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BalticSea2020

PHOSPHORUS INDICES

STATUS, RELEVANCE AND REQUIREMENTS FOR A WIDER USE AS EFFICIENT PHOSPHORUS MANAGEMENT MEASURES IN THE BALTIC SEA REGION

PREFACE

This report is prepared by Agro Business Park on request of Baltic Sea 2020, within the frames of the "Intensive Pig Production Programme". It is a follow up on earlier reports that analyse and discuss best available technologies to reduce loss of plant nutrients from intensive pig production. Earlier reports (Foged, 2010) concluded that:

- An official phosphorus index should be developed and used in all countries as a condition for the environmental permitting of intensive livestock farms. The empirical models supporting the index should be developed regionally or country-wise by researchers, as the relevance of the parameters as well as the associated phosphorus loss-risk varies between regions and countries. The practical application of the index should be related to fields rather than field blocks or larger geographical areas. This enables farms to spread as much livestock manure and other phosphorus fertiliser as possible with a minimum of risk for phosphorus loss to the environment. The implementation and enforcement of the phosphorus index requires official standards for the different parameters in the index, set out in national regulations.

The report is mainly based on presentations and discussions at the Baltic Sea 2020-organised "P-index workshop" on 20 January 2011 at Royal Academy of Science, Stockholm, Sweden. Representatives from science, environment, farmers, farm advisory, and administration in Sweden, Denmark, Norway, Finland, Germany and Poland presented the current status for P-indices in their respective countries, and discussed the relevance and the requirements for a wider use of P-indices as efficient phosphorus management measures in the Baltic Sea Region.

Tjele, 6 May 2011

Henning Foged

Project Manager

AGRO BUSINESS PARK

TABLE OF CONTENT

EXECUTIVE SUMMARY AND RECOMMENDATIONS

Status

Denmark

A P-index has been developed by researchers and tested in practice in cooperation with the farm advisory service. Farmers and their advisers are apparently satisfied with the tool, while the authorities hesitate, probably because they fear the costs of the enforcement. The index tool is web-based, consisting of pre-calculated P-index maps covering the entire Denmark as well as P mitigation planning tools. The major challenges are lack of data (mainly on soil P status), and uncertainties / need for additional validation of the model. Furthermore, it requires some practice by the user to interpret.

Finland

No P-index has been developed, but researchers have, through modelling and research on erosion, experience and competence in assessing risks for P losses and their mechanisms. This experience in combination with good understanding of effects of mitigation measures forms valuable bases for developing P-indices in Finland.

Germany

No P-index is available but two other tools have been developed; “risk maps associated with compulsory use of cultivation practices” and “the P-balance calculation”. The German P-measures, introduced as official regulations in 2010, are not the same as a P-index, but with their focusing on the P-balance, it is more advanced than a mere P-norm.

Norway

A P-index has been developed which is used voluntary by farmers and their advisers. It is simple and effective in its structure, and has a pedagogic presentation via a web tool and has been proven in practical use. Farmers and their advisers can test the effects on the P-index calculation of different management practices.

Sweden

A P-index has been developed and tested in practice, but implementation in agricultural practices has not yet happened. The index is advanced, it requires quite an amount of data and special software to be installed on the computer. Its practical adaptation has failed as farmers and their advisers seem to be in doubt about the usefulness of the index tool. The Swedish regulation of maximum animal density is in combination with the flat-rate P norm acknowledged within the research community as a very effective way to avoid high P surpluses.

Relevance

Phosphorus losses to the Baltic Sea are too high, and should be reduced with about 15,000 tonnes per year, (www.helcom.fi). At least 95% of the phosphorus load enters the Baltic Sea via rivers or as direct waterborne discharges. Intensive rearing of livestock is identified in the Helcom

Baltic Sea Acton Plan as a key point source. Diffuse losses (mainly from agriculture but also from forestry and scattered dwellings) contribute to 49% of phosphorus inputs to the Baltic Sea.

Based on these facts, there is an apparent need to develop and support the implementation of a P-index, a tool that, on top of soil analyses, P-norms and standard values for livestock manure, can assess the risk for P-loss from agricultural fields, and estimate the effects of different mitigation measures.

Phosphorus fertiliser is costly in the crop production, with a present price of circa € 2 per kg. The high and increasing price for phosphorus is a result of depleting resources internationally. It is in farmers interests to save phosphorus and to ensure long term availability for livestock nutrition.

Requirements for a wider use

A workshop in Stockholm in January 2011, organised by Baltic Sea 2020, concluded that efforts are needed to ensure a wider use of P-indices as efficient phosphorus management measures in the Baltic Sea region. The following objectives and activities where identified, using a "problem tree analysis" method:

Overall objective:

- To reduce losses of P from agriculture (intensive rearing of livestock included) to acceptable levels

Immediate objectives:

- Improve the quality / fill some gaps in the design of the present P-indices developed in the region;
- Increase knowledge and awareness about the potentials of P-loss risk tools; and
- Ensure that farmers have incentives to use P-indices.

Activities needed to reach these objectives:

- Further development of P-index models / algorithms, preferably in cooperation with farmers and farmers' advisory services. This includes: effects of mitigation measures, balancing the algorithms (relevant factors) with the data availability, transparency of the index calculations, ways of presentation of calculation results and their interactivity;
- Establish an interregional cooperation for exchange of experience in developing P-index models and sharing of best practices in design and use of the P-indices;
- Increase availability of cost-efficient and high quality data input, e.g. soil P content, effects of field cultivation/mitigation measures, standard values for livestock manure, erosion parameters;
- Validation of P-indices – testing whether the P-index models corresponds to practice;
- Propose relevant incentives / framework conditions – legislation, subsidies, etc.; and
- Involve farmers and their advisers to ensure their ownership to the P-index as a management tool.

The further development of P-indices for the Baltic Sea countries requires pragmatism in the

process. The Danish and Swedish indices appear to be technically well developed, but maybe too complex for practical implementation (with respect to the availability of necessary data acquirement and their ability to present the calculations in a pedagogic and transparent way to the farmers).

Despite the relevance of country-specific P-indices, regional cooperation in the further development of the P-indices is highly relevant. Issues especially relevant for a regional cooperation include:

- Finding the right balance between model complexity (detail in knowledge output) and data availability, also considering the cost-efficiency of the data;
- Validation of the tool, its reliability to predict risk for P-loss and effects of mitigation measures such as constructed wetlands, recirculation of drainage water, etc.;
- Ways to organise involvement of different stakeholder groups, here under farmers and authorities; and
- Policy issues – developing framework conditions that ensure international commitments in relation to phosphorus and national goals for phosphor reduction targets are met.

A regional cooperation could make researchers discuss / seek to align their quite different model structure. The existing models are different from country to country; however, it might be beneficial if the basic structures of the P-index models would be aligned, while the different parameters could have different weight (even 0) in different countries. The Norwegian model, consisting of a permanent index and a variable (where the farmer can influence via his management decisions) seem to be easy to work with.

Concrete recommendations to Baltic Sea 2020

Baltic Sea 2020 is recommended to establish a forum for Baltic cooperation in development of efficient P-indices which are widely accepted by farmers and authorities. The objective of such a forum would be to inspire each other to develop functional P-indices in the region (e.g. the suitable geographical area to cover with the P-index).

