


From non-renevable resource to eutrophication – challenge for global phosphorus governance

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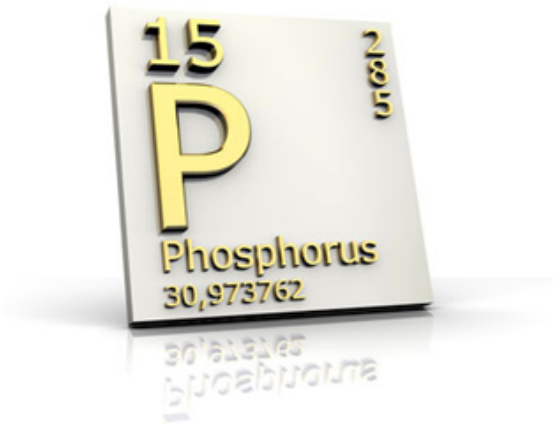
Plan of the lecture

- Phosphorus: *Why is P so important?*
- Challenges: *How much time we have and need?*
- P regulations at EU level: *acceleration is visible.*
- State and the future of P governance
- P recycling: *How to increase the time of P life to ensure susainability?*



Phosphorus

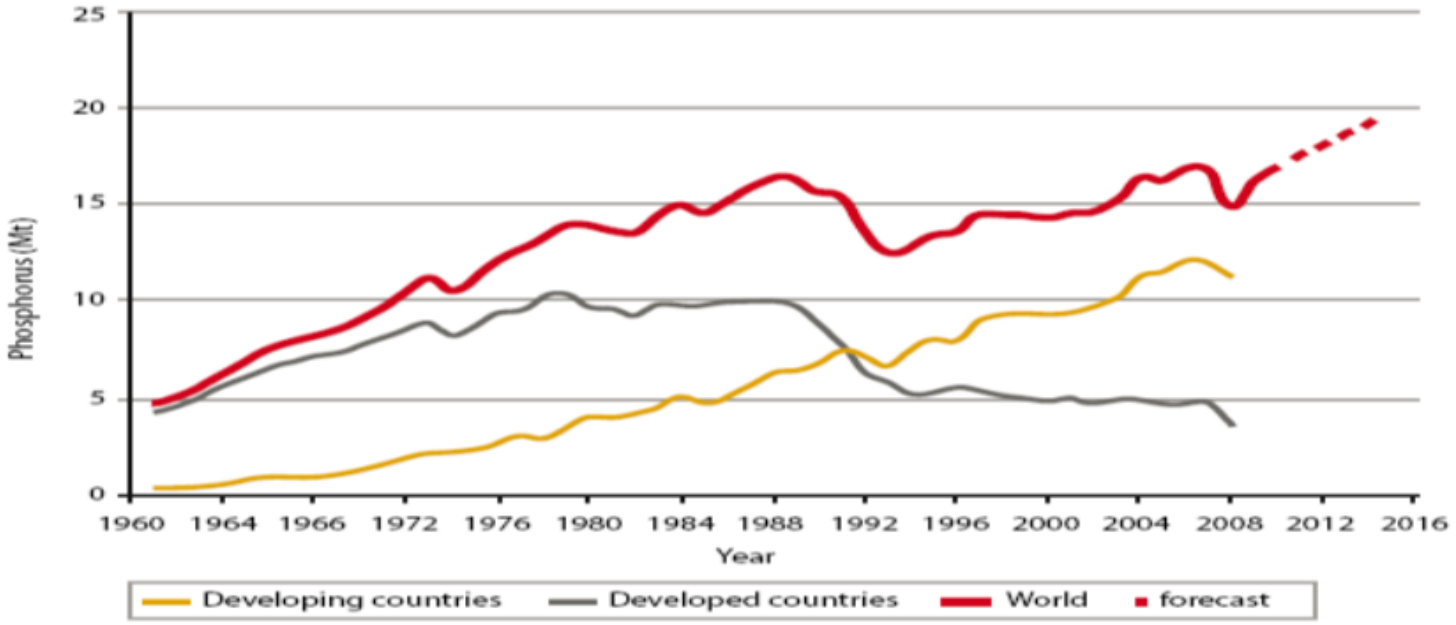
- is essential for food production,
- there is no known substitute for phosphorus in agriculture,

Around 90% of the phosphate rock extracted globally is for food production.

Phosphorus

- demand for phosphorus is increasing globaly (since the end of the 19th century),

Global phosphorus fertilizer consumption (Heffer and Prud'homme, 2010)



Increasing population, global diet trends (more meat and dairy) and biofuel production increasing the land area.

Phosphorus

- its global supply is limited,

Estimates of availability of remaining phosphate rock reserves (Cordell, 2010)

Author	Estimated lifetime of reserves	Assumptions/notes
Steen (1998)	60-130 years	2-3% increase demand rates, 'most likely' 2% increase until 2020 and 0% growth thereafter if efficiency and reuse measures are implemented.
Smil (2000)	80 years	At 'current rate of extraction'
Smit *et al.* (2009))	69-100 years	Assuming 0.7-2% increase until 2050, and 0% increase after 2050
Vaccari (2009)	90 years	At 'current rates'
Fixen (2009)	93 years	At 2007-2008 production rates

It takes 10 - 15 million years to form phosphate rock.

Phosphorus

- reserves are geographically concentrated

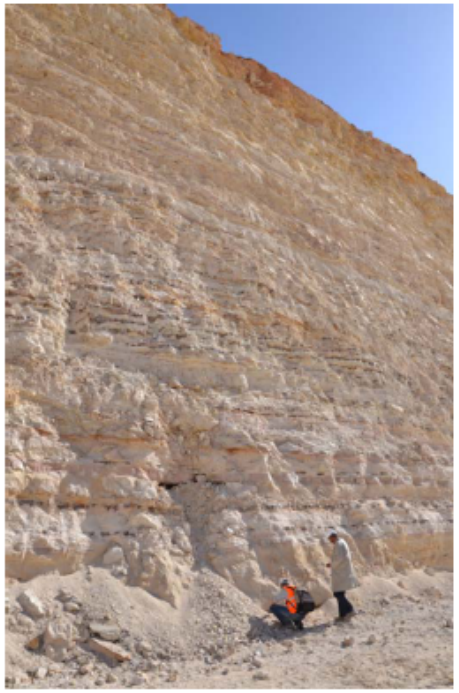
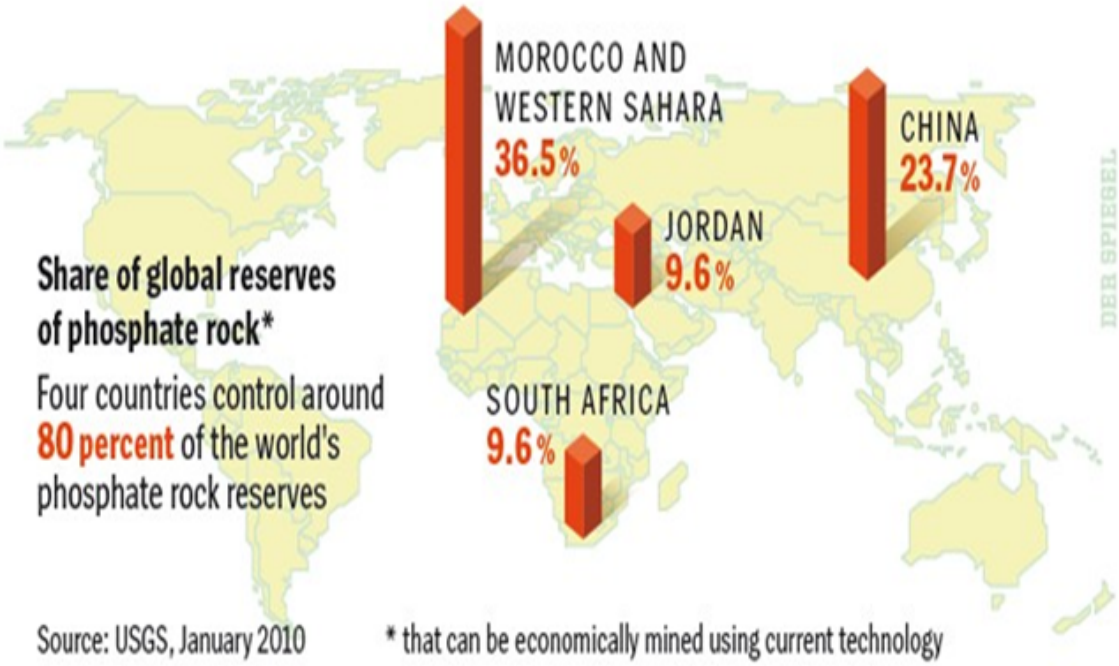


