FAIRWAY
Farm System Management and Governance
for Good Water Quality and Drinking Water Supplies

FAIRWAY REPORT series

Evaluation of Decision Support Tools

R.K. Laursen, F. Bondgaard, P. Schipper, K. Verloop, L. Tendler, R. Cassidy, L. Farrow, D. Doody, F. A. Nicholson, J. R. Williams, I. Wright, J. Rowbottom, I. A. Leitão, A. Ferreira, B. Hasler, M. Glavan, A. Jamsek, N. Surdyk, J. van Vliet, P. Leendertse, M. Hoogendoorn and L. Jackson-Blake.

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EXECUTIVE SUMMARY

A comprehensive evaluation of selected European decision support tools (DSTs) has been conducted based on testing of appropriate DSTs across the FAIRWAY case study sites. The tested DSTs cover farm, catchment and regional scales and support nutrient or pesticide management, including risk assessment and identification of cost-effective mitigation measures. The overall purpose of the evaluation is to provide information and input data for subsequent development of a framework to highlight the ways in which DSTs can be applied successfully to establish and improve awareness of diffuse pollution of vulnerable drinking water resources among farmers and other stakeholders.

Following a survey and review process which identified 36 potential DSTs, a shortlist of twelve DSTs have been tested at nine FAIRWAY case study sites across the EU. The participating case study sites all face different challenges; therefore different DSTs were identified for testing. After selection of the DSTs for each case study site, bilateral contact with the owners of the DSTs was established to obtained support and access to the software. This was followed by a trial period, using local data for each site, and involving meetings with and demonstrations to stakeholders. During the process, barriers to exchange between countries were identified. Additionally, information about the farmers and stakeholders 'needs' in term of functionality, use and access to DSTs, including their attitude toward DSTs, were collected. Being able to exchange and test this number of DSTs across EU is unique and has provided valuable information and insights.

Results of the evaluations indicate that exchange of DSTs between countries is challenging due to various barriers to use e.g. different legislation, input data requirements and regional differences in precipitation, soil types etc. Therefore, most countries have comparable DSTs designed to address similar problems. During the trials all case studies found inspiration and ideas from other countries' DSTs which they would consider implementing in their own area. Thus, the conclusion was that the countries preferred to adopt ideas and either enhance existing or develop new region-specific DSTs, rather than to attempt to modify a DST developed for another country.

Based on the tests of DSTs, criteria relating to functionality, use, access and output were identified which a DST should fulfil if it is likely to be successful. However, it was emphasized by the test persons in the FAIRWAY case study sites that support and advice from well-educated and communicative skilful advisors are highly valuable for the end user to make the right decisions.

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1. AIM AND OBJECTIVES

The aim of Task 5.2 was to evaluate a selection of decision support tools (DSTs) and the mitigation measures incorporated within them in the FAIRWAY case study sites at farm, catchment and regional scale. The detailed objectives were to:

- Identify the 'needs' in terms of functionality, use and access to DSTs.
- Evaluate selected DSTs using available datasets in case study sites where appropriate.
- Demonstrate and/or test the DSTs in cooperation with farmers and other stakeholders, and measure attitudes towards the demonstrated DSTs and the incorporated mitigation measures both before and after the demonstration period.

The overall purpose of the task was to provide information and input data for Task 5.4, where a framework will be established to highlight the ways in which DSTs can be applied successfully to establish and improve awareness of diffuse pollution of vulnerable drinking water resources among farmers and other stakeholders.

This report entitled *'Evaluation of Decision Support Tools'* is divided into two parts. Part 1 is a summary report including the main findings and conclusions. Part 2 includes detailed descriptions of the work undertaken and the findings of the testing of the DSTs and the mitigation measures incorporated within them in the participating FAIRWAY case study sites.

2. APPROACH AND METHODOLOGY

Task 5.2 is a continuation of Task 5.1. In Task 5.1 a literature survey and review of the existing DSTs used by farmers, farm advisers, water managers and policy makers for water, nutrient and pesticide management in the project partner countries involved in this task, and elsewhere in Europe, was conducted.

The review resulted in a selection of a set of 36 DSTs (see Table 5 in report D5.1, Nicholson *et al.*, 2018) that could be further assessed for their potential suitability for managing nitrate and pesticide losses to water within the case study catchments of the FAIRWAY project.

A set of information sheets (see delivery D5.1, Nicholson *et al.*, 2018) that summarised the operation and outputs of the tools were produced to provide an easily accessible source of key information on DST capabilities. A subset of the DSTs were demonstrated to a group of project partners and Multi Actor Programme (MAP) leaders at a workshop the 17th of April 2018 at ADAS, Boxworth, UK. Videos of the presentations about the DSTs were made for dissemination to the other project partners. Additionally, a 'distribution key' (see milestone M5.1) was developed based on specified characteristics of the DST, i.e. targeting groundwater or surface water, nitrate or pesticides, and meant to support regional policy makers or sustainable farm management. Moreover, DSTs were categorized on the basis of their functionality (i.e. evaluation of current practices, strategic advice farm management and implementation of mitigation measures; operational management i.e. climate smart, innovations for equipment, IT-apps, instructions/rules for sustainable application).

