPs should contain

- **Contour Stone Bounding** (line of stones or a stone bund along a contour; conservation of water and soil resources).
- **Soil Contour Bounding** (construction of small bunds across the slope of the land; soil conservation).
- **Permeable Rock Dams** (long, low structures across valley floors; controlling gully erosion and deposition of silt).
- **Tied Contour Ridges** (small earthen ridges; tree planting and crop production).
- **Check dams** (small dam constructed across a drainage line; lower the speed of concentrated flows, storm events, sediment reduction).
- Modification of soil structure and porosity to reduce erosion and P transfer via **catch crop** implementation and/or, **mulching** on maize fields and/or, **grass** under permanent cultures and vegetative.
- **Vegetative Filter Strips** (VFS).

Buffer types

Filter strips - Bands of grass along streams and lakes that filter storm runoff and waste water by trapping sediment, fertilizers, pesticides and other potential pollutants

Grassed waterways - Carry water from farm fields to nearby streams

Table 4. Design Modifications for Stormwater Practices in Arid and Semi-Arid Watersheds

Stormwater Practice	Arid Watersheds	Semi-Arid Watersheds
ED Dry Ponds	PREFERRED multiple storm ED stable pilot channels dry forebay	ACCEPTABLE dry or wet forebay needed
Wet Ponds	NOT RECOMMENDED evaporation rates are too high to maintain a normal pool without extensive use of scarce water	LIMITED USE liners to prevent water loss require water balance analysis design for a variable rather than permanent normal pool use water sources such as AC condensate for pool aeration unit to prevent stagnation
Stormwater Wetlands	NOT RECOMMENDED evaporation rates too great to maintain wetland plants	LIMITED USE require supplemental water submerged gravel wetlands can help reduce water loss
Sand Filters	PREFERRED requires greater pretreatment exclude pervious areas	PREFERRED refer to COA, 1994 for design criteria
Bioretention	MAJOR MODIFICATION no irrigation better pretreatment treat no pervious area xeriscape plants or no plants replace mulch with gravel	MAJOR MODIFICATION use runoff to supplement irrigation use xeriscaping plants avoid trees replace mulch with gravel
Rooftop Infiltration	PREFERRED dry well design for recharge of residential rooftops	PREFERRED recharge rooftop runoff on-site unless the land use is a hotspot
Infiltration	MAJOR MODIFICATION no recharge for hotspot land uses treat no pervious area multiple pretreatment soil limitations	MAJOR MODIFICATION no recharge for hotspot land uses treat no pervious area multiple pretreatment
Swales	NOT RECOMMENDED not recommended for pollutant removal, but rock berms and grade control needed for open channels to prevent channel erosion	LIMITED USE limited use unless irrigated rock berms and grade control essential to prevent erosion in open channels

Thank you for your attention