Photo: D. Rappen, ETH Zurich

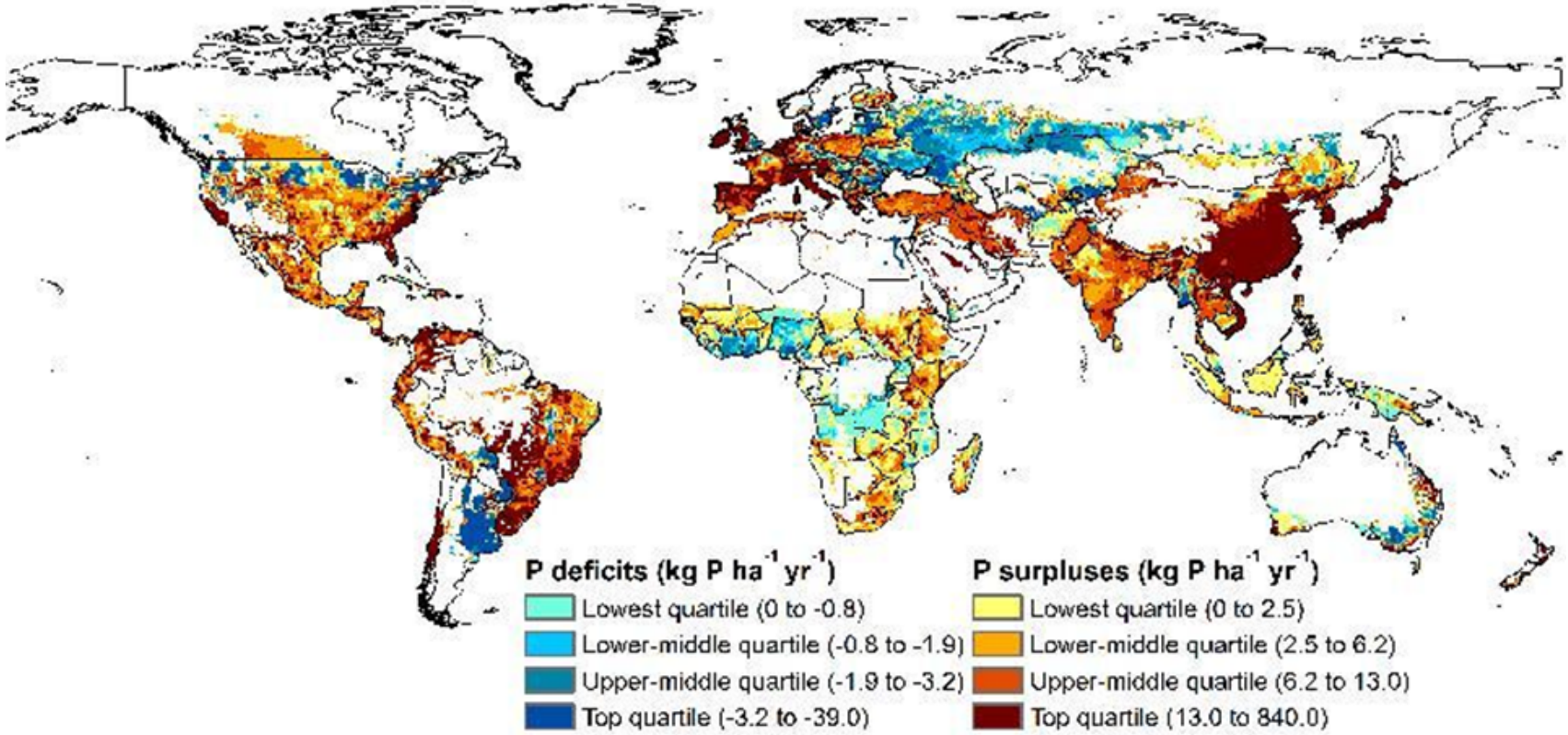
Sedimentary phosphate deposits at Sidi Chennane, Morocco.



Security of supply / political stability of the countries

Global map showing imbalances in the way that phosphorus, an essential plant nutrient, is being used around the world.

(Credit: G. K. MacDonald, E. M. Bennett, P. A. Potter, N. Ramankutty. Agronomic phosphorus imbalances across the world's croplands. Proceedings of the National Academy of Sciences, 2011.)



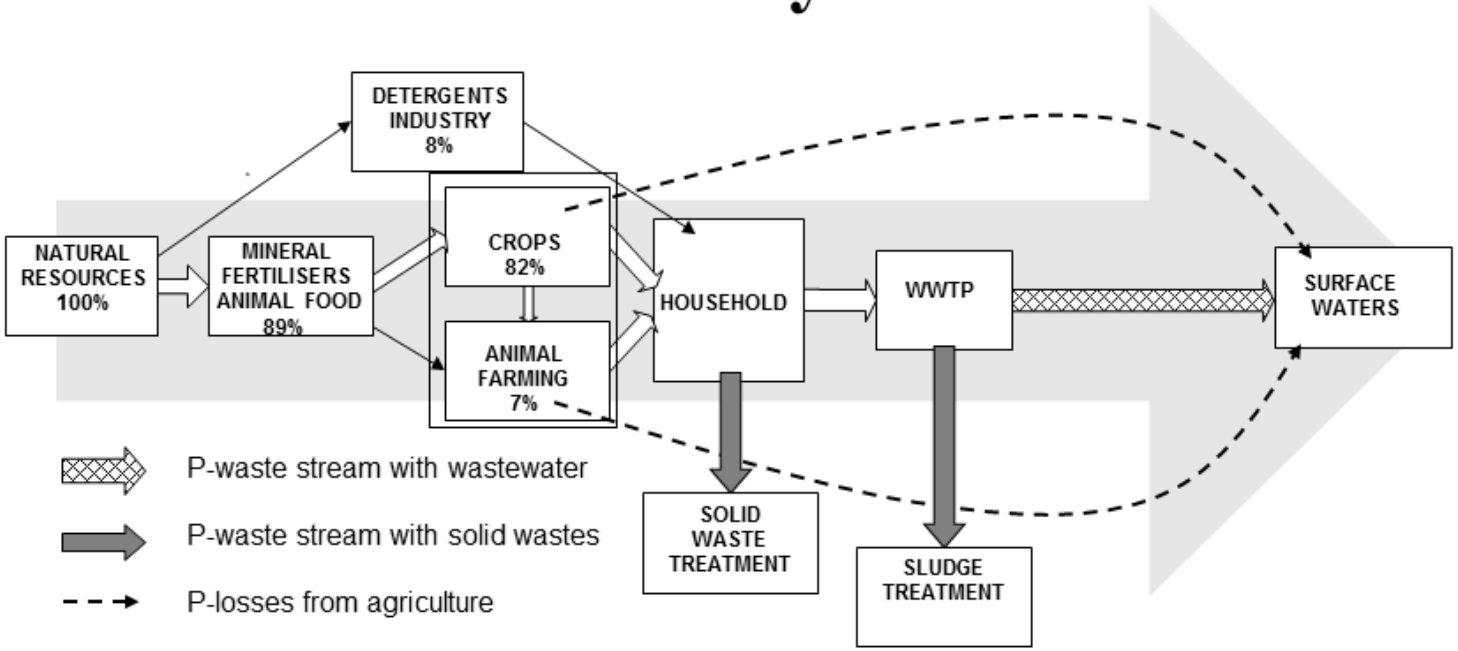
"Until you can quantify how phosphorus is actually currently being used, it's difficult for policy-makers to go ahead and make informed decisions at a national or global scale."

Phosphorus

- energy intensive process of mining, processing and transporting phosphate rock and fertilizers

Around 30% of energy use in agriculture in the US is from fertilizer production and use.

Short „life” of P in consumming oriented society



Phosphorus

- phosphorus concentrations in freshwater and terrestrial systems have increased by at least 75% in the last half-century.

Cost of controlling just the P input alone would be as much as 90% less than to control both P and N *(Schindler 2012)*

Phosphorus

- Small ponds in agricultural landscape

year 1972 and...

30 years later

- Ensure food security,
- Dercrease use of P mined,
- Increase P independence (eg. EU),
- Dercrease environmental impact of P:
  - mining, processing, transporting (energy, emissions),
  - wastewater and agricultural run-off streams (water quality).

Phosphorus import to EU 27

- Annual import of 3 kg P per person (500 mln citizens)

in form of fertilizer (finished products), phosphoric acid, phosphate rock, feed additives **(70%)**

in form of traded goods (food, feed, feed concentrates) **(30%)**

Sustainable phosphorus use report

EU Regulations

- the existing European regulatory framework, such as the **Nitrates Directive (1991)** and the **Water Framework Directive (2000)**, focuses on combating the leaching of nitrogen, **not phosphorus**,

- the majority of agro-environmental measures under the **Common Agricultural Policy** are designed around a definition of **nutrients as a 'pollution'** problem, rather than from a resource management and recycling perspective.

Baltic Sea Action Plan (2007)

- there are no regulatory targets for phosphorus management within the EU.