Based on the information provided by Task 5.1 the MAP leaders initially selected the DSTs they intended to demonstrate and/or test as part of Task 5.2. The initial selection can be found in milestone M5.1.

2.1 OVERALL WORKPLAN

In Task 5.2 the focus was on testing and evaluation of selected DSTs in the FAIRWAY case study sites. Thus, Task 5.2 was divided into three phases:

1. Selection and planning
   During Phase 1 each FAIRWAY case study site focused on finalising the selection of DSTs they would test and/or demonstrate. To help this process the participating case study sites were asked to fill out Evaluation Scheme 0 (See Appendix). This required the participating case study sites to re-evaluate the 36 DSTs (see Table 5 in report D5.1, Nicholson *et al.*, 2018) identified as of national importance to the project partner countries for managing nitrate and pesticide losses to water as part of Task 5.1, and identify barriers for transferring a DST into a new context. Once the case study sites had selected a set of DSTs for testing, the planning of the 2nd and 3rd phases started, and each case study site produced a workplan for the testing and/or demonstration of the DSTs (the workplans are presented in Part 2 of this report).

2. Testing and demonstration
   In Phase 2, the participating case study sites established bilateral contact with the owners of the DSTs and obtained access to the software. Pre-testing of the DSTs then started, and any necessary test datasets were prepared. At the beginning of this phase, Evaluation Scheme 1 (See Appendix) was completed. The evaluation scheme was designed to help the MAP leaders evaluate the selected DSTs further with regard to scale, data requirements, level of experience/training required, stakeholders etc. Once the pre-testing of a DST had proven successful (i.e. the case study site could obtain software access, get support from the owner of the DST and provide the required input data), the testing of the DST and evaluation of results started. In many case study sites this also included demonstration of the DST to relevant stakeholders and recording of the outcomes.

3. Implementation
   In Phase 3, the participating case study sites evaluated the possibilities for implementation of each the DSTs (or parts of the DST) in a national or federal state context, based on the results and findings of the testing. This was further discussed during a workshop held the 12th of March 2019 at Aarhus University, Roskilde, DK. At the workshop the results of the testing of the DSTs were demonstrated and implementation discussed.

In Part 2 of this report, a detailed description of the assessment and testing of the DSTs, evaluation of the results and findings, and a discussion of the implementation can be found for each of the participating FAIRWAY case study sites.

In the following chapter of Part 1, the main results and conclusions of the testing and demonstration of the DSTs (and any mitigation measures incorporated within them) in the participating FAIRWAY case study sites are presented.

3. RESULTS AND DISCUSSION

In Task 5.2 the DSTs selected for testing and/or demonstration by the participating FAIRWAY case study sites are listed in Table 1, which also notes the target application in terms of nitrate or pesticides and the scale of application.

Table 1. DSTs selected for test and/or demonstration by the participating FAIRWAY case study sites.

No.	Case study site	DSTs selected for test and/or demonstration	Scale	**Target** N: Nitrate Pe: Pesticide
1	Island Tunø (DK)	A historical case study where testing of a DST is not relevant as the problem has been solved		
2	Aalborg (DK)	Environmental Yardstick for Pesticides* (NL); SIRIS ** (FR); TargetEconN ** (DK)	On-farm use (*); catchment scale and regional scale (**)	Pe
3	Anglian Region (UK)	Environmental Yardstick for Pesticides (NL)	On-farm use	Pe
4	La Voulzie (FR)	SIRIS (FR)	Catchment scale	Pe
5	Lower Saxony (DE)	Mark Online (DK); NDICEA (NL)	On-farm use	N
6	Axios River (GR)	Not involved in Task. 5.2		
7	Derg catchment (IE)	SCIMAP** (UK) Phytopixal** (FR); Farmscoper* (UK)	On-farm use (*); catchment and regional scale (**)	Pe
8	Overijssel (NL)	Düngeplanung (DE)	On-farm use	N
9	Noord Brabant (NL)	Plant Protection Online (DK)	On-farm use	Pe
10	Vansjø (NO)	Not involved in Task. 5.2		
11	Baixo Mondego (PT)	MANNER-NPK (UK)	On-farm use	N
12	Arges-Videa (RO)	Not involved in Task. 5.2		
13	Dravsko Polje (SI)	ANCA (NL)	On-farm use	N

Table 1 shows that the selected DSTs differ in focus and application. Accordingly, the DSTs have been divided into categories to ease comparison and draw conclusions on specific issues:

1. Farm level DSTs
   Aims: Improve individual farm nutrient or pesticide management, contaminant load estimation, identifying cost-effective mitigation measures, compilation of relevant data, documentation of farm management. Two types of DSTs were considered:

   1.1. Improvement of on-farm nutrient management
   (Mark Online, Düngeplanung, MANNER-NPK, ANCA, NDICEA)
   1.2. Improvement of on-farm pesticide management by considering potential environmental harm (Environmental Yardstick for Pesticides, Plant Protection Online)

2. Catchment and regional level DSTs
   Aims: Identify high-risk areas for losses and prioritise mitigation measures; identify cost-effective management options to decrease nitrate or pesticide pollution. Three types of DSTs were considered:

   2.1. Risk assessment of pesticide applications (SIRIS, SCIMAP, Phytopixal)
   2.2. Identify cost-effective measures to reduce nitrate and pesticide loads to water (Farmscoper)
   2.3. Identify cost-effective allocation, location and choice of nitrogen (N) mitigation measures in order to reduce N loads to water (TargetEconN)

The above two categories have been used to structure the presentation of the results and conclusions. The report concludes with general remarks that apply for all case studies.