The forum would then share experiences of existing P-indices and develop the optimal:

- **Algorithms**, which logically must be a compromise between scientific accuracy and applicability, not least with respect to the price / availability of data. The roundtable revealed a big variation in the construction of the P-indexes in the region, and this provides a window of opportunity for inspiring each other with best practices;
- **Presentations**, i.e. pedagogy, transparency and interactivity in the user interface. It is important to adapt to current ways of using IT, where applications have smart graphics, user profile settings, web access and interactivity. It is important for the end users that it is as easy accessible and user friendly as possible.
- **Embeddings**, i.e. how to organise the P-index calculation institutionally and with respect to other field management activities. A cost effective development and use (research/development/maintenance, advisory, enforcement, and practical management) is important, not the least for farmers and their advisers.

- Framework conditions, i.e. which regulations and incentives have to be put in place to support a wider use of P-indices. The use of P-indices will probably not be seen as relevant by farmers unless regulations of fertilisation with phosphorus are introduced (e.g. P-norms, P-indices and standard values for livestock manure). As the market conditions are today, farmers often prefer overdosing with P rather than using manure separation, despite the high cost of phosphorus fertiliser. It is therefore relevant to discuss different types of instruments to ensure a balanced use of phosphorus as fertiliser.

Roundtable participant emphasized that researchers, farmers, advisers and regulators all are key players, and should participate in such a forum in order to secure that all interests and needs are considered. Authorities (national, international) will probably have an indirect role in the forum.

All developed and tested methods for assessing P-loss risks in the region have their advantages and disadvantages, and it is therefore important that all countries participate in the forum. Countries which have yet not developed P-indices should also participate to get inspired to develop tools adapted to their national frameworks. It is highly relevant to involve Norway in the forum (although Norway is hardly part of the Baltic Sea Region) as the Norwegian P-index is well developed, tested and proven in practical use. Germany has not developed a P-index as such, but focus on P-balances and the regulations are more advanced that a maximum P-norm The German P measures were introduced as official regulations in 2010, and should also be included in the discussion and evaluation of efficient P management measures.

BACKGROUND

Agriculture is the largest source to eutrophication in the Baltic Sea. Current measures to reduce plant nutrient loss to the aquatic environment are not considered sufficient to achieve a good ecological status in the Baltic Sea. Countries within the Baltic Sea catchment area face a severe challenge to reach their commitments within the HELCOM Baltic Sea Action plan, and phosphorus (P) seem to be especially difficult. There is an urgent need to identify and implement cost efficient P management measures.

A promising, cost effective tool to reduce runoff and leaching of P to waters is the P-index. This empirical model for weighing different risk parameters for P loss into a combined risk factor can be used as guidance for selection of field management practices at field level or at larger units. It was first developed in the USA in the 1990's, and has since then been further developed by researchers in for instance Denmark, Finland and Sweden.

According to a recent survey by Baltic Sea 2020, the only country around the Baltic Sea which request farmers to use P indices is Germany. An official internet based P-index is available in Norway, offered to farmers as a help/guidance in relation to fertilizing plans. In Denmark, Sweden and Finland, use of P-indices or very similar models is so far limited to pilot studies, and other Baltic Sea countries do not use it at all.

A more general use of P-indices in the Baltic Sea area, especially on fields fertilized with livestock manure, is probably a cost effective way to reduce P loss from land to the Baltic Sea.

This report seeks to provide answers to the following issues:

1. What is the current status of indices developed in Denmark, Sweden, Finland and Germany?

- Are they ready for general use? (E.g.to what extent have they been tested in pilot studies, and evaluated, what do the studies show about their potential to reduce leaching, their reliability, the costs for users etc. Is there a need to further prove P-index potential to reduce P loss from agriculture further?)
- To what extent are they used today in general practice?

2. What is the perception of P index amongst stakeholders (farmers, advisory services, authorities etc.)?

- To what extent is the P-index known today?
- What is the attitude amongst different stakeholders towards the index (relevance, function, cost etc)?
- Are standard values for livestock manure a prerequisite for the use of P-indices?
- Could the P-index be a beneficial supplement a flat rate P-norm?

3. What can and should be done to apply the P index from pilot to full scale implementation?

- Is further research needed?
- Does methodology need to be further developed?
- Is change in legislation needed? Can/should it be included in national policy, as a requirement for farmers to achieve environmental support?
- What needs to be done to have farmers advisory services promote the use of P-index?
- How can it be perceived as an attractive tool for farmers?

METHODOLOGY

Representatives from research, authorities, NGO's and farm advisory services, covering the countries in the Baltic Sea region with experience from P-indices (Germany, Denmark, Sweden, Norway and Finland) were invited to a workshop to clarify the questions mentioned above. Polish representatives were invited as observers, because of the large diffuse load of phosphorus to the Baltic Sea originating from Polish agriculture.

The problem tree methodology (see for instance http://www.comminit.com/en/node/201228/3083) was used for clarification of requirements for a wider use of P-indices as efficient phosphorus management measures in the Baltic Sea Region.

STATUS FOR USE OF P-INDICES IN THE BALTIC SEA REGION

The following section summarizes the major messages provided at the roundtable discussion from the country representatives concerning status for use of P-indices:

Denmark

Hans Estrup Andersen, National Environmental Research Institute, Aarhus University:

- The Danish method calculates and maps 4 sub-P-indices describing P loss by: erosion, surface runoff, matrix leaching and macro pore transport.
- The major challenges are lack of data, and uncertainties / need for additional validation of the models.
- Suggested measures to mitigate losses of P include stop for active drainage, manure management, recirculation of drain water and use of constructed wetlands.

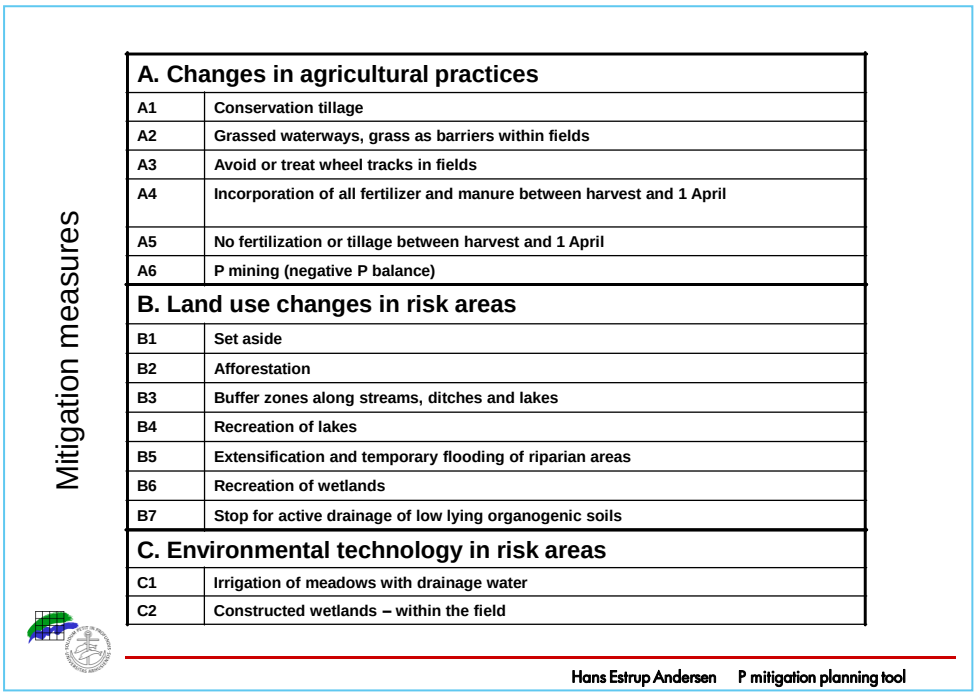

Figure 1: Example of measures to mitigate losses of nutrients from agriculture in Denmark

- A tool is established on http://np-risikokort.dk, but it is not maintained due to lack of financing.
- The tool was tested in two areas with 1000 + 700 ha, involving 4 farms, 2 advisors, and 204 fields.