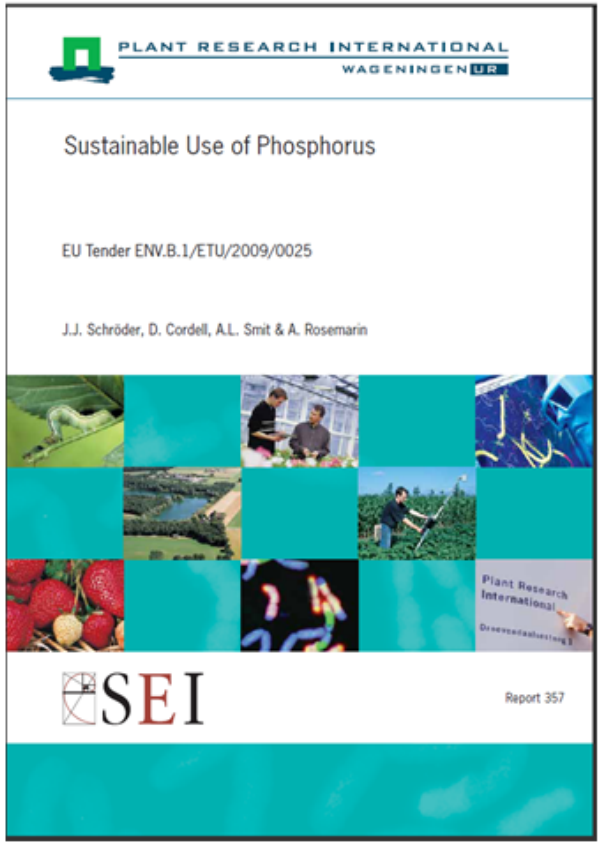
- in the Baltic Sea Region, only the Baltic Sea Action Plan stipulates phosphorus targets, and they are **strictly voluntary**.

http://www.helcom.fi/stc/files/BSAP/BSAP_Final.pdf

Report on „**Sustainable use of phosphorus**” (2010)

EU food security relies on imported phosphorus, both in fertilisers and ‘embedded' in imported foods and animal feeds.

Actions should be engaged to **reduce Europe's phosphorus dependency**, including optimizing land use and agricultural P use, P-recovery and recycling, reducing food wastes and P-losses.



http://ec.europa.eu/environment/natres/pdf/sustainable_use_phosphorus.pdf

Roadmap to a Resource Efficient Europe (EC 2011)

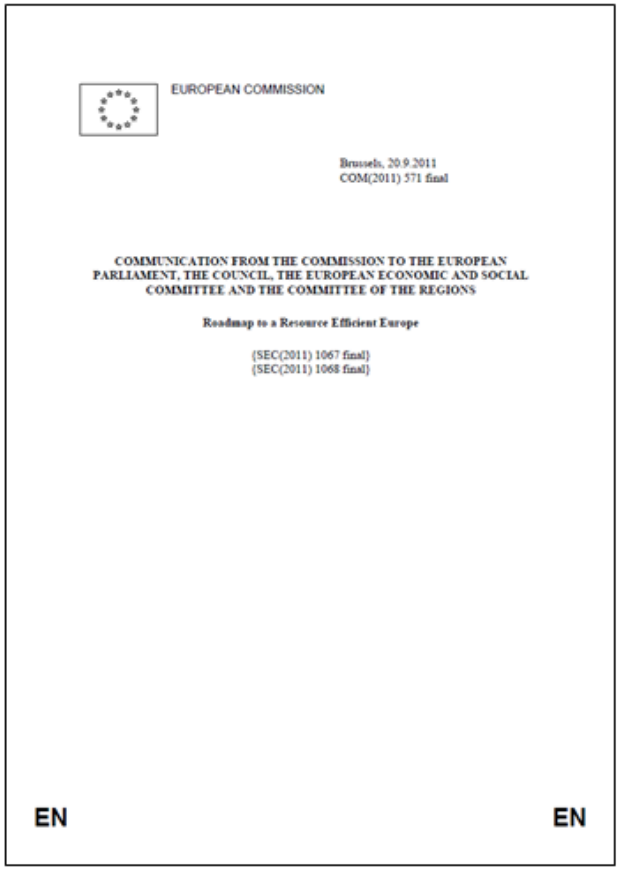
In areas such as:

- consumption and production,
- waste,
- ecosystem services.

Approval to explore future governance alternatives for **promoting effective recycling across sectors in society**.

One of major interest here:

„Green paper on phosphorus” in 2012



EUROPEAN COMMISSION

Brussels, 20.9.2011
COM(2011) 571 final

COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS

Roadmap to a Resource Efficient Europe

{SEC(2011) 1067 final}
{SEC(2011) 1068 final}

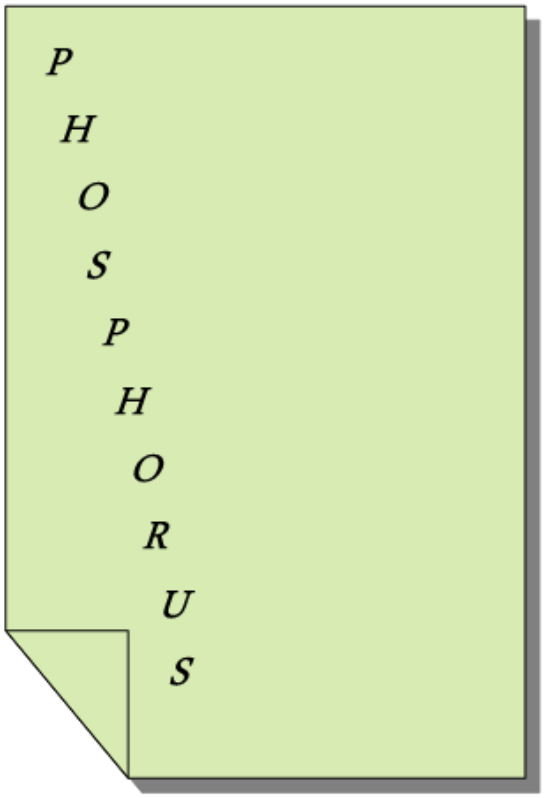
EN EN

http://ec.europa.eu/environment/resource_efficiency/pdf/com2011_571.pdf

Green Paper on Phosphorus (2012)

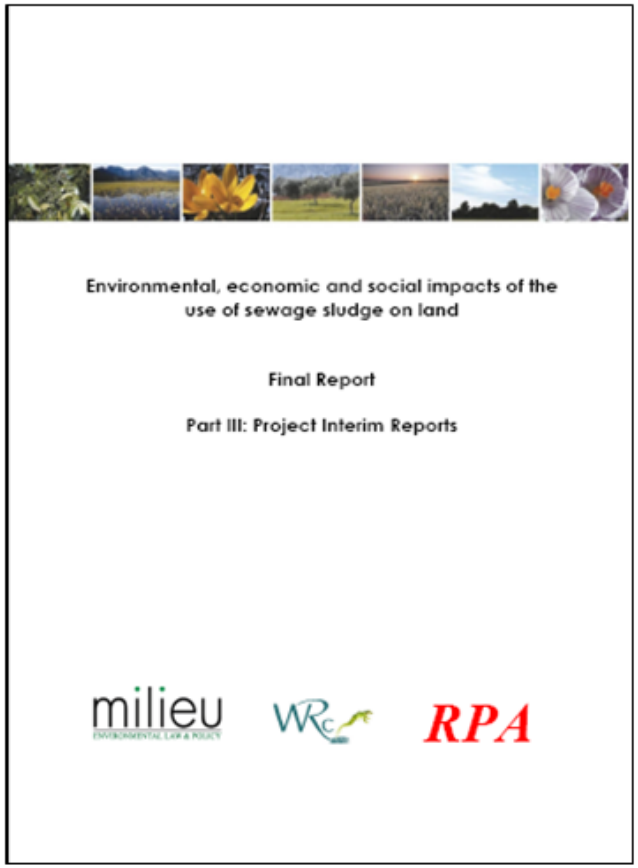
- Will be a basis of discussion with stakeholders and institutions, to define a phosphorus resource efficiency strategy,

- European Green Paper on Phosphorus is being prepared by the European Commission and should be published in early summer 2012.



Wastewater sludge in EU

- **Production increased** dramatically with the implementation of environmental programms to improve the quality of discharges from WWTP.
- Directive 86/278/EEC requires that sewage sludge **has to be treated before use in agriculture**
- Different terms and doses
- In some countries prohibited



http://ec.europa.eu/environment/waste/sludge/pdf/part_iii_report.pdf

Situation in EU (SEI report 357 /2010)

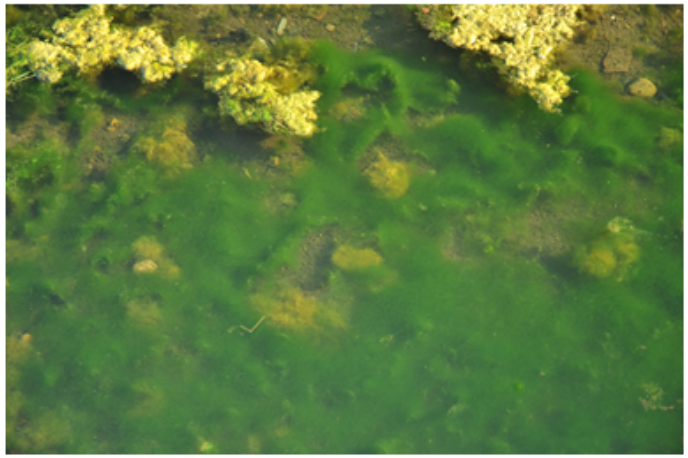
- Phosphorus entering Swiss households in the form of food is 7,5 Mkg of P annualy. **Only 24% of this amount is reused in agriculture (half of it as sewage sludge and other half as compost).** More than 90% of the sewage sludge is incinerated and the resulting ashes are not recycled but end up in a deposit.