3.1 REMARKS ON FARM LEVEL DSTS

In some cases, existing DSTs used in the case study area were evaluated in comparison with the test DST, while in others the motivation for testing the DST was the absence of a useful alternative. Key objectives of the implementation and testing of each DST in the case studies related to i) evaluating the potential benefits/opportunities presented by the DST, ii) identifying any barriers to implementation and iii) assessing stakeholder perception of the DST and these are presented in the following. In Part 2 of this report, a detailed description of the testing of the DSTs in each participating case study site is presented.

3.1.1 Improvement of on-farm nutrient management

Improvement of on-farm nutrient management was the focus of testing 5 DSTs (Mark Online, Düngeplanung, MANNER-NPK, ANCA and NDICEA) across 5 case study sites. The main results related to the objectives of the testing and the advantages, disadvantages and stakeholder perception for each of the DSTs are summarized below.

DST: Mark Online (developed in Denmark) was tested at Case Study no. 5 in Lower Saxony (Germany). Key outputs from Mark Online include farm fertilizer plans (for arable and grassland crops) to be directly used by farmers, and nutrient balances at both field and farm scales. The objective of testing was to see how fertilizer planning, documentation and control are undertaken in other countries and how the DSTs for that purpose are designed. Mark Online has similarities to Düngeplanung which is already used in Germany and so was a useful comparator DST.

Advantages: The key advantage of Mark Online was the comprehensiveness of the model and the inclusion of cross-compliance checking (e.g. it covers Greening targets) - only one tool is required to cover all on-farm nutrient management budgeting. The Danish approach uses a farm-specific N-quota that limits the total amount of fertilizers to be applied, but allows flexibility and farmer judgement on how allocation of nutrients in an agronomically sensible way should take place within the farm. At the same time, it also renders stricter controls within farms possible. The potential to link soil type to yield level, following the Mark Online approach, would have benefits in the Lower Saxony case study in the future.

Disadvantages: The complexity of the all-inclusive system, however, means that advisory assistance is necessary for use in most cases. Geographic differences included the need to translate soil types present in Lower Saxony into their Danish equivalents, differences in the Danish and German legal frameworks, and in the way databases are linked. In Denmark more

open and linked agricultural databases (e.g. fertilizer sales, stocking rates, manure transport) are available than in Germany.

Stakeholder perception: Participating farmers in the case study area liked the modular design of Mark Online and the possibility to compile useful management information within the software. It covers more aspects than the German software Düngeplanung, however, Mark Online reflects current Danish legislation. Although most farmers in the case study complied quite well with it, some would face problems with their current management practice if they had to follow Danish law (e.g. the obligation to establish cover crops, restricted fertilizer use in autumn, strict soil phosphorus - P-levels).

DST: Düngeplanung (developed in Germany) was tested at Case Study no. 8 in Overijssel (Netherlands). The main output from Düngeplanung is a farm-level nutrient plan. The objective of the testing was to evaluate Düngeplanung in comparison with the existing "PerceelVerdeler" DST (parcel distributer). This DST was developed for grassland and fodder crops in the Netherlands but does not extend to arable crops. As Düngeplanung covers all crop types, the testing provided an opportunity to suggest and plan extensions to the existing DST for the benefit of more farmers.

Advantages: The conceptual model and specific functions within Düngeplanung could be used to extend the existing Dutch DST for fertilizer planning. Moreover, interesting characteristics are the broad spectre of crops addressed in Düngeplanung as well the consistent and accurate correction of fertilizer rates for residual nutrients that are released by fertilization of crops grown in earlier years. Further exchanges between the Dutch and German developers will be necessary.

Disadvantages: Düngeplanung could not be implemented directly in the case study area due to differences in the input data and parameters used in the Netherlands. One of the issues is that rates of organic and mineral fertilizer N and P are limited in the Dutch regulation. On the basis of these limits expressed in kg per ha and the areal of the farm land a farm budget for N and P is established. This budget, just like in Denmark, can be freely allocated to the crops and parcels over a farm. Thus farm fertilizer plans should respect the farm N quota, and when N quota are lower than the fertilizer recommendations, they should suggest an optimal distribution of the N and P quota. Uncertainty regarding the applicability of German fertilizer recommendations to Dutch conditions would also require additional tests and comparisons.

Stakeholder perception: Düngeplanung was demonstrated and discussed with farm advisors. They recommended to adopt strong characteristics in the Dutch systems like the PerceelVerdeler and to waive immediate implementation in the current case of Overijssel.

