Reducing the risk of phosphorus losses from the agricultural sector by use of targeted reduction policies

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Introduction

Phosphorus (P) and nitrogen (N) are essential for **profitable arable and livestock-based agriculture** as well as for the functioning of natural ecosystems.

Excessive application of P can lead to its **accumulation in the soil**. Leaching of accumulated P can subsequent damage aquatic ecosystems by accelerating **eutrophication** of lakes and streams.

Eutrophication influence the production of ecosystem functions and services, and **reduce benefits** from other uses, e.g. fishing, recreation, and drinking water, of the aquatic resource.

Accumulation of P in the soil is a growing environmental problem, which is partially caused by the **intensive application of animal manure** to agricultural fields.

However, P can be lost from the soil through different pathways which are very **site dependent**.

Objective

This study was conducted to analyze which effect a tax on the phosphorus index (PI) have:

- On the **interaction between livestock and arable farmers** to improve utilization of P within a catchment area
- On **P surplus** and on the **accumulation rate of P** in the soil **over time** .
- On **P-index estimates, nitrogen application levels** and **Farm profit**

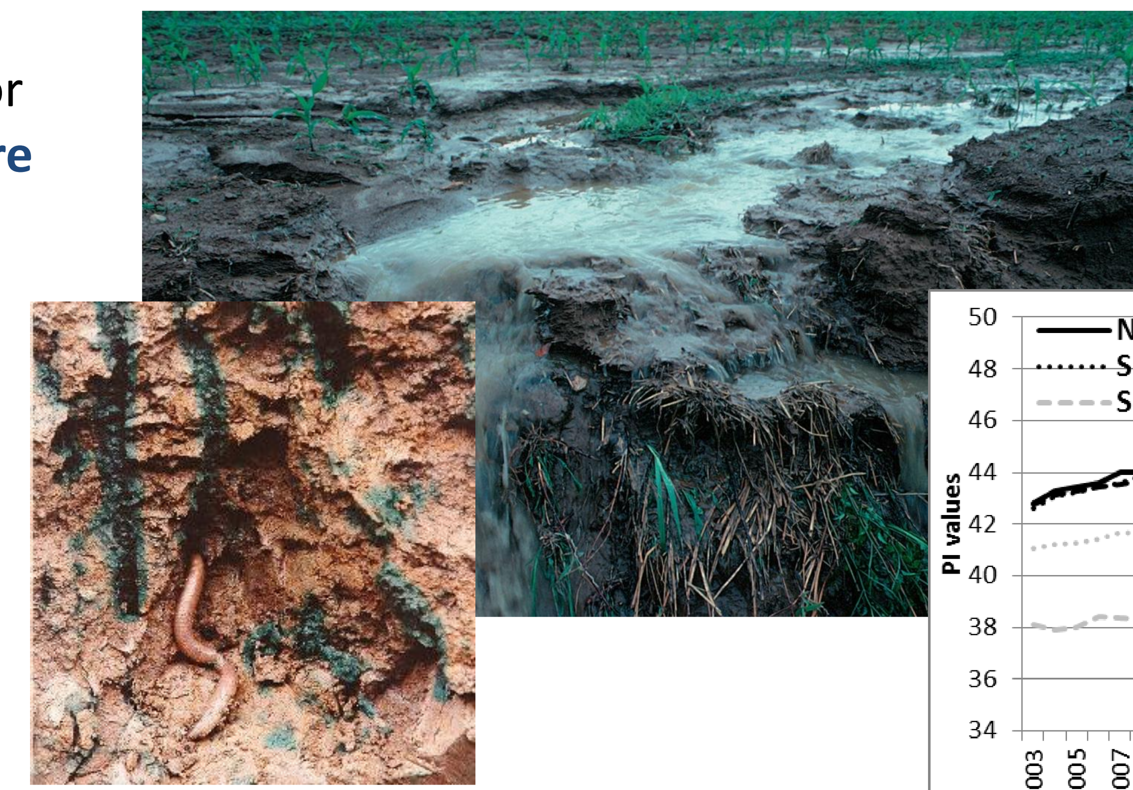
The results are compared to the obtained effect from implementing a **mineral fertilizer tax**, a **tax on P surplus applications** and a **subsidy for filter strip implementation**.

Method

We model the **private farm-level** choice of **optimal fertilization** assuming that farmers **maximize profit** from crop production growing a **mix of crops** at fields with different **soil types** .