- Phosphorus in food entering the Dutch households is nearly 20 Mkg. **10% (2 Mkg of P) is recycled to agriculture or private gardens.** Agriculture reuse of sludge is banned in the Netherlands and sludge is incinerated.

Some initiatives now starting:

- Sweden has an environmental goal decided by its parliament, **to recycle 60% of the phosphorus from wastewater as fertiliser, and half of these back to agricultural land, at the latest in 2015**.

- The association of Waterboards in the Netherlands have recently put in their policy statement incentives **to stimulate the recovery of phosphorus from municipal waste water.**



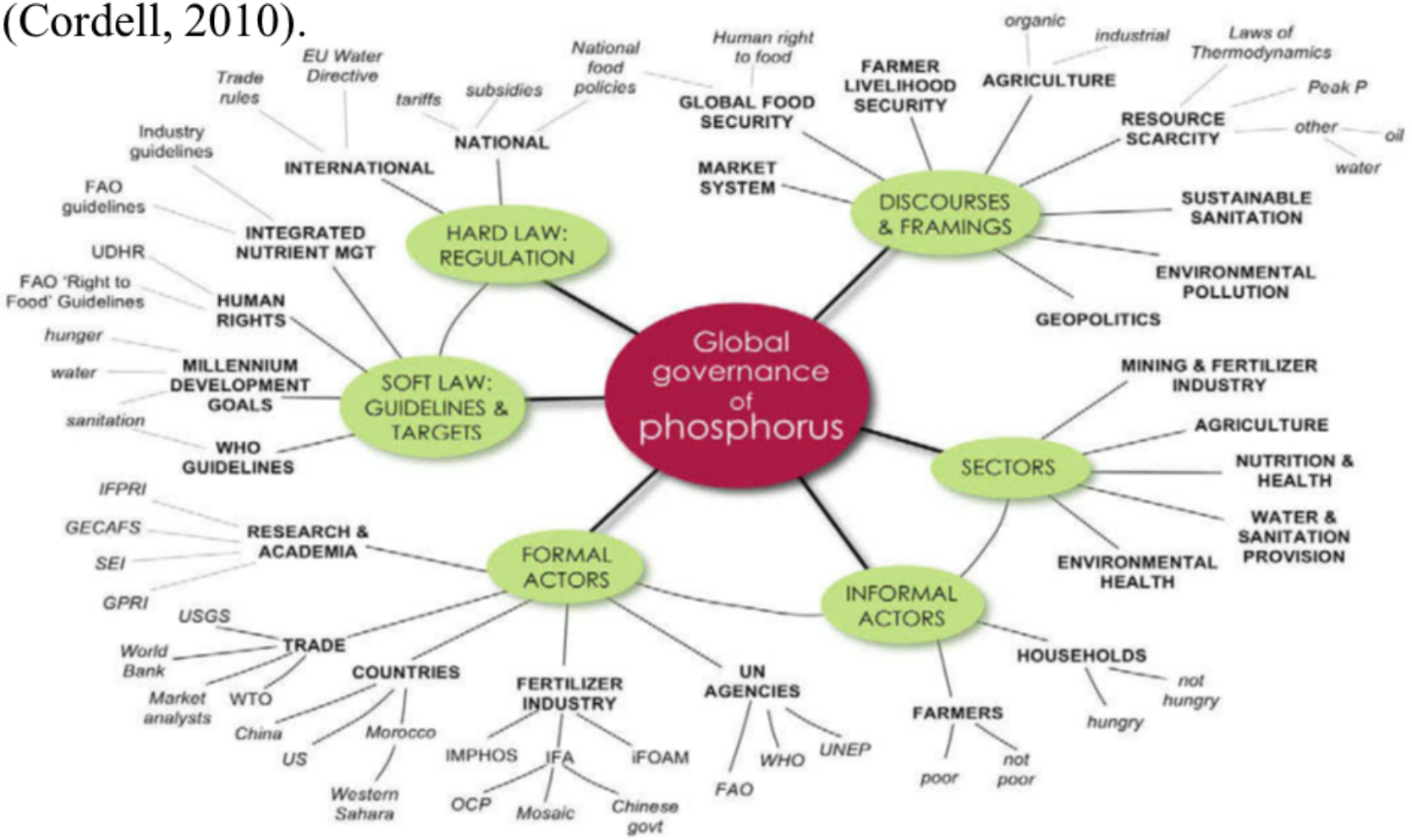
EU phosphorus recycling potential

- **The EU could recycle about 50% of its annual phosphate consumption** of 1.34 million tonnes of phosphorus in the form of phosphate fertilizers (Haarr, 2005).

Gaps in EU P related legislations

- P as a resource - lack of proper law for sustainable management,
- P as a nutrient - regulations on fertiliser use exists,
- P as a „recycled nutrient" – no clear regulation,
- P as a pollutant – regulations on wastewater treatment exists,

Map of various institutional elements governing global phosphorus, including: regulations, policy, actors, sectors and discourses or framings (Cordell, 2010).



FAO *Food and Agricultural Organization of the United Nations;* GECAFS *Global Environmental Change and Food Systems program;* GPRI *Global Phosphorus Research Initiative;* IFA *International Fertilizer Industry Association;* iFOAM *International Federation of Organic Agriculture Movements;* IFPRI *International Food Policy Research Institute;* IMPHOS *The World Phosphate Institute;* OCP *Office Cherifien de Phosphate (Morocco's phosphate company);* SEI *Stockholm Environment Institute;* UDHR *Universal Declaration on Human Rights;* UN *United Nations;* USGS *US Geological Survey;* WHO *World Health Organization of the United Nations;* WTO *World Trade Organization*

Cordell, 2010. The story of phosphorus...

Future P governance:

10 DRAFT CRITERIA FOR PHOSPHORUS SUSTAINABILITY IN THE CONTEXT OF GLOBAL FOOD SECURITY (Cordell 2008)

1. **Long-term timeframes** (50-100 years);
2. **Equitable** distribution (**accessible** and **affordable** to all farmers) – either fertilizer markets are accessible, or access to non-market fertilizers such as manure and excreta;
3. **Cost-effective** from a whole-of-society perspective (not single stakeholder perspective);
4. Sufficient quantity and quality (ie. future **demand** can be met by **supply**);
5. **Minimal adverse environment impacts**, including at all key life-cycle phases (eg. cadmium levels and radium-phosphogypsum management at the mine, energy intensity of production and transport, minimises losses to waterways).

Cordell, 2008. SENSE Earth system governance; Cordell, 2010. The story of phosphorus...

Future P governance:

10 DRAFT CRITERIA FOR PHOSPHORUS SUSTAINABILITY IN THE CONTEXT OF GLOBAL FOOD SECURITY (Cordell 2008)

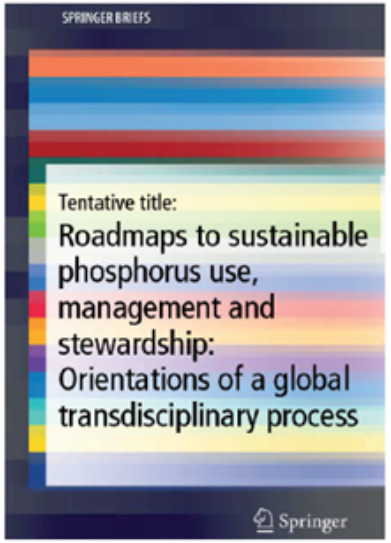
6. **Minimal losses** in the entire food production and consumption system;
7. **Ethical sources, distribution and use** - not supporting and trading with a country illegally occupying regions with phosphate reserves.
8. Potential synergies and/or **value-adding** to other systems (eg. water, energy, sanitation, poverty reduction, environmental health).
9. Independent **monitoring** of phosphorus resources and future trends, **transparent** and publicly available data and analysis (eg. P rock resources, future demand scenarios).
10. **Adaptive capacity to respond to shocks** (eg. price, peak P, geopolitical disruptions etc.).

Cordell, 2008. SENSE Earth system governance; Cordell, 2010. The story of phosphorus...