DST: MANNER-NPK (developed in the UK) was tested at Case Study no. 11 in Baixo Mondego (Portugal). The main outputs from MANNER-NPK are estimates of crop available nutrients based on applications of organic manure, as well as N losses and N use efficiency. These can be used to develop on-farm nutrient management plans. The PLANET DST available from ADAS which incorporates MANNER-NPK is an extension tool which could be used for this purpose. The objective of testing in Portugal was to identify a DST which could be used to address nitrate issues affecting drinking water quality. Although fertilizer plans have already been made by some farmers, there are currently no DSTs available for this purpose in Portugal, so the development of a similar DST could be of great benefit.

Advantages: A DST with MANNER-NPK's functionality would be of benefit to farmers in the case study area, since they would have access to information they do not have with the current fertilizer plans. No equivalent exists at present.

Disadvantages: MANNER-NPK was developed for the UK and uses UK climatic data so the applicability of the DST directly to the case study area is limited. Farm record keeping in the case study area was not accurate enough to provide reliable data on nutrient applications. Currency values and cost estimates provided by the model would also have to be adjusted for Portuguese conditions.

Stakeholder perception: There is support for the provision of a similar DST. Clear benefits to users were identified.

DST: ANCA (developed in the Netherlands) was tested in Case Study no. 13 in Dravsko Polje (Slovenia). The main output from the DST is a farm-level assessment of nutrient flows on dairy farms. These can be used to identify management changes on the farm which may reduce emissions and improve sustainability. The objective of the testing at the Slovenian case study site was as a potential DST to demonstrate that dairy farmers have produced milk in accordance with sustainability standards. No equivalent tool is available in Slovenia.

Advantages: The DST provides insights into Slovenian farming systems. Use of ANCA highlighted important differences between the farming systems in the Netherlands and Slovenia including poor crop nutrient uptake efficiency from organic fertilizers on Slovenian farms, high GHG emissions due to the lack of modern equipment and looser restrictions on organic nitrate application in The Netherlands (170 kg/ha; derogation for farms with grazing livestock 250 kg/ha) compared to Slovenia (all farms 170 kg/ha).

Disadvantages: Differences in farming systems between Slovenia and the Netherlands limited the application of the DST. There is no facility within the DST to alter grazing or cropping systems to be more applicable to Slovenia. Some data, such as soil texture, required for ANCA's operation are not readily available in Slovenia. Help for users was only available in Dutch.

Stakeholder perception: Farmers perceptions differed from advisors. Farmers perceive DSTs as an administrative burden and are concerned about them being difficult to use. Farm advisors were very supportive of DSTs (particularly with a visual display output) and would be keen to get access to them.

DST: NDICEA (developed in the Netherlands) was tested in Case Study no. 5 in Lower Saxony (Germany). The main output from the DST is an estimate of N-mineralisation in the soil. It goes beyond simple N budgeting for each crop since it accounts for the complex interaction of the soil-crop-management system. By integrating live weather data, it takes into account the most variable influence factor for crop development. The objective of the testing was a comparison with the German DST *Integrated Plant Production System (ISIP)* which also estimates N availability to the crops. Specifically, the testing focussed on whether NDICEA could be more precise in mapping N-dynamics in the soil, since NDICEA considers more information than ISIP concerning soil properties and soil tillage.

Advantages: The DST provides information on N availability in the soil, based on the most relevant factors; optionally own (farm) data on soil and crop quality can be used. The DST has a user-friendly design, self-explanatory application and provides results as clear graphical representations.

Disadvantages: Output crucially depends on the quality of input data (comprehensive calibration is needed). Since local climate data is not readily available in the case study in Lower Saxony and has a high spatial variability, the obtained results are not reliable.

Stakeholder perception: Farmers generally like the idea of having an estimate of N availability in the soil during the growing period. But the feasibility crucially depends on the reliability of the results. Since it was not possible to run the DST with local climate data and validation (with measured against modelled numbers) of the results is missing, there was no benefit for farmers in using it at the current time.

3.1.2 Improvement of on-farm pesticide management by considering potential environmental harm

Improvement of on-farm pesticide management by considering potential environmental harm was the focus of testing 2 DSTs (Environmental Yardstick for Pesticides and Plant Protection Online) across 3 case study sites. The case study site objectives and the advantages, disadvantages and stakeholder perception for each of the DSTs are summarised below.

DST: Environmental Yardstick for Pesticides (developed in the Netherlands) was tested in Case Study no. 2 in Aalborg (DK) and in Case study no. 3 in Anglian Region (UK). It is a management DST for farmers and advisors, and key outputs include the assignment of environmental impact points for the risk to water and soil organisms, as well as the risk of leaching to groundwater. In Denmark, the objective of the testing was to see how pesticide management and risk assessment is undertaken in other countries and compare it to the Danish pesticide tax system, which reflects the risk of the pesticides. In the UK the Environmental Yardstick for Pesticides was tested to see whether it can supplement existing DSTs, and be used by agronomists and land managers to enhance knowledge of pesticides that can contaminate drinking water resources.

In the following section advantages, disadvantages and stakeholder perceptions are summarised for the testing of the Environmental Yardstick for Pesticides in Aalborg (DK) and Anglian Region (UK) respectively.