The model is evaluated over **a time period of 30 years**. The model consists of a range of sub-equations e.g. containing:

1. **Trading of manure** between farms
2. Crop-specific N-yield-response functions.
3. Application of **N is restricted in line with Danish legislation**.
4. **Minimum application of P** is modelled based on P available in the soil and values for P-removal by crops at harvest. There is **no upper limit for P application**.
5. Developments in **soil P over time** is based on Ekholm et al. (2005) and depend upon the soil P level in year 0 and P surplus applications.
6. **The PI** is dependent on current soil P, application rates of P and filter strip implementation.



The phosphorus index – PI

Areas most vulnerable to P losses are often limited to small well-defined areas of the watershed near or connected to surface waters - so called **critical source areas**.

The critical source areas are defined from the coincidence of **source factors** (soil, crop, P application rates) and **transport factors** (leaching, runoff, erosion). The **PI is estimated at field level** dependent on **local conditions** in the field and estimate the risk of P being lost to the water environment.

The Danish PI exist of 4 different PI measures, one for each P loss pathway: **Erosion**, **Surface runoff**, leaching via **Macro-pores** and leaching via the **Soil-Matrix**. In this project we put a tax on $\mathbf{PI^{EROSION}}$

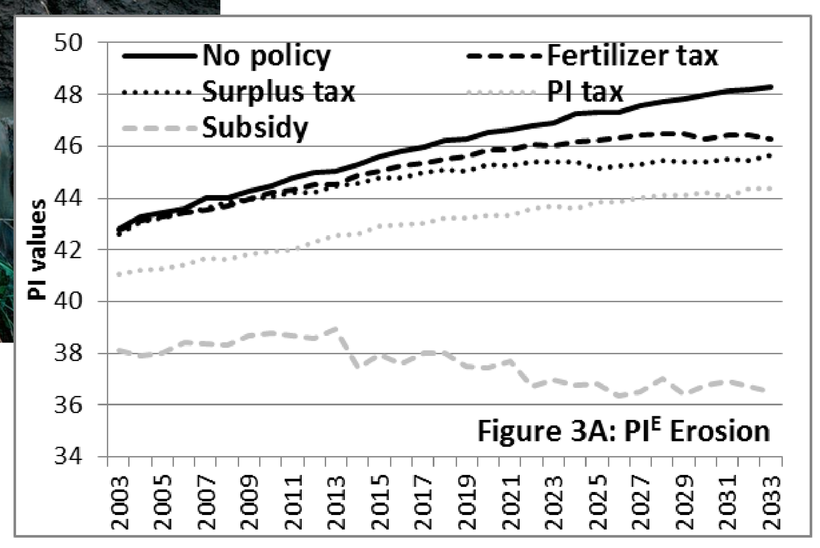
Results 1: Total P- and N-application rates

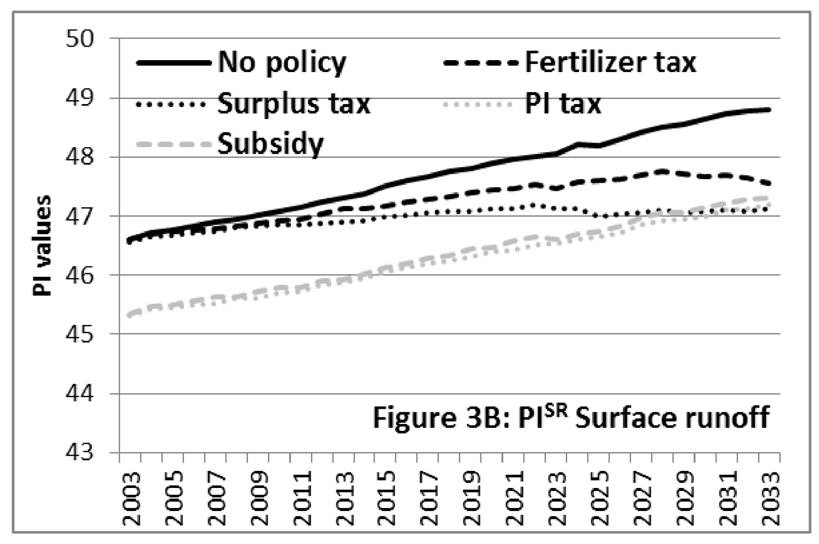
- are reduced differently among different policies.
- Only with the general policies, the P surplus is reduced significantly.
- With the general policies total N is reduced significantly because of increased manure-trade. With the targeted policies total N is reduced as well, but due to land converted to filter strips. .