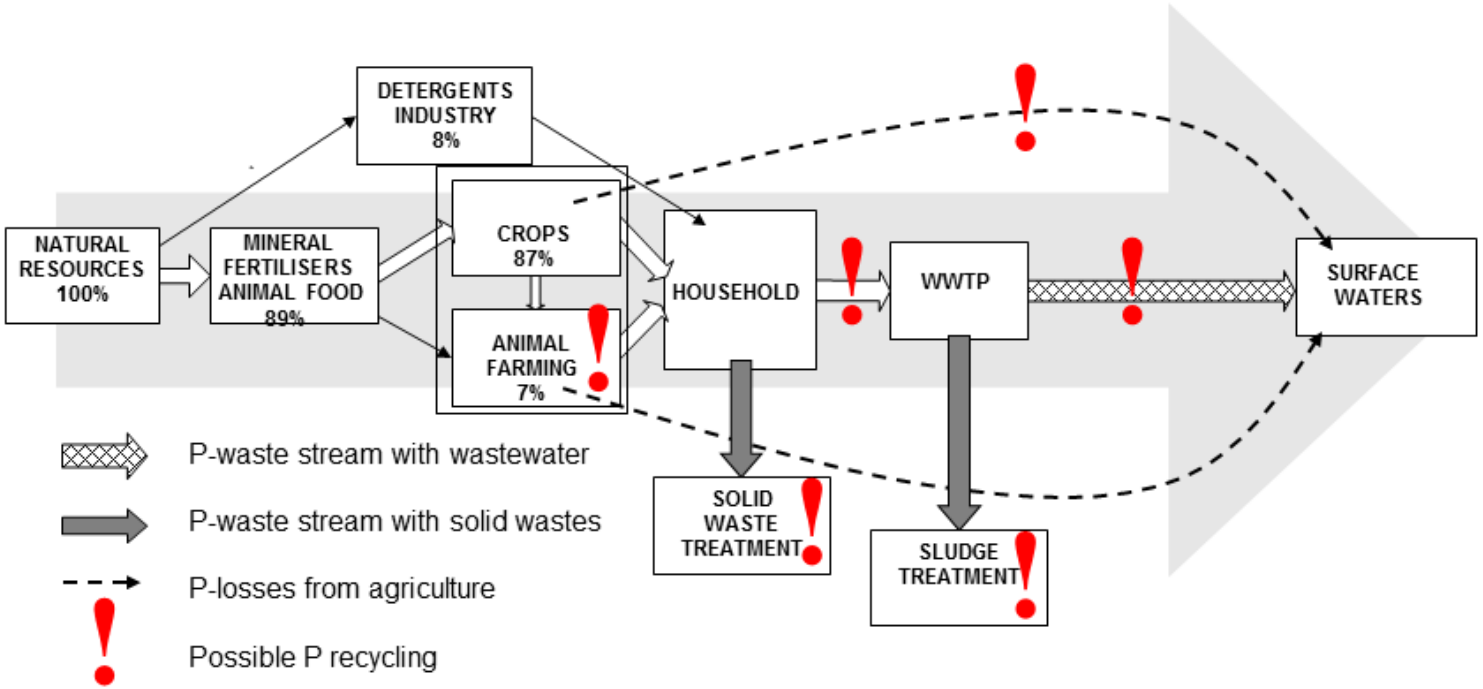
New governance measures are required to ensure that P use is sustainable

A new regulatory approach would need to…

…capture the required holistic perspective in a regulatory framework as part of governance.



Options for P recycling



What can be improoved?

- P-mining
- P-industry
- P-use in agriculture
- Household level
- Wastewater and sludge
- Surface water (P-receivers)

What can be improved? P-mining

- Extraction now rather efficient in many mines, up to 95% of prospect estimates,

but...

- Still potential to improve extraction technologies, digging techniques, benefication techniques, reuse of process water, use of by-products, processing of tailings in many cases.
- Deposits that are considered unsuitable for conventional products may be suitable for unconventional products.
- Some by-products currently inexploitable for technological and economic reasons.

What can be improved? P-processing

Treatment of phosphate rock with sulfuric acid to form phosphorus fertilizer.

Jerry Grigar & J. Lemunyon

What can be improved? Detergents industry

REGULATION No 259/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 14 March 2012 amending Regulation (EC) No 648/2004 as regards the use of phosphates and other phosphorus compounds in consumer laundry detergents and consumer automatic dishwasher detergents

L 94/16 EN Official Journal of the European Union 30.3.2012

REGULATION (EU) No 259/2012 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL
of 14 March 2012
amending Regulation (EC) No 648/2004 as regards the use of phosphates and other phosphorus compounds in consumer laundry detergents and consumer automatic dishwasher detergents
(Text with EEA relevance)

THE EUROPEAN PARLIAMENT AND THE COUNCIL OF THE EUROPEAN UNION,

Having regard to the Treaty on the Functioning of the European Union, and in particular Article 114 thereof,

Having regard to the proposal from the European Commission,

After transmission of the draft legislative act to the national parliaments,

Having regard to the opinion of the European Economic and Social Committee (1),

Acting in accordance with the ordinary legislative procedure (2),

Whereas:

(1) In its Report of 4 May 2007 to the Council and the European Parliament, the Commission evaluated, pursuant to Regulation (EC) No 648/2004 of the European Parliament and of the Council (3), the use of phosphates in detergents. Following further analysis, it has been concluded that the use of phosphates in consumer laundry detergents and consumer automatic dishwasher detergents should be limited in order to reduce the contribution of phosphates from detergents to eutrophication risks and to reduce the cost of phosphate removal in waste water treatment plants. Those cost savings outweigh the cost of reformulating consumer laundry detergents with alternatives to phosphates.

(2) Efficient alternatives to phosphate-based consumer laundry detergents require small amounts of other phosphorus compounds, namely phosphonates which, if used in increasing quantities, might be of concern for the environment. While it is important to encourage the use of alternative substances with a more favourable environmental profile than phosphates and other phosphorus compounds in the manufacture of consumer laundry detergents and consumer automatic dishwasher detergents, such substances should, under their normal conditions of use, present no risk, or a lower risk, to humans and/or the environment. The REACH (4) system should therefore, where appropriate, be used to evaluate such substances.

(3) The interaction between phosphates and other phosphorus compounds requires a careful choice of the scope and level of the limitation on the use of phosphates in consumer laundry detergents and consumer automatic dishwasher detergents. The limitation should apply not only to phosphates, but also to all phosphorus compounds in order to preclude a mere substitution of other phosphorus compounds for phosphates. The limit on phosphorus content should be low enough to effectively prevent the marketing of phosphate-based consumer laundry detergent formulations, while being high enough to allow the minimum quantity of phosphonates required for alternative formulations.

(4) It is currently not appropriate to extend limitations on the use of phosphates and other phosphorus compounds in consumer laundry detergents and consumer automatic dishwasher detergents to industrial and institutional detergents at the level of the Union because suitable technically and economically feasible alternatives to the use of phosphates in those detergents are not yet available. As concerns consumer automatic dishwasher detergents, alternatives are likely to be more widely available in the near future. It is therefore appropriate to provide a restriction on the use of phosphates in those detergents. Such a restriction should apply from a future date by which time alternatives to phosphates are expected to be widely available, in order to stimulate the development of new products. It is also appropriate to specify a maximum permissible phosphorus content, based on evidence including existing national restrictions for phosphorus in consumer automatic dishwasher detergents. However, it is also necessary to provide that the Commission should, before that restriction becomes applicable throughout the Union, carry out a thorough assessment of the limit value based on the most recent available data and, if justified, present a legislative proposal. That assessment should cover the impact on the environment, industry and consumers of consumer automatic dishwasher detergents with phosphorus levels above and below the limit value set out in Annex VIa

(1) OJ C 133, 3.5.2011, p. 71.
(2) Position of the European Parliament of 14 December 2011 (not yet published in the Official Journal) and decision of the Council of 10 February 2012.
(3) OJ L 104, 2.4.2004, p. 1.
(4) Regulation (EC) No 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH), establishing a European Chemicals Agency (OJ L 396, 30.12.2006, p. 1).

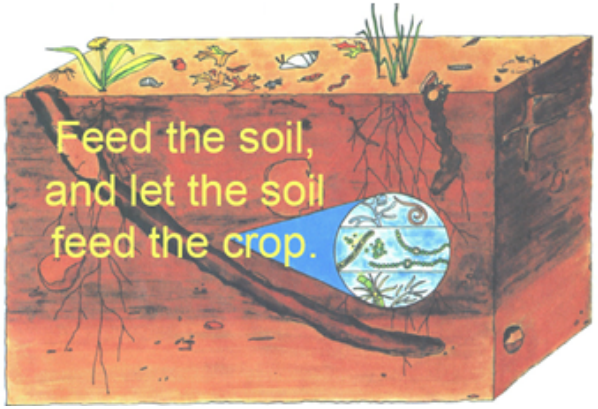
'*ANNEX VIa*

LIMITATIONS ON THE CONTENT OF PHOSPHATES AND OF OTHER PHOSPHORUS COMPOUNDS

Detergent	Limitations	Date as of which the limitation applies
1. Consumer laundry detergents	Shall not be placed on the market if the total content of phosphorus is equal to or greater than 0,5 grams in the recommended quantity of the detergent to be used in the main cycle of the washing process for a standard washing machine load as defined in section B of Annex VII for water of hard water hardness — for "normally soiled" fabrics in the case of heavy-duty detergents, — for "lightly soiled" fabrics in the case of detergents for delicate fabrics,	30 June 2013
2. Consumer automatic dishwasher detergents	Shall not be placed on the market if the total content of phosphorus is equal to or greater than 0,3 grams in the standard dosage as defined in section B of Annex VII	1 January 2017'

What can be improved?
P management in agriculture

- Focus on **use efficiency,**
- **Appropriate fertilisation practices** (esp. manure use - increasingly evident in EU),
- **Erosion control,**
- **P accumulated in soil** - it is a big bank of P in the future (in China, it has been estimated that 85 million tonnes has accumulated in the soil since 1985).