Aalborg (DK):

Advantages: In Denmark, the key advantage of the Environmental Yardstick for Pesticides was found to be the visual representation of the risk of a pesticide leaching to the groundwater. This visual approach would be beneficial to include in for example the Danish DST Plant Protection Online as it would make it easy for farmers and advisors to understand the risks of pesticides. In Denmark the risk is controlled by taxes on pesticides (i.e. a high tax means high risk). However, no visualisation is provided of whether the tax is high due to risk of leaching to the groundwater, risk to water and soil organisms, human health etc.

Disadvantages: Application of the Environmental Yardstick for Pesticides is less relevant to Denmark than the Netherlands, as the Netherlands has more products available for the control of weeds in maize, potatoes and winter wheat. Additionally, the Environmental Yardstick for Pesticides is mostly designed for single products and not mixtures, which means it cannot calculate the risk when products are mixed to avoid the resistance challenge in weed control, pest and fungal diseases.

Stakeholder perception: In Denmark stakeholder perception was not evaluated. This was because the risk profiles generated by the Environmental Yardstick for Pesticides for the pesticides allowed for use on maize, potatoes and winter wheat in Denmark did not always match those in the Danish Pesticide taxes (see section 3.2.1 on the French DST SIRIS). A DST must be more relevant for the stakeholders before involving them in the assessment.

Anglian Region (UK):

Advantages: The Environmental Yardstick for Pesticides brings together several interesting sources of information in a way that appears to be more accessible to farmers and agronomists than currently available tools in the UK. The DST is especially valuable as an informative DST. Additionally, pesticides are considered together and can easily be compared.

Disadvantages: For implementation and application in the UK, adaptation and new data (e.g. label and authorisation data, integrated pest management (IPM) data) would need to be added; some of this data is less easy to find. Moreover, the DST focus on environmental impact including rate and risk of drift, which is not the only aspect driving product choice. Efficacy, the need for repeated applications, harvest intervals etc. also need consideration. Whilst the red/amber/green (high, medium and low risk) was liked by some, others feared that markets, using selected information, might ask growers not to use 'red' (high risk) products even though these might be the best in regard to efficacy.

Stakeholder perception: The Environmental Yardstick for Pesticides was found to be a useful DST by most farmers and agronomists. However, they would prefer it to be incorporated into an existing DST.

DST: Plant Protection Online (developed in Denmark) was tested in Case Study no. 9 in Noord Brabant (Netherlands). Plant Protection Online includes several plant protection tools for weeds, diseases and pest control in individual fields. For Noord Brabant the most interesting are 'the problem solvers' (Pesticide (mix) selection for specific weed species, diseases or pests in crops respectively); 'the Identification key' (identify/recognise weeds, pests and diseases) and 'users mixture' (compare efficacy of mixtures on weed species). These tools were tested in the Noord Brabant province because it has been directed to reduce pesticide leaching to groundwater. The Environmental Yardstick for Pesticides is already used in the case study area, but a specific advice tool for farmers does not exist and Plant Protection Online could provide the inspiration for the development of a new DST.

Advantages: Plant Protection Online has interesting components that are useful for advisors, e.g. the advice on low/reduced dosages, no treatment and information on damage thresholds.

Disadvantages: Plant Protection Online, in its current form, would be difficult to implement in the Netherlands, as it was not developed for Dutch crops and pesticides. Thus the DST is lacking in a number of the crops and pests/diseases present in the Netherlands.

Stakeholder perception: It is not practical for farmers as it involves too many steps, too much input data is necessary, and it is not practical for use in the field (e.g. there is no mobile app). If implemented, it would be preferable to incorporate the interesting components of Plant Protection Online into existing apps.

3.2 REMARKS ON CATCHMENT AND REGIONAL LEVEL DSTS

3.2.1 Risk assessment of pesticide applications

Risk assessment of pesticide applications was the focus of testing 3 DSTs (SIRIS, SCIMAP and Phytopixal) across 3 case study sites. The case study site objectives and the advantages, disadvantages and stakeholder perception for each of the DSTs are summarised below.

DST: SIRIS (developed in France) was tested in Case Study no. 2 in Aalborg (Denmark) and in Case study no. 4 in La Voulzie (France). The main output from SIRIS is a ranking of pesticides according to their potential to reach surface water and groundwater. In Denmark, the objective of the testing was to see how pesticide risk assessment is undertaken in France and compare it to both the Danish pesticide tax system, which reflects the risk of the pesticides in Denmark, as well as the output from the Dutch DST Environmental Yardstick for Pesticides (refer to section 3.1.2). In La Voulzie (France) SIRIS was selected as it is one of few DSTs available for predicting pesticide loss at the catchment scale, and it has not yet been tested there. The objective of the testing was to compare the modelled pesticide risk at catchment scale with the measured pesticide concentrations in the groundwater.

In the following section, the advantages, disadvantages and stakeholder perceptions are summarised for the testing of SIRIS in Aalborg (Denmark) and La Voulzie (France) respectively.

Aalborg (Denmark):

Advantages: A good surveillance program for experts which can handle leaching of pesticides at catchment level.