- It was concluded from the field tests that P-indices should be calculated on field level rather than at block level, in order to avoid that a single spot in an entire block would limit the crop production possibilities in the rest of the fields in the field block. It is envisaged to be able to estimate cumulated effects of mitigation measures.
- Farmers are positive to P index because it focuses mitigation measures on risk areas rather than affecting all areas.
- Interactively recalculating the P index with own data is very educational; increase attention on potential risk factors other than just the P balance.
- Danish Environmental Protection Agency is presently considering funding of a further development of the Danish P-index.

Thyge Nygaard, Danish Society for Nature Conservation:

- Pointed out that there are no restrictions on spreading phosphorus on fields in Denmark, due to political negligence, and consequently the annual accumulation of P is 8-10 kg per ha.
- Stated that cliff erosion, loss from peat soils, and loss from mineral soils are the main sources of current P losses in Denmark.
- Suggests that mitigating measures should be distinguished between having short term or long term goals/effects.
- Suggested that cultivated peat soils should be taken out of production, and there is no need for a P-index to locate these fields – we know where they are.
- Concluded that although a P-index would be helpful to resolve P-problems, many things can be done without a P-index.

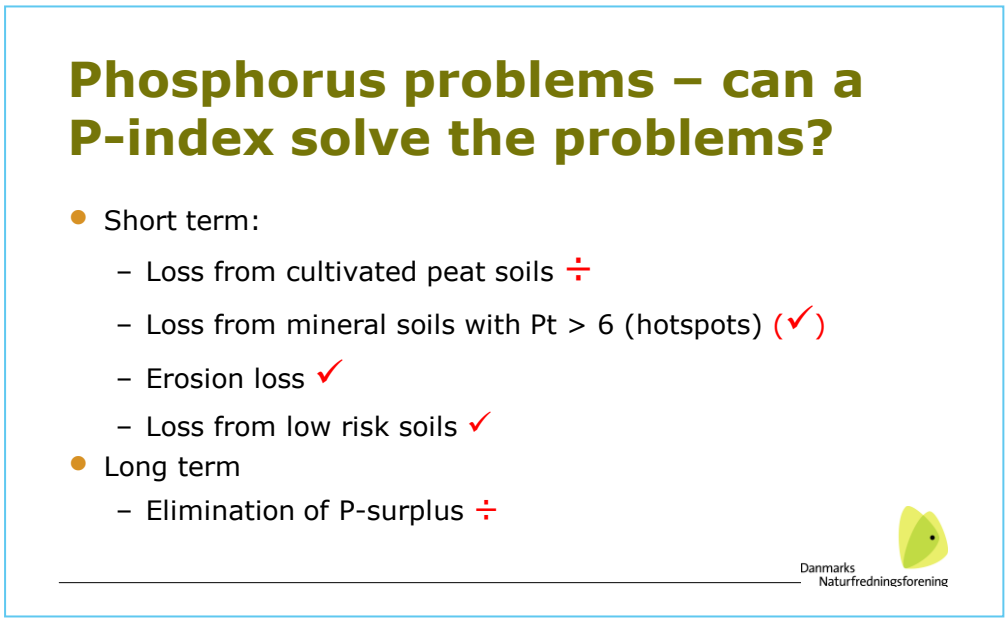

Figure 2: Potentials of a P-index in the short and long term

Conclusion Denmark

In Denmark, a P-index has been developed by researchers and tested in practice in cooperation with the farm advisory service. Farmers and their advisers are apparently satisfied with the tool, while the authorities hesitate, probably because they fear the costs of the enforcement. The index tool is more complicated in its structure than for instance the Norwegian, and requires probably some routine or deeper knowledge to interpret. The major challenges are lack of data, and uncertainties / need for additional validation of the models.

FINLAND

Jari Koskiaho, Finnish Environment Institute:

- The VIHMA tool is based on monitoring of erosion and nutrient loading (both N and P) during more than 20 year in different parts of Finland, representing different soil types and conditions (slope, soil type, cultivation, P-status, condition of drainage (e.g. surface/sub-surface, age)), as well as the effects of mitigation measures (e.g. buffer zones and constructed wetlands).
- The VIHMA tool can thus be used for modelling of nutrient losses and the effects of mitigation measures under various circumstances.
- VIHMA results show a large reduction of particle bound P loss when ploughing is replaced with reduced cultivation practices on sloping fields.
- The VIHMA tool is not a P-index, but the experience with it / the data collected during 20 years gives the Finnish researchers a good basis for a possible P-index development.

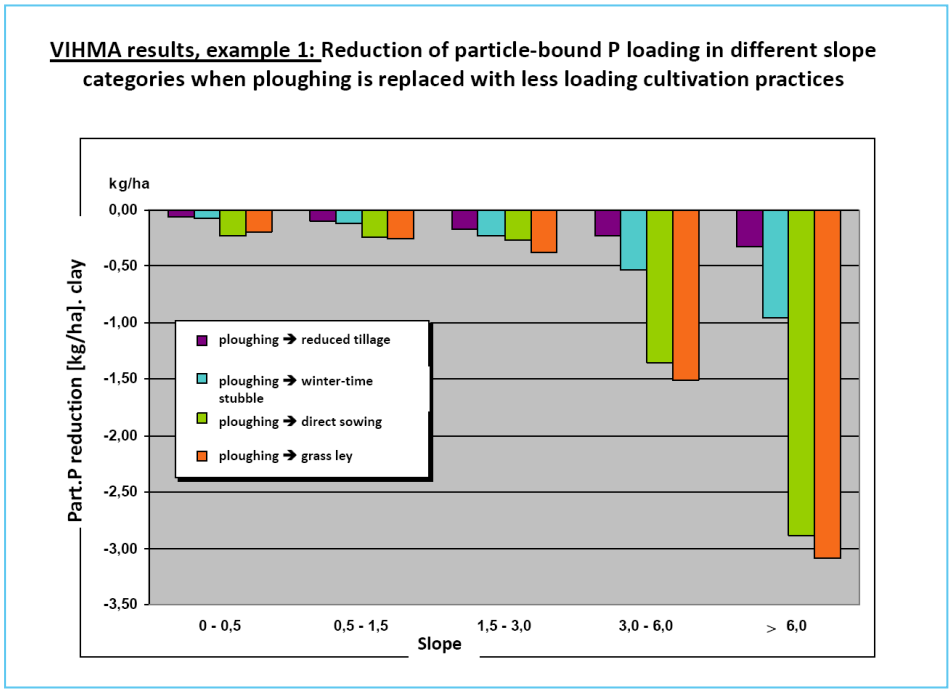

Figure 3: Effect on particle-bound P loss as function of field slope and tillage methods

Kari Ylivainio, MTT Agrifood Research Finland and Airi Kulmala, the Central Union of Agricultural Producers and Forest Owners:

- The "RUSLE model" estimates average soil loss (t/ha/year) considering rainfall/runoff, soil erodability, slope length and steepness, cover/management and support practices.
- The model has been tested for calculation of erosion risks and has been found useful to predict erosion quite precisely.
- Farmers have given positive feedback to the results of the RUSLE tool.
- Evaluation of the model indicates that erosion should be estimated in grids of 2 x 2 metres - 25 x 25 metres is too coarse grids.