Jerry Grigar & J. Lemunyon

What can be improved?
P management in household scale

- Use of P free detergents

- Change in consumption (quantity) and diet

What can be improved? P management in household scale

- Separate and compost organic waste

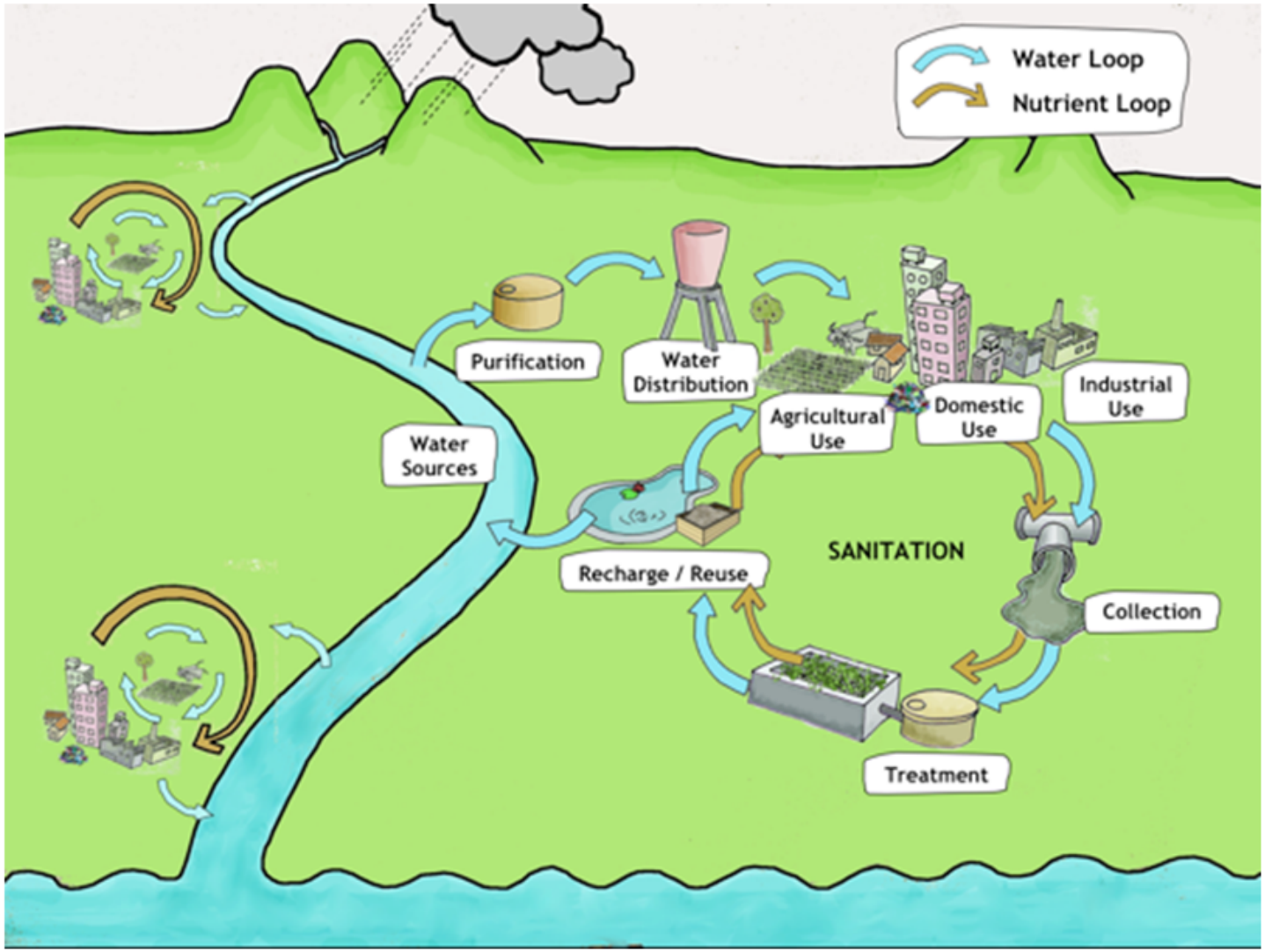
What can be improved?
P management in household scale

- „Scoop the poop”
- Plant a buffer
- Control your roof runoff
- ...



What can be improved? Wastewater

- Linking sanitation and agriculture
  - Urban wastewater treatment systems
  - On site treatment
  - Ecological sanitation


Water Loop
Nutrient Loop
Purification
Water Distribution
Water Sources
Agricultural Use
Domestic Use
Industrial Use
SANITATION
Recharge / Reuse
Collection
Treatment

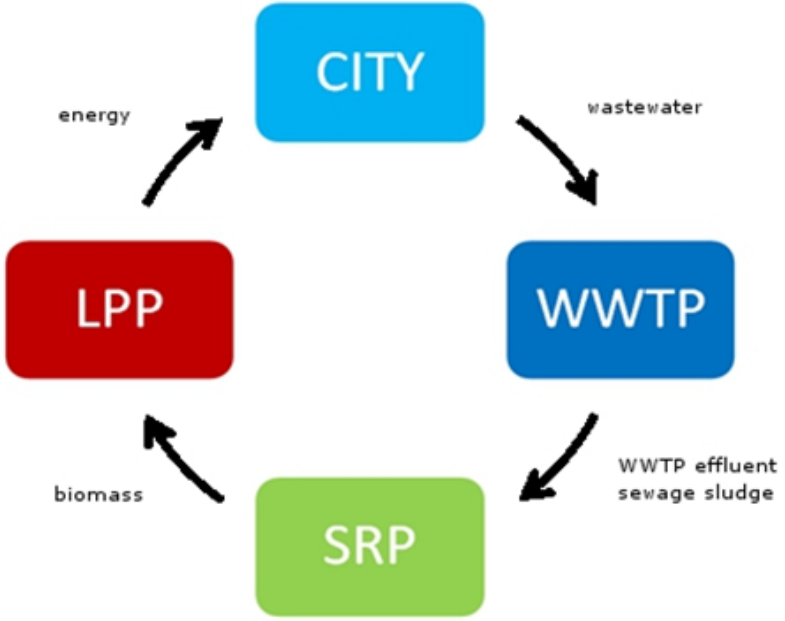
Fish cultured in wastewater-fed

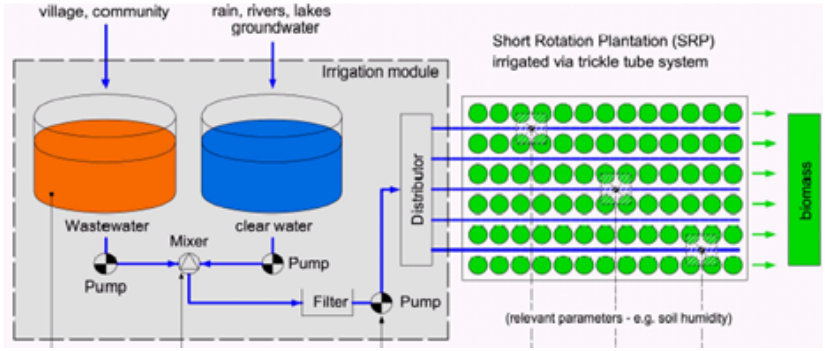
Harvesting water spinach cultivated in sewage