Disadvantages: The risk profiles generated by SIRIS and the Environmental Yardstick for Pesticides for the pesticides allowed for use in maize, potatoes and winter wheat in Denmark do not always match each other and the Danish Pesticide taxes; e.g. Roundup Bio (glyphosate 360 g/litre) was assessed to have a high risk in France, low risk in the Netherlands and low-medium risk in Denmark. However, comparison of the risk assessments is difficult due to different assessment methods, soil types etc. The differences should be explored further if implementation is to be considered.

Stakeholder perception: It is worrying for stakeholders that one DST can indicate that a pesticide should be banned (high risk) in one country, while another DST finds the same pesticide to be safe to use (low risk) in another country.

La Voulzie (France):

Advantages: SIRIS is a web-based DST developed for French conditions. It is easy to use for a watershed or water company manager or non-specialist modeller with knowledge relating to transfer of pesticides. Input data is easily available via a database and the DST can easily be applied in other catchments. Overall the DST is suitable for working at the catchment scale and identifies pesticides that must be restricted.

Disadvantages: Comparison of results from SIRIS with measured data show differences that are difficult to explain. Some features of the model systematically prevent SIRIS from correctly reproducing the behaviour of certain pesticides. SIRIS does not propose mitigation measures, which means the DST cannot be used for creating scenarios where practices are changed. It is not possible to simulate the impact on groundwater of unauthorized products and metabolites. Difficult to transfer from France for use in other countries.

Stakeholder perception: Not evaluated.

DST: SCIMAP (developed in the UK) was tested at Case Study No. 7 site in the Derg cross-border river catchment in Northern Ireland (NI) and the Republic of Ireland (RoI). Overland flow is the primary pathway for contaminants in the case study area. SCIMAP is a GIS-based spatial modelling approach which identifies areas in the landscape (based primarily on an elevation model and incorporated land use information) at greatest risk of overland flow generation, and thus contaminant mobilisation, during rainfall events. DST outputs are maps at a range of scales which

can be integrated with other data and used in management decisions. The objective of testing was to assess the potential of the DST as a management tool for stakeholders (water companies, catchment managers) and to aid in prioritising areas for implementing mitigation measures against MCPA pesticide impacts.

Advantages: The visual mapping of risk provided by this approach is very useful and intuitive for users. The GIS based system (available also in open source formats) is easy to use with basic training and the maps, once generated, can be used by diverse groups and experience levels.

Disadvantages: No consideration of groundwater pathways is included in the model, so it is only applicable in cases where surface flow dominates. The locations of pesticide sources are also not explicitly defined in the model – the user needs to add additional expert information on fields where pesticide applications are likely and combine that with overland flow risk. For the case study the biggest limitation is data availability. The accuracy of the SCIMAP approach is limited by the resolution of the digital terrain model (DTM); a 1-2 m resolution DTM is necessary to resolve high risk areas at sub-field scale and the available 5 m DTM for testing is too coarse. SCIMAP is only as good as the input data used. The software is only available to non-UK users as a web-version going forward and the user must provide all input data.

Stakeholder perception: Stakeholders appreciated the ease-of-use of the approach and found the visual maps of results easy to interpret. Some concerns were raised about data availability and costs in NI and RoI. Other countries have LiDAR (light detection and ranging) coverage of the surface of the Earth – in NI/RoI it is only available at high cost from commercial suppliers. The SCIMAP approach is now being used in the INTERREG Source to Tap (www.sourcetotap.eu) project which is ongoing in the same catchment.

DST: Phytopixal (developed in France) was tested in the Case Study No. 7 site in the Derg cross-border river catchment in Northern Ireland and the Republic of Ireland. Phytopixal is similar in objective to SCIMAP, but is a protocol implemented by the user to produce spatial risk maps that are used to identify areas in the landscape at greatest risk of overland flow, and thus pesticide mobilisation, during rainfall events. The objective of the testing was to assess the potential of the DST as a management tool for stakeholders (water companies, catchment managers) to assess the cost/benefits of available mitigation measures within the catchment.

Advantages: As the DST is a protocol rather than an application or toolbox, input data can be selected and defined by the user in whichever GIS platform they are familiar with. Results can be resampled to whichever scale the user requires (farm, sub-catchment or catchment levels).

Disadvantages: Phytopixal is a written protocol which has to be developed into a risk assessment framework by the user within whichever GIS software they have access to. This requires a higher level of GIS expertise and more time to set up and test than “off-the-shelf” DSTs. As with SCIMAP, the model is only as good as the input data used.

Stakeholder perception: Stakeholders with GIS experience appreciated the protocol-based approach and stakeholders generally found the visual maps of results easy to interpret. As with SCIMAP, some concerns were raised about data availability and costs.

3.2.2 Identify cost-effective measures to reduce nitrate and pesticide loads to water

Identifying cost-effective measures to reduce nitrate and pesticide loads to water was the focus of testing the DST Farmscoper at one case study site. The case study site objectives and the advantages, disadvantages and stakeholder perception for the DST are summarised below.

DST: Farmscoper (developed in UK) was tested in the Case Study No. 7 site in the Derg cross-border river catchment in Northern Ireland and the Republic of Ireland. Farmscoper is an advanced export coefficient model which estimates diffuse losses of P, N, pesticides and sediment from single or multiple farms and quantifies the expected impacts and economic costs of mitigating losses to water or the atmosphere. Outputs from the DST are graphical and tabular estimates of contaminant loads, on farm nutrient budgets and the economic costs of measures and combinations of measures.