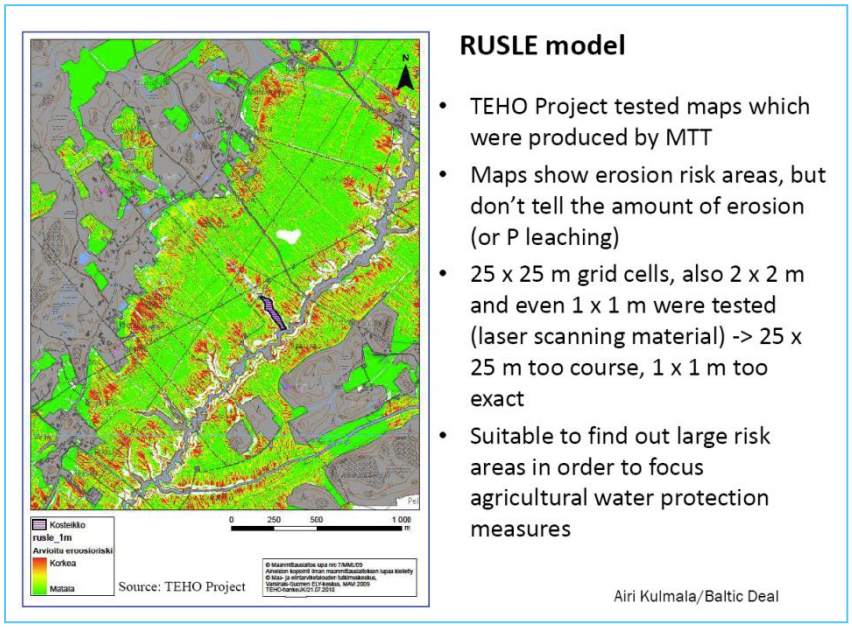

Figure 4: The RUSLE model is suitable for identification of larger risk areas

Conclusion Finland

In Finland, no P-index has been developed, but researchers have via work with modelling and research in erosion etc. a large experience and competence with assessing risks for P losses and their mechanisms, as well as knowledge to effects of mitigation measures; a relevant expertise in case P-indices should be developed in Finland.

GERMANY

Thorsten Breitshuh, BELANU – Beratung lantwirtschaftlicher Unternehmen:

- German law prescribe a maximal P balance of 9.7 kg P per ha (however, can be lower in case of low P-content in soils). A balance is better that a defined flat rate or other norm, because it gives more freedom to the farmer.
- Germany has official standard values for livestock manure for every region, which can be replaced by farms' own analyses of liquid manure types.
- The P-balances are highest in the western regions with high livestock densities. Growing maize for biogas plants (or for cattle) increase the P-balance due to the P used in feeding, which thereafter ends in the fields via the livestock manure. These facts underpin the relevance of P-regulation in livestock intensive regions/farms.
- In addition to the P-balance calculations, German authorities have developed field-maps with erosion-endangered field-blocks. The German authorities require that field cultivation practices are adjusted to the risk for erosion, and the requirements are regulated via the EU regulations for Cross Compliance.

Summary

The two german systems (control of P-balances and reducing the Risk of erosion) to reduce P-loses into the water are ready for general use.
They are evaluated an they are obligatory for each farmer.

Results:
- we still have a P-input in the rivers an the seas
- mainly in the east the P-losses are on a low level

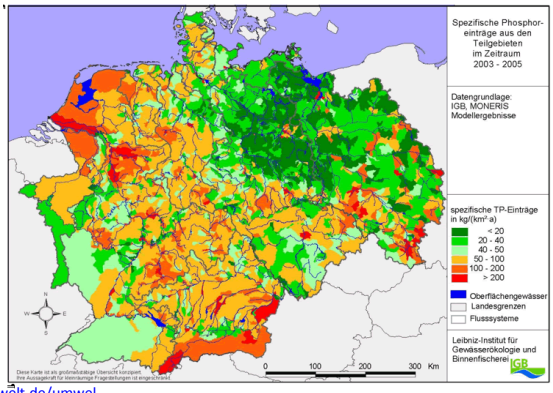

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Figure 5: P-balances are highest in regions with high livestock density

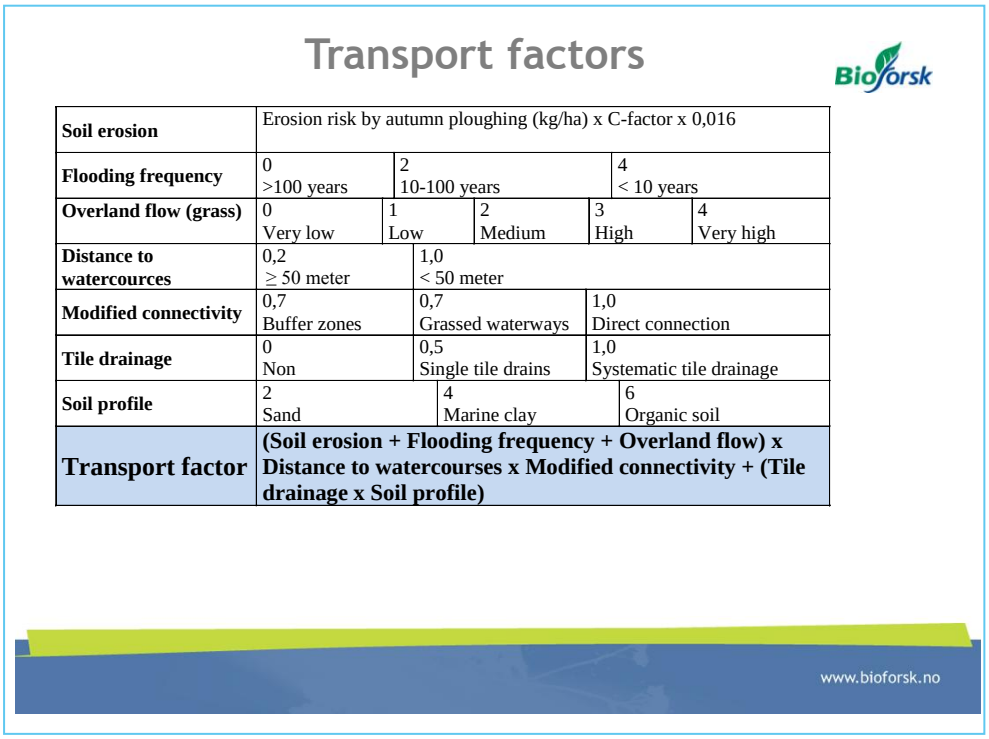
Conclusion Germany

Germany is probably the country in the Baltic Sea Region with most regulated P use even though no P-index is developed . The two implemented tools, "risk maps associated with compulsory use of cultivation practices", and "the P-balance calculation", are easy to use. A P-index system is developed for instance in Mecklenburg-Vorpommern (north-east-Germany).