Harvesting duckweed cultivated on contaminated surface water to feed fish

Linking sanitation and agriculture

Urban wastewater treatment systems





Linking sanitation and agriculture

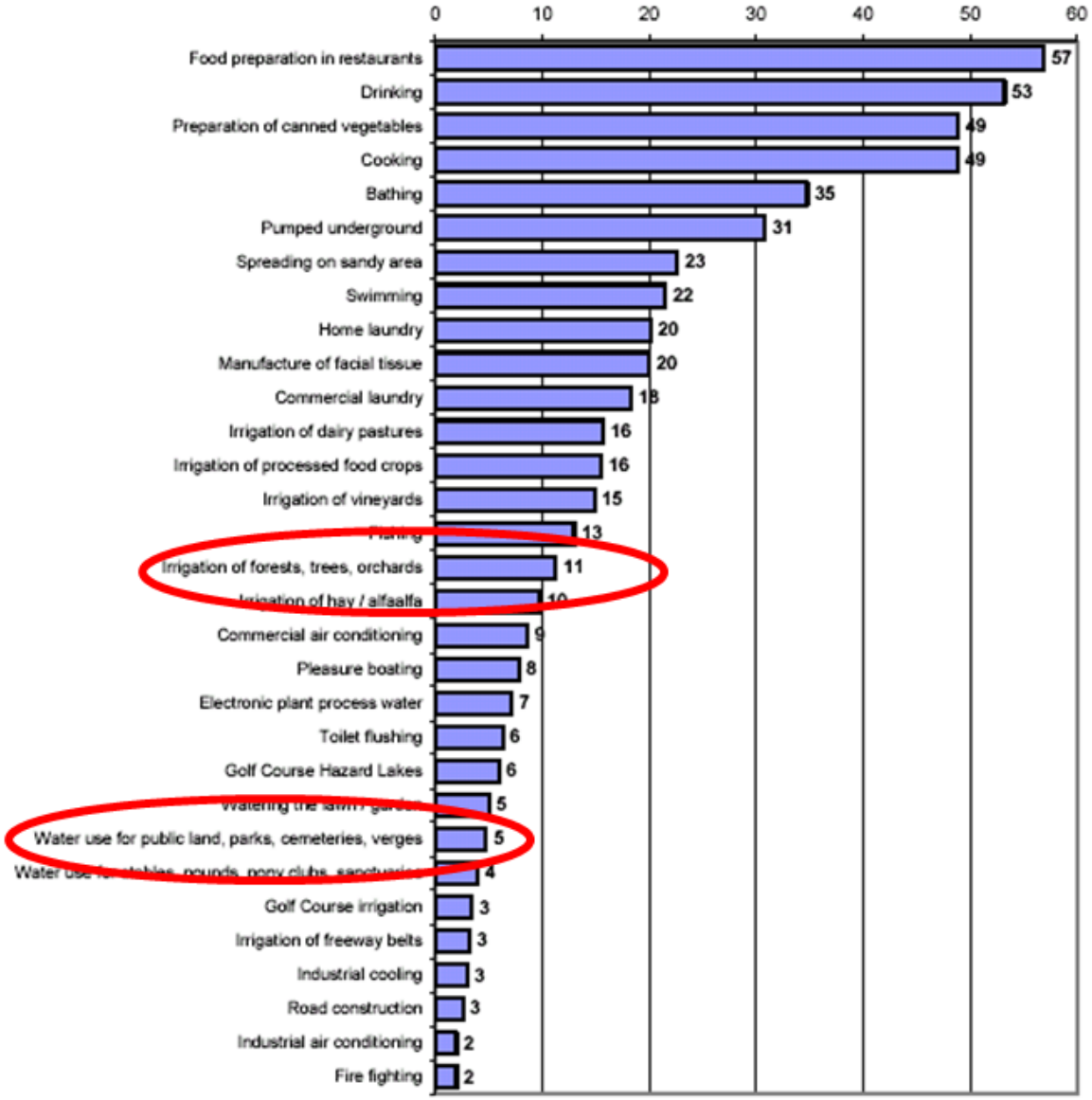
Urban wastewater treatment systems

Urban reuse: urban green area irrigation, fire protection, toilet flushing in commercial buildings.

Photo by Susan Horvat

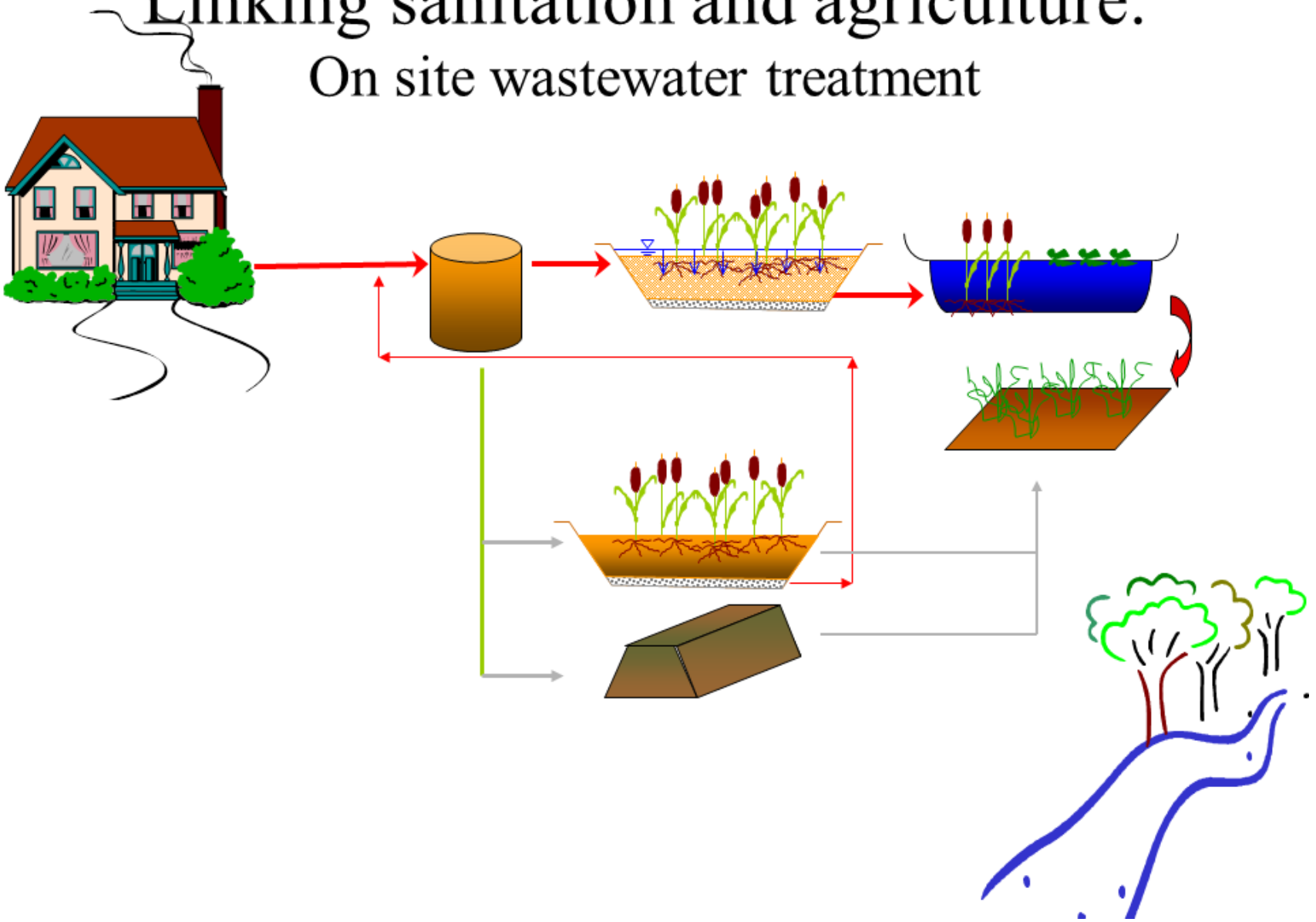
http://www.hazenandsawyer.com/work/expertise/reclamation-reuse/

Resistance to:



Linking sanitation and agriculture.

On site wastewater treatment



Linking sanitation and agriculture
Ecological sanitation

- appropriate in rural and semi-urban areas of developing countries where farmers cannot afford chemical fertilisers,