Advantages: Farmscoper is easy to use with an intuitive Excel-based interface. Data are input at farm level and multiple farms can be combined up to catchment scales. The model export coefficient approach has a strong scientific basis. Actual farm data can be used or representative farm type data from censuses. The capability to evaluate the cost-benefits of combinations of mitigation measures is a potentially powerful tool to support water managers in drinking water catchments. Outputs from the DST are clear graphics and tables.

Disadvantages: Pesticide usage in the model is not as well-defined as for nutrients and based on general pesticide usage data for England/Wales. Usage in NI/RoI is different and this limits the application of the DST in the case study catchment. It would be possible to modify the DST to account for these differences. Similarly, geo-climatic differences between Ireland and England/Wales mean that runoff estimates are lower than actual when the model is applied. This would require significant re-development of the DST. Farm level data availability is limited in NI/RoI due to farm confidentiality and this will limit the application of the model using individual farm rather than census data. Mitigation measure options and economic costs also need to be updated for NI/RoI

Stakeholder perception: Stakeholders were very positive about the potential utility of Farmscoper, particularly in modelling multiple scenarios of mitigation options and identifying which will be most cost-effective. No similar DST exists in NI/RoI and the water companies, in particular, expressed an interest in seeing if the model could be adapted for use. There were some concerns raised about the restrictions of data availability in NI/RoI.

3.2.3 Identify cost-effective allocation, location and choice of nitrogen (N) mitigation measures in order to reduce N loads to water

Identifying cost-effective allocation, location and choice of N mitigation measures in order to reduce N load to water was the focus of testing the DST TargetEconN at one case study site. The case study site objectives and the advantages, disadvantages and stakeholder perception for the DST are summarised below.

DST: TargetEconN (developed in DK) was tested in Case Study No. 2 in Aalborg (DK). TargetEconN minimizes the total costs of achieving N load targets in a catchment, down to ID 15 catchment level (i.e. catchments of approximate 15 km^2). The model provides detailed results on the cost-effective allocation of N abatement as well as the choice of measures and the amount of each measure. The objective of the testing was to assess how and where to apply N mitigation

measures, to minimize the costs of meeting the nutrient load reduction target in the Water Framework Directive (WFD). The testing of TargetEconN will continue as part of Task 5.3 “Assessment of cost and benefits for farmers, water companies and society” in Work package 5 in the FAIRWAY project.

Advantages: An advantage of TargetEconN is the identification of which mitigation measures are cost-effective at field parcel level, including which measures to apply.

Disadvantages: The data inputs to the model on crops grown and fertilizer inputs are extensive, and was feasible since Denmark has good access to data. A further disadvantage is that the model is set up in GAMS, which is optimisation software that requires expert knowledge to be run.

Stakeholder perception: Aalborg Water Utility finds that information down to field level is attractive, but that information about the cost-effective mitigation solutions might not be, as involvement and acceptance by farmers is essential for them and negotiations are part of the solutions.

The Ministry of Environment and Food had a contradictory opinion; the Ministry found that field level results are too detailed, but that the assessment of the cost-effectiveness of N mitigation measures is highly relevant.

3.3 Main Findings from the Testing of DSTs

The testing of DSTs in the FAIRWAY case study sites has shown that many countries have developed similar DSTs to address similar problems. Thus important steps in the exchange process were to understand what other countries are doing, compare the tested DSTs with existing national DSTs and get some inspiration for enhancing existing DSTs used in the case study sites. In a few cases where no equivalent DST exists, the testing aimed to assess the potential for a DST to be used in that country and to draw on the ideas presented.

The main findings from testing of nutrient management DSTs at the FAIRWAY case study sites are summarised in Table 2.

Table 2. Main findings from the FAIRWAY case study sites testing of nutrient management DST. The asterisk (*) indicates that these findings recur for Pesticide management DSTs, Table 3.

Nutrient management DSTs
Topic:
• All DSTs aim to assist farmers in efficient nutrient use / efficient fertilizer planning.
Input data:
• Complexity of input data varies* (e.g. number of relevant nutrients). • Soil data is an obligatory input, but the DSTs use different soil classification systems. • Current crop information is an obligatory input, but information on crop rotation (field history) is not always included. • Reliable records on fertilizer use are obligatory, but these are not always available. • Weather data is necessary for most DSTs. No single DST covers all EU climate zones. • Individual (farm-specific) measurements (e.g. soil mineral N) can be included in some DSTs. • Databases must be regularly updated and maintained*.
Output:

• All DSTs provide information on restrictions on fertilizer use. These, however, are presented in different formats (N-quota, field-specific max. amounts, etc.).
• Outputs are clear recommendations e.g. max. amounts of fertilizers to be purchased, etc.
• Advice is provided at different levels* (farm level, field level).
• The output depends on the quality of the input data*.
• Mitigation measures:
  ○ Hardly any concrete advice on measures*.
  ○ But most DSTs can handle catch crops (e.g., Mark Online, Düngeplanung, NDICEA).
  ○ Environmental effects of measures are generally not quantified*.
  ○ Difficult to transfer from one country to another as the DST is developed for country specific situations (differences in climate, geographic, soil types, fertilizer recommendations, legal frameworks, farming systems, etc.).