NORWAY

Marianne Bechmann, Bioforsk:

- The P-index in Norway is a dynamic tool with big educational value, catching farmers' attention by visualising the effects of his practices and applied mitigation measures.
- The Norwegian index is rather similar to the Pennsylvanian P-index (Sharpley et al., 2001).
- It is based on easily available input data, out of which some are permanent, for instance erosion risks, and other are variables, for instance application of P via fertiliser and choice of mitigation measures (for instance grassed waterways).
- Testing of the P-index in small catchments showed that there was a fairly good relationship between the calculated P-index and measured P losses.



Soil erosion	Erosion risk by autumn ploughing (kg/ha) x C-factor x 0,016				
Flooding frequency	0 >100 years	2 10-100 years	4 < 10 years		
Overland flow (grass)	0 Very low	1 Low	2 Medium	3 High	4 Very high
Distance to watercources	0,2 ≥ 50 meter	1,0 < 50 meter			
Modified connectivity	0,7 Buffer zones	0,7 Grassed waterways	1,0 Direct connection		
Tile drainage	0 Non	0,5 Single tile drains	1,0 Systematic tile drainage		
Soil profile	2 Sand	4 Marine clay	6 Organic soil		
Transport factor	**(Soil erosion + Flooding frequency + Overland flow) x Distance to watercourses x Modified connectivity + (Tile drainage x Soil profile)**				

Figure 6: P transport factors

Anne Falk Øgaard, Bioforsk:

- The use of the tool is not enforced via legislation, but there is a considerable interest from authorities. The aim of the Norwegian P-index tool is to put together the current knowledge about factors important for P losses and the current recommendations for mitigation of P losses.
- Farmers own evaluation of P losses from their fields was quite similar to P-index calculations.

- The tool is available at http://webgis.no/pindeks
- The tool shows the permanent index for the field, and the variable P-index, depending on management and mitigation measures.
- The Norwegian computer program “Skifteplan” (field management plan) is now being extended with a P-index calculation; many of the parameters needed are anyway used for field planning.

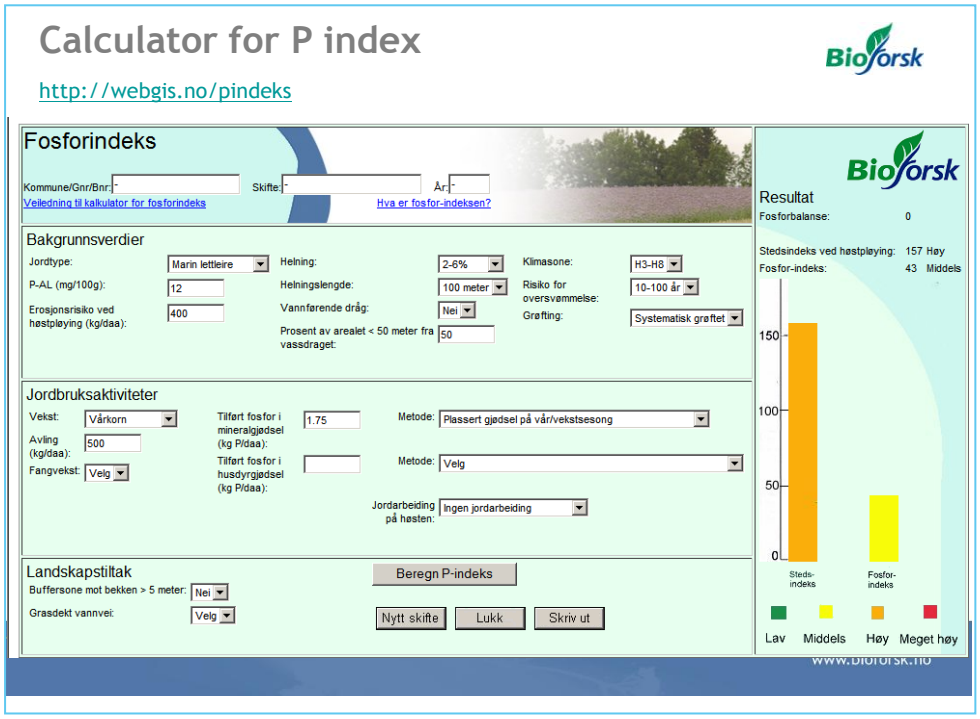


Figure7: Presentation of interactive P-index calculator

Conclusion Norway

Norway has developed a P-index, which is used voluntary by farmers and their advisers, which is simple and effective in its structure and have a pedagogic presentation via a web tool, where farmers and their advisers can see effects on the P-index calculation of different management practices.

SWEDEN

Faruk Djodjic, Swedish University of Agricultural Sciences:

- The development of the Swedish index started about 10 years ago. It is inspired by US indices, but adjusted, because the US indices does not in a sufficiently way take into account the losses through soil layers, but mainly surface losses. Additionally, there are quite different manure management practices in the US, wherefore P-loss risks are different in Sweden and USA.
- The Swedish tool is a windows based program. It gives farmers a text-based presentation with an interpretation of the index calculation. However, the implementation of this tool in practice has failed, the reasons being 1) lack of input data, for instance missing soil maps, and 2) farmers not seeing the benefits of the calculations.
- Emphasized the importance of the communication between stakeholders in order to ensure all stakeholders needs and interests are considered.
- Commented that Denmark and Norway are ahead of Sweden regarding availability of data on soils and erosion risks.
- The Swedish regulation of maximum animal density is acknowledged within the research community as a very effective way to avoid high P surpluses.