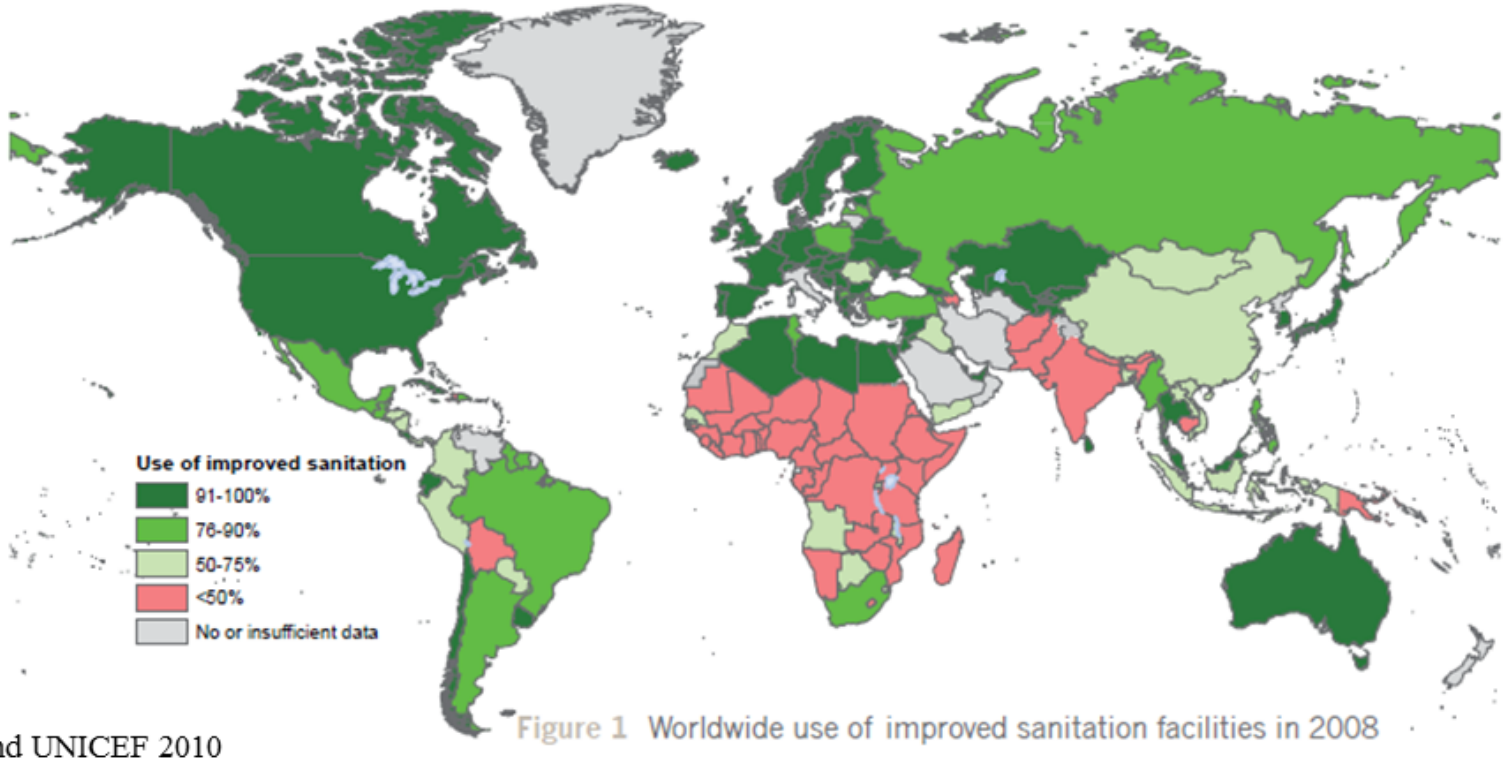


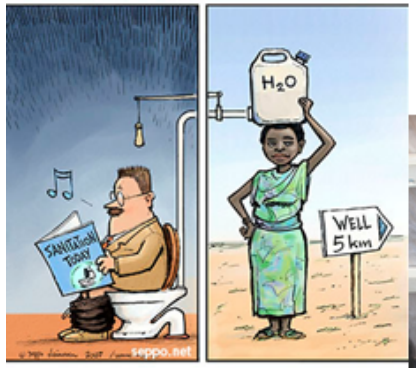
Figure 1 Worldwide use of improved sanitation facilities in 2008

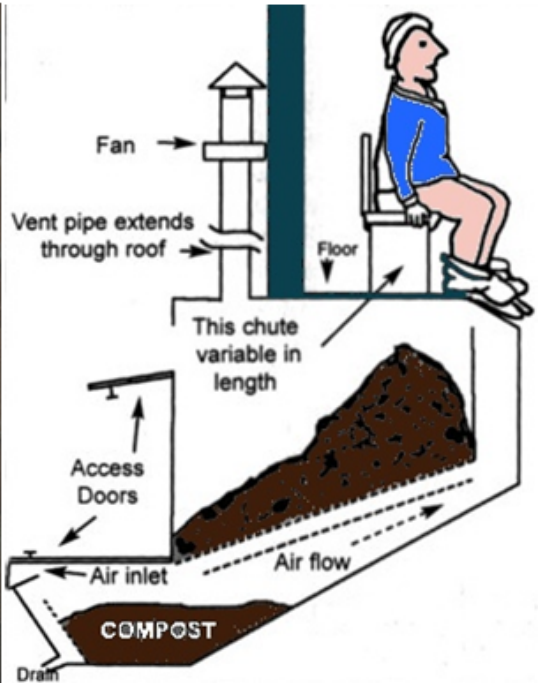
WHO and UNICEF 2010

Linking sanitation and agriculture

Ecological sanitation – dry toilets

- The sanitation system should ***not use more water than necessary***,
- The recycling of wastewater for agriculture saves freshwater.





Removal of finished
compost from Finishing Drawer

Linking sanitation and agriculture

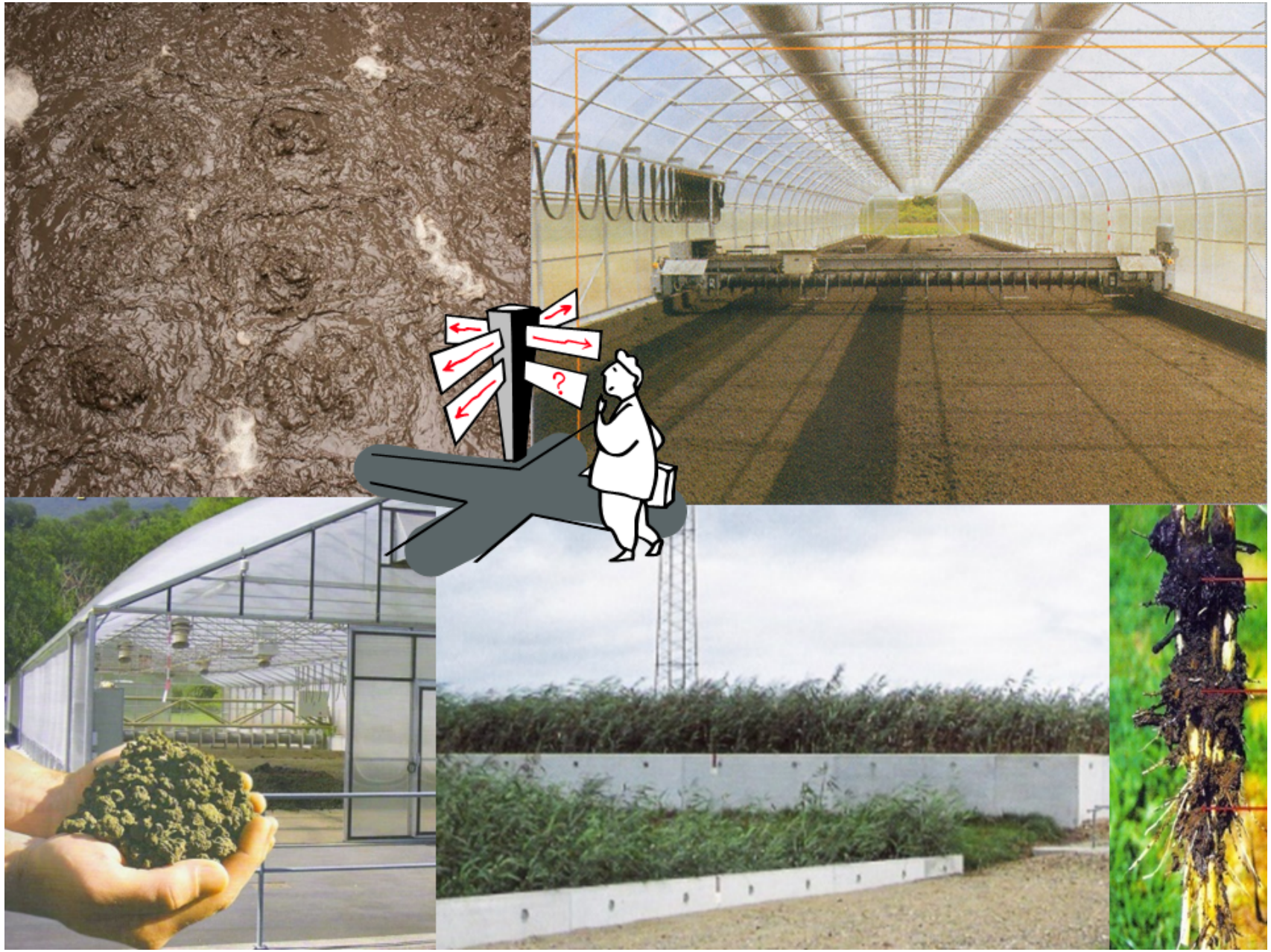
Ecological sanitation – urine separation

⇨ The average human produces 500 L of urine and 50 L of faeces per year.

- This is equivalent to about 5.5 kg of NPK (4 kg of N, 1 kg of K and 0.5 kg of P) per capita per year.
- One year of urine from one person can support agriculture over an area of about 300 to 400 m^2.

What can be improved? Sludge

- Linking sanitation and agriculture



Recycling P from wastewater and sludge - benefits

- Saving the resource (which is non renewable)
- Saving the energy (mining, processing, transport)
- Tertiary wastewater treatment (if used directly)
- Protection of surface water (wastewater receiver)
- Saving water (in case of wastewater irrigation)
- Closing the loop between urban and rural areas
- Creating sustainable local society (independency)
- Increasing of biomass production
- Production of renewable energy sources
- Economic (less money for mineral fertilizers, additional income for farmers for sludge utilization)

What can be improved? P recovery from receivers

- Reactive filters for agricultural pollution control

World is in Your hands...