	Mineral fertiliser P (ton)	Total P (ton)	P surplus (ton)	Mineral fertiliser N (ton)	Total N (ton)
No policy (2003)	162	400	61	1,130	1,908
No policy (2033)	144	380	61	580	1,359
Fertilizer tax	109	342	4	559	1,340
P surplus tax	121	358	0	557	1,346
Subsidy	133	370	64	524	1,304
PI tax	144	379	59	563	1,341

Results 2: PI Erosion and run off

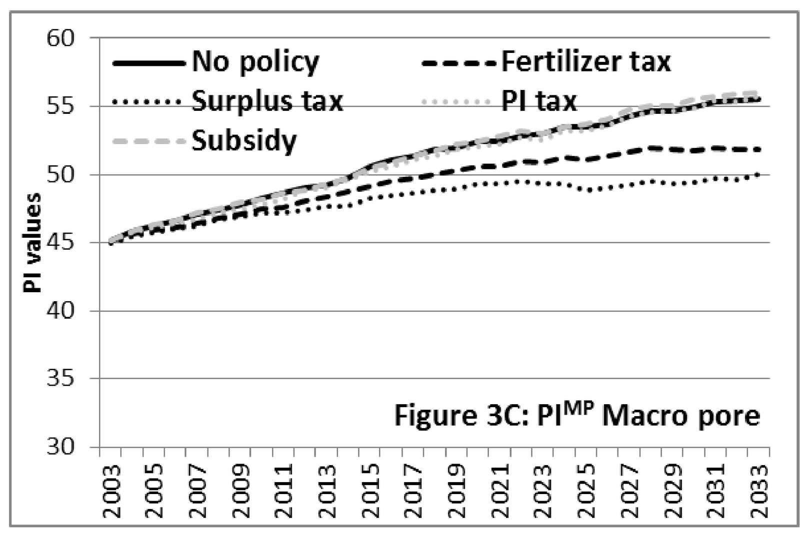
Targeted policies reduces the risk of erosion and run off significantly, where the **general policies** only in the long run reduces surface losses.

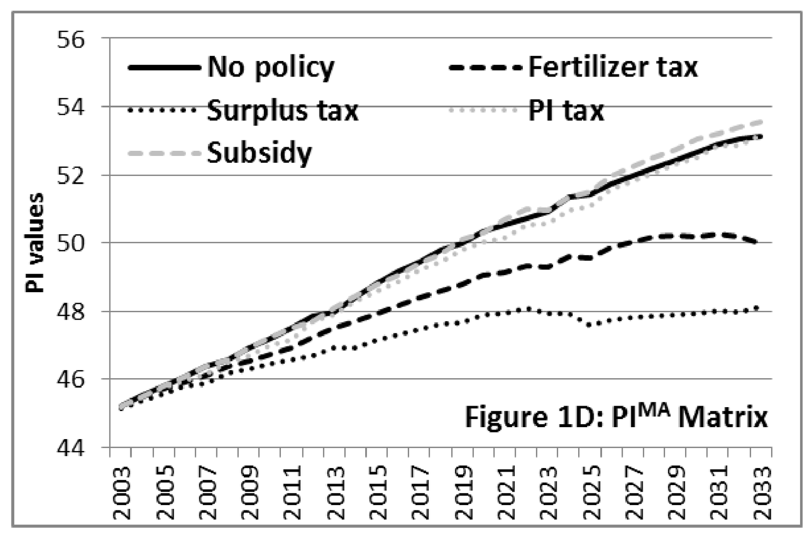




Results 3: PI subsurface run off

General policies reduces the risk of macro-pore and matrix losses significantly, where the **targeted policies** have no effect or even increases the risk of sub-surface losses.





Conclusions

- A $PI^{EROSION}$ tax and a subsidy for filter-strips are very efficient in immediately reducing the risk of surface losses. But the policies allow build-up of P at non-targeted soils and therefore slightly increase the risk of subsurface losses.
- General policies motivates farmers to reallocate P-surplus and reduces the risk of subsurface losses significantly. Also the risk of surface losses is reduced but over a long time-span.
- Total N is reduced with all policies but only the general policies reduce total P and P surplus significantly.
- Based on the evaluated parameters and total income we conclude that the P surplus tax could be a second best policy, combined with a filter-strip subsidy targeted high risk fields of surface losses it could become very efficient.