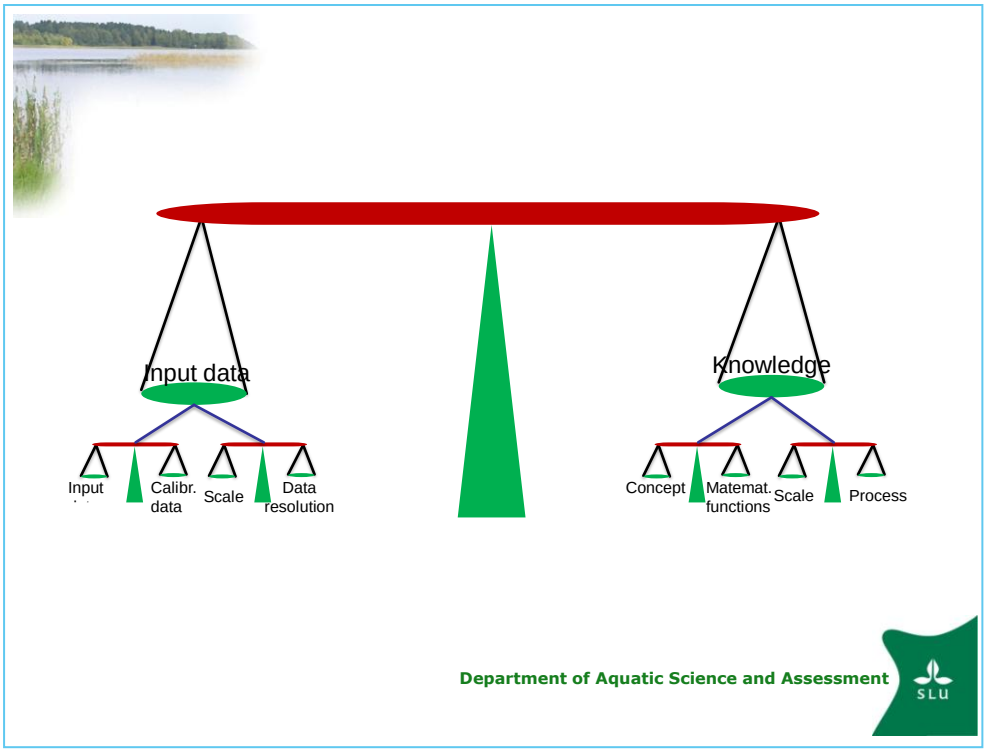


Figure 8: Developing P-indices is a balance between ambitions (knowledge) and possibilities (input data)

Line Strand, Swedish Rural Economy and Agricultural Society:

- The Swedish P-index was tested some years ago by three advisories (Västergötland, Östergötland and Uppland). Conclusions were: 1) too complicated to use for farmers, 2) lack of input data, 3) low losses – no gains for farmers, 4) not-pedagogic enough. The test showed that the P-index is more useful for authorities than for farmers.
- The Danish P-index has been tested in Sweden in an area with soil and erosion conditions similar to Denmark. Further research was recommended to develop an efficient P-index.

Conclusion Sweden

The Swedish P-index has been tested in practice, but the implementation in agricultural practices has not yet happened. The index is apparently advanced, but the adaptation on a practical level has failed as farmers and their advisers apparently are in doubt about the usefulness of the index tool. It requires quite an amount of data and special software to be installed on the computer. The Swedish regulation of maximum animal density is in combination with the flat-rate P norm acknowledged within the research community as a very effective way to avoid high P surpluses.

RELEVANCE AND REQUIREMENTS FOR A WIDER USE

Having relevant experts from Germany, Denmark, Norway, Sweden, Finland and Poland gathered at the roundtable discussion in Stockholm on 20 January was an ideal situation for clarifying the relevance of P-indices, and for clarifying the requirements for a wider use as an efficient phosphorus management measure in the Baltic Sea Region.

Relevance

The presentations confirmed that phosphorus turnover mechanisms in nature are complex. Ensuring the crops needs for phosphorus supply on the one hand, and avoiding loss of phosphorus loss to the aquatic environment on the other hand is not regulated in a simple way.

Preconditions for a balanced application of P on fields are that

- Soil P-levels are known on field level, and maybe also even on more detailed geographical level – see the following figure;

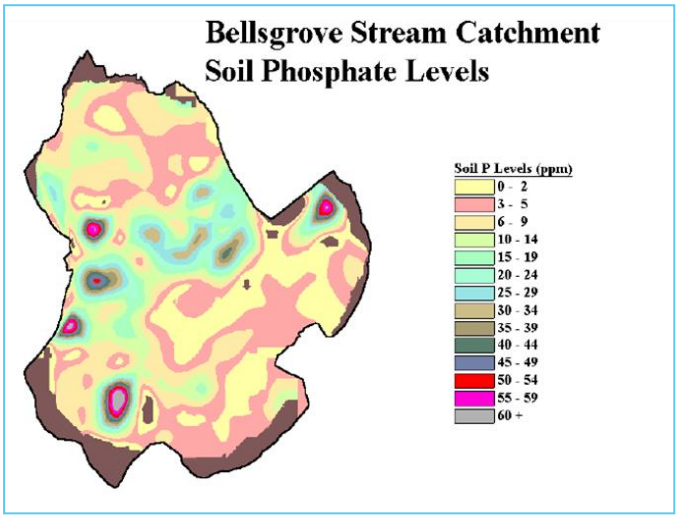


Figure 9: The variation in soil P levels in a field (Humphries et al., 1996)

- Phosphorus needs of the crops are known (norms). Fertilising with phosphorus however mainly contribute to the phosphorus pool in the soil, wherefore the soil pool and the crop rotation rather than the individual crop is more important for fertilisation levels; and
- Standard values for livestock manure are available, so that the amount of phosphorus fertiliser stemming from manure is known.

However, phosphorus loss risks are also, as clarified during the roundtable discussion, highly associated with many other factors. The other factors can be divided in the following:

- Nature given conditions, for instance the slope of the field, the soil structure, and the level of precipitation; and
- Field cultivation practices, for instance the use of drainage and the maintenance condition of the drainage system, the use of buffer zones, and soil tillage methods

Phosphorus losses to the Baltic Sea are too high, and should be reduced with about 15,000

tonnes per year, most from Poland and Russia, least from Denmark (HELCOM homepage). At least 95% of the phosphorus load enters the Baltic Sea via rivers or as direct waterborne discharges. Diffuse losses (mainly from agriculture, but also from forestry and scattered dwellings) contribute 49% of phosphorus inputs to the Baltic Sea.

Local and regional high livestock densities results in high amount of manure. Costs connected to manure transport and spreading sometimes make farmers' spread high amounts of manure and thereby P on a limited area. Although this is, in some countries and to a certain degree, regulated by P-norms and standard values for livestock manure, surplus fertilization may still occur under such circumstances.

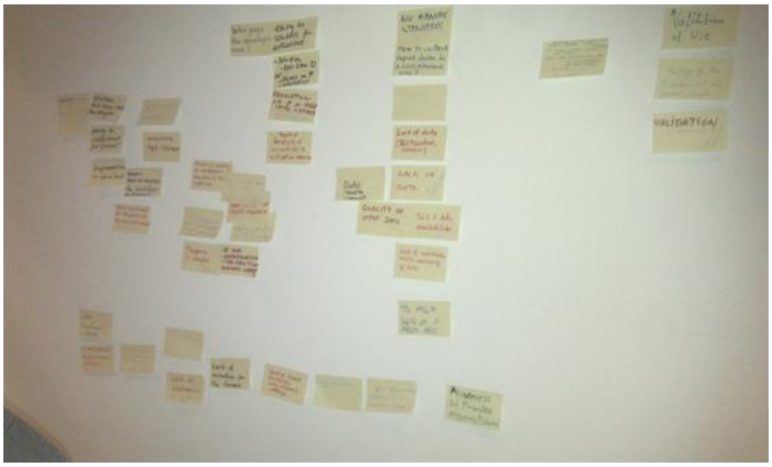
Phosphorus is costly in crop production, presently circa € 2 per kg, wherefore farmers prefer to use as little mineral fertilizer as possible. The high and increasing price for phosphorus is a result of depleting resources internationally. It is in farmers own interests to save phosphorus in order to ensure sufficient resources available for livestock nutrition.

Based on these facts, there is an apparent need to develop and support the implementation of a P-index that on top of soil analyses, P-norms and standard values for livestock manure can assess the risk for P-loss from agricultural fields, and determine the effects of mitigation measures.

However, the P-indices needs to be further developed in a dialogue with the stakeholders.

Requirements for a wider use

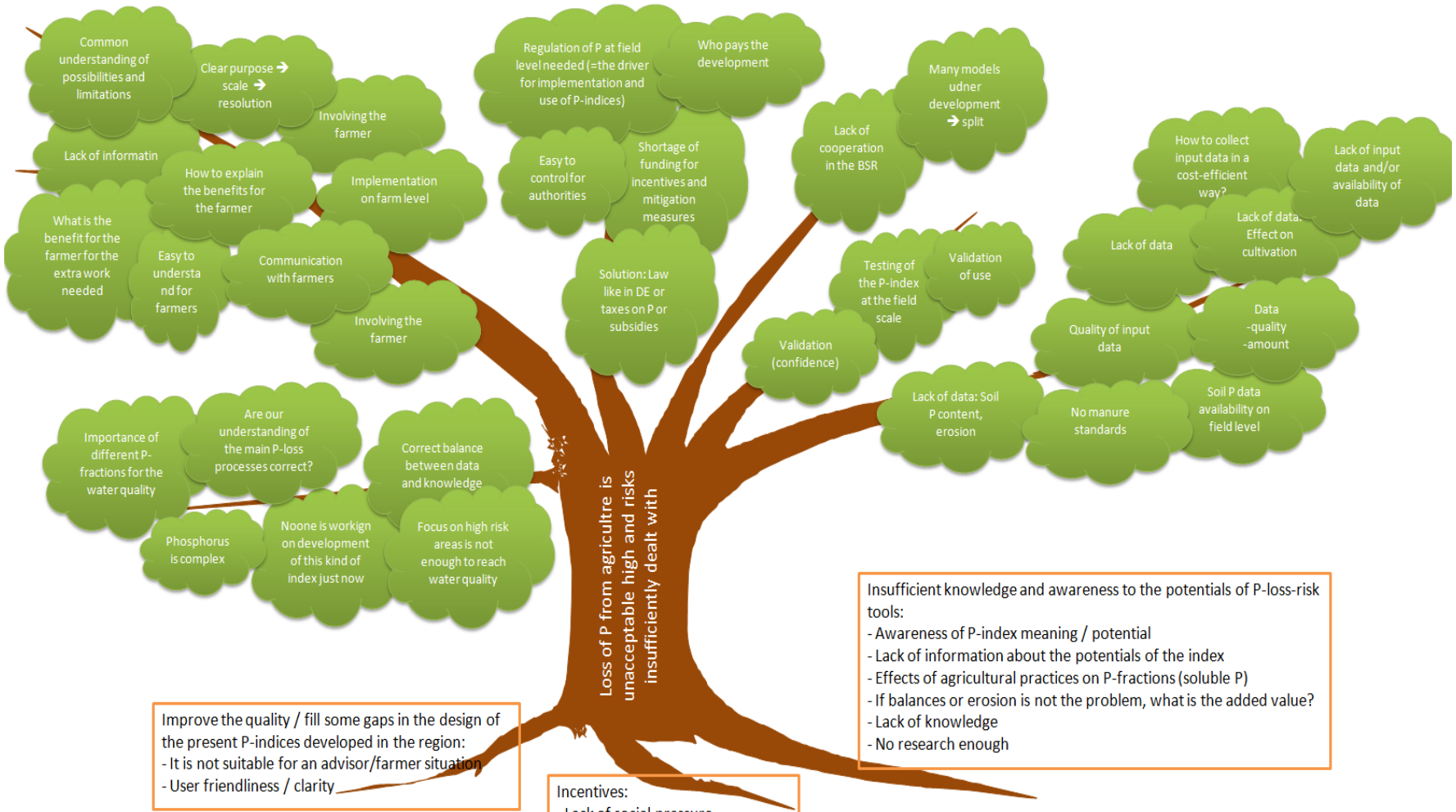
The experts gathered at the roundtable in Stockholm on 20 January 2011 gave their view on what is needed for a wider use of P-indices, and make them an efficient phosphorus management measures in the Baltic Sea Region, using the problem tree analysis method: Each of the delegates were asked to write down on post-it notes 2-3 key-problems in the given situation, see from their perspective, and afterwards to present and motivate these key-problems, where after the post-it notes were arranged on the wall according their character.



Picture 10: Post-it notes were used to build the "problem tree"

The “problem tree” has:

- A stem, that defines the key problem, namely that “P-indices are not used to their full potential to reduce loss of P from agriculture”.
- Three major roots, symbolising the major causes, namely
    - issues related with gaps in the quality and design of present P-indices;
    - issues related with farmer incentives; and
    - issues related with insufficient scientific and other knowledge, information and awareness
- Six major branches, symbolising current challenges for a wider use of P-indices:
    - Gaps in the P-index models/algorithms;
    - Lack of interregional cooperation;
    - Data availability, cost-efficiency and quality;
    - Validation of P-indices;
    - Framework conditions – legislation, subsidies, etc.; and
    - Farmers’ ownership to the P-index as a management tool – we need to prove the relevance of a P-index


Loss of P from agricultre is unacceptable high and risks insufficiently dealt with
Common understanding of possibilities and limitations
Clear purpose → scale → resolution
Involving the farmer
Lack of informatin
How to explain the benefits for the farmer
Implementation on farm level
What is the benefit for the farmer for the extra work needed
Easy to understa nd for farmers
Communication with farmers
Involving the farmer
Regulation of P at field level needed (=the driver for implementation and use of P-indices)
Who pays the development
Easy to control for authorities
Shortage of funding for incentives and mitigation measures
Solution: Law like in DE or taxes on P or subsidies
Many models udner development → split
Lack of cooperation in the BSR
Testing of the P-index at the field scale
Validation of use
Validation (confidence)
How to collect input data in a cost-efficient way?
Lack of input data and/or availability of data
Lack of data
Lack of data. Effect on cultivation
Quality of input data
Data -quality -amount
Lack of data: Soil P content, erosion
No manure standards
Soil P data availability on field level
Importance of different P-fractions for the water quality
Are our understanding of the main P-loss processes correct?
Correct balance between data and knowledge
Phosphorus is complex
Noone is workign on development of this kind of index just now
Focus on high risk areas is not enough to reach water quality
Improve the quality / fill some gaps in the design of the present P-indices developed in the region:
- It is not suitable for an advisor/farmer situation
- User friendliness / clarity
Insufficient knowledge and awareness to the potentials of P-loss-risk tools:
- Awareness of P-index meaning / potential
- Lack of information about the potentials of the index
- Effects of agricultural practices on P-fractions (soluble P)
- If balances or erosion is not the problem, what is the added value?
- Lack of knowledge
- No research enough
Incentives:
- Lack of social pressure
- The economic drivers
- Lack of incentives for the farmers

Using “the problem tree method”, roots and branches can then be converted / mirrored into:

- Overall objective:
    - “To reduce loss of P from agriculture to acceptable levels and to deal with associated risks”
- Immediate objectives:
    - Improve the quality / fill some gaps in the design of the present P-indices developed in the region;
    - Ensure that farmers have incentives for use of P-indices; and
    - Increase the knowledge and awareness to the potentials of P-loss risk tools.
- The activities needed to reach these objectives can be grouped as follows:
    - Further development of P-index models / algorithms, here under effects of mitigation measures, balancing the algorithms (relevant factors) with the data availability, transparency of the index calculations, ways of presentation of calculation results and their interactivity;
    - Establish an interregional cooperation for exchange of experience and investigation of possibilities for sharing of best practices in design and use of the P-indices;
    - Increase availability of cost-efficient and high quality data input, here under soil P content, effects of field cultivation/mitigation measures, standard values for livestock manure, erosion parameters;
    - Ensure validation of P-indices – testing whether the P-index models corresponds to practice;
    - Propose relevant framework conditions – legislation, subsidies, etc.; and
    - Involve farmers and their advisers to ensure their ownership to the P-index as a management tool.

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Guide agro-environnemental de fertilisation (suite) – http://www.mddep.gouv.qc.ca/milieu_agri/agricole/guide-index.htm

Rostock-university – site describing P-index research: http://www.auf-pe.uni-rostock.de/en/research/p-index/, http://www.auf-pe.uni-rostock.de/

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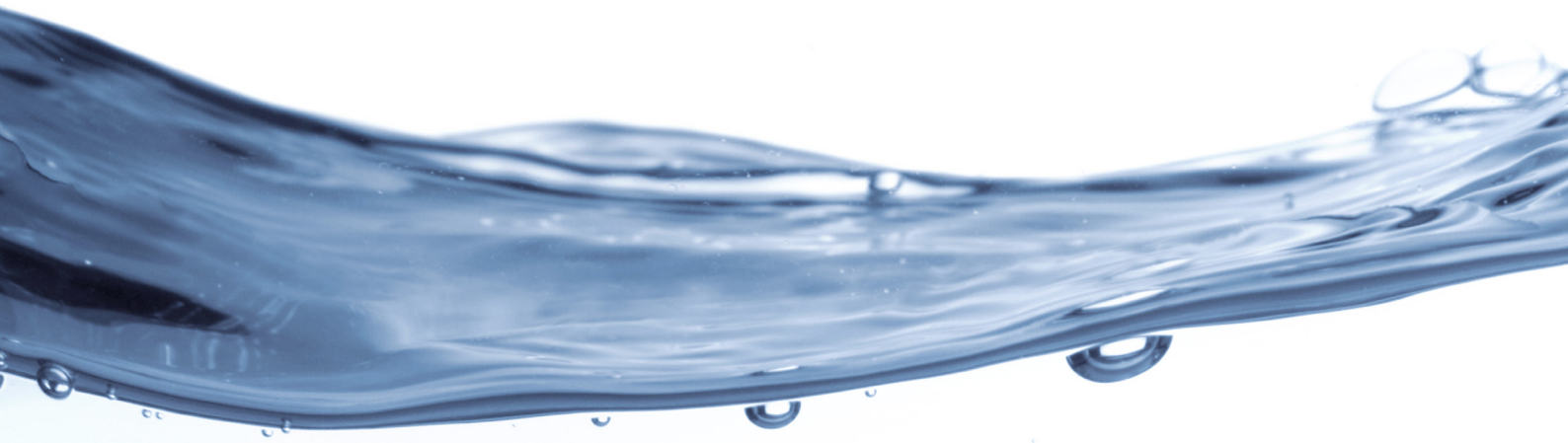
ANNEX A: AGENDA FOR THE P-INDICES ROUNDTABLE

09.30	Coffee and sandwich
10.00	Welcome, Baltic Sea 2020
10.05	Background and rational for the seminar,
	Henning Lyngsø Foged, Agro Business Park/Lotta Samuelson Baltic Sea 2020
10.20	Danish P –index
	Model setup, current implementation and experiences from field tests – Hans Estrup Andersen, Aarus University
	Potential role of P-index related to nature conservation – Thyge Nygaard, Danish Society for Nature Conservation
11.00	Norwegian P-index
	Model setup and experiences from current implementation, Marianne Bechmann/Anne Falk Ogaard, Bioforsk
11.20	Swedish P-index
	Model setup and current implementation, Faruk Djodjic, Swedish University of Agricultural Science
	Experiences from field test, Stina Olofsson & Katarina Börling, Swedish Board of Agriculture/Line Strand, Swedish Rural Economy and Agricultural Society
12.00	Lunch
13.00	Finnish P-index/VIHMA model
	Model setup and current implementation, Jari Koskiaho, Finnish Environmental Bureau
	Experiences from field test, Airi Kulmala, MTK/Kari Ylivainio, MTT
13.40	German P-index
	Model setup and current implementation, Torsten Breitschuh, Verband für Agrarforschung und bildung.
14.20	Concluding discussion:
	What is the potential and relevance of the P index to reduce runoff/leaching of P from agricultural land to waterways and the Baltic Sea?
	What can and should be done to apply the P index from pilot to full scale implementation?

ANNEX B: PARTICIPANTS IN P-INDICES ROUNDTABLE

Name	Institution	Email address
Hans Estrup Andersson	University of Aarhus, National Env. Reserach Institute	hea@dmu.dk
Henning Lyngsø Foged	Agro Business Park	hlf@agropark.dk
Thyge Nygaard	The Danish Society for Nature Conservation	tny@dn.dk
Airi Kulmala	MTK	airi.kulmala@mtk.fi
Kari Ylivainio	MTT	kari.ylivainio@mtt.fi
Jari Koskiaho	Finnish Environment Administration	jari.koskiaho@ymparisto.fi
Thorsten Breitschuh	Verband für Agrarforschung und Bildung Thüringen e.V.	Breitschuh.Werdershausen@t-online.de, Breitschuh@belanu.de
Anne Falk Ogaard	Bioforsk	Anne-Falk.Ogaard@bioforsk.no
Marianne Bechmann	Bioforsk	Marianne.Bechmann@bioforsk.no
Arkadiusz Tujaka	Institute of Soil Science and Plant Cultivation	atujaka@iung.pulawy.pl
Faruk Djodjic	Swedish Univeristy of Agricultural Science	faruk.djodjic@slu.se
Ingrid Rydberg	Swedish Environment Protection Agency	ingrid.rydberg@naturvardsverket.se
Katarina Börling	Swedish Board of Agriculture	katarina.borling@jordbruksverket.se
Stina Olofsson	Swedish Board of Agriculture	stina.olofsson@jordbruksverket.se
Line Strand	Swedish Rural Economy and Agricultural Society, Uppsala	line.strand@hush.se
Lotta Samuelson	Baltic Sea 2020	ls@balticsea2020.org



BALTIC SEA 2020
BOX 50005, Lilla frescativägen 4B, 104 05 Stockholm, Sweden,
Tlf +46 (0)8 673 97 64, Fax +46 (0)8 673 97 60,
info@balticsea2020.org, www.balticsea2020.org