Operational issues:
• Language skills needed (most DSTs and supporting documentation are only available in the local language) and require knowledge of national conditions/site conditions*. • DSTs need to be continuously improved e.g. via feedback by users*. • DSTs need to be continuously updated and maintained (e.g. to match current law, new findings, etc.)*. • Input data has to be updated regularly* (e.g. changes in farm management).

For the pesticide management DSTs several of the main findings from the testing of the nutrient management DSTs recur (marked with an asterisk (*) in Table 2). Some additional findings for pesticide management DSTs are added in Table 3.

Table 3. Additional findings from the FAIRWAY case study sites testing of pesticide management DSTs. See Table 2 for findings that recur for both Pesticide and nutrient management DSTs.

Pesticide management DSTs
Topic:
• The DSTs make relevant information accessible and easily available by bringing them together in one tool.
Input data:
• Exchange of pesticide management DSTs seems difficult because the use of and restrictions on individual pesticides differ from one country to another. Additionally, the risk profiles are not similar. • Output for mixtures of products is not always available. This would be beneficial for farmers as they often use this strategy. • Pesticide management DSTs that include mitigation measures are difficult to exchange between countries as they have been developed for country- or case study-specific situations and the effectiveness and costs differ regionally.
Output:
• Several of the tested pesticide management DSTs provide overland flow risk mapping. The visual representation is useful, as it is intuitive. • The output and the interpretation can be too simple because not all processes and factors are included in the DST. In this case, a user must understand the background of the DST and its limitations (e.g. only surface water is considered).

3.4 General Overview of DST Functionality

For all the DSTs tested, summary information was collated covering cross-case-study issues which could influence future development and implementation. This information was collated and grouped into the following categories: (1) Barriers to exchange (2) Requirements of a DST in terms of functionality, use and access and (3) Stakeholder attitudes to DSTs and mitigation measures.

3.4.1 Barriers to exchange

During the final selection of the DSTs valuable information about the barriers which may prevent or limit the exchange of a DST from one country to another was collected. The information from each participating case study site was collected in Evaluation Scheme 0 (see Appendix). Additional barriers were identified during testing and are described in Part 2 of this report. Table 4 summarises the identified barriers.

Table 4. Identified barriers to the exchange of DSTs from one country to another.

Barriers	**Note**
Language	At the outset of the project, all countries, responding to an assessment of 36 potential test DSTs (see Table 5 in report D5.1, Nicholson *et al.*, 2018), identified language as a key barrier to transferring DSTs from one country to another. As reported in Task 5.1, often the DST and supporting information are only available in the local language (Nicholson *et al.*, 2018).
Lack of support / documentation	For some DSTs the case study test groups identified lack of support and supporting documentation as a barrier to exchange.
Specialist software or skills required	Some of the complex DSTs require specialised personnel to run them and interpret the results (e.g. the DST requires expertise in GIS).
Software access	Some DSTs are commercial products requiring passwords for login. If the DSTs are not owned by project partners, software access has been reported to be a barrier to exchange.
Financial cost	For several DSTs financial cost has been reported to be a barrier for exchange from one country to another.
Data requirements	There is a wide variation in the data requirements for the DSTs as they vary in sophistication. Thus, most case study sites reported that data requirements might be a barrier for transferring a DST from one country to another. For example, in Northern Ireland little farm data is publically available, in contrast to Denmark where a large amount of data is publically available. Since different classification systems are used in different countries, data conversion to the required format is often required. This is crucial since the quality of the input data determines the quality of the output.
Developed based on country specific legislation	Some DSTs are developed based on country specific legislation, which is a barrier to a direct exchange of the DSTs. However, part of the DST and/or the principles could be exchanged. For example, Mark Online (DK) was successfully tested in Lower Saxony and it was found that some elements could be integrated into the German system. However the different legislation and its implementation in Denmark and Germany must be respected and limits the direct exchange of a DST between these countries.
Differences between regions (e.g. climate) / farm types	Regional differences can present a barrier for exchange (e.g. the precipitation pattern in Britain and Northern Ireland is not the same) or farm types (e.g. farms in Slovenia are much smaller than farms in the Netherlands). Generally, it is difficult to exchange software if it is calibrated to national conditions.

Due to the identified barriers (Table 4), the results of the testing of DSTs in the FAIRWAY case studies concluded that direct exchange and implementation of a DST is generally not possible. In all cases it was reported that some kind of adaption/re-development of the DST would be required first. However, in many cases the exchange of a conceptual model and/or specific functions or modules would be possible.

Furthermore, every country, at some level, seeks ideas/inspiration for developing their ‘own’ DST rather than using an existing DSTs, and often we ‘reinvent the wheel’. DSTs are often developed with government funding to address a specific need in that country or region. The funding is not provided for the benefit of other “potential” users elsewhere in the EU (the additional cost that this would entail cannot be justified). Commercial applications face similar limitations but tend to be less geographically constrained e.g. is Plant Protection Online applied in Denmark, Baltics and Poland. A new EU DST that is currently under development is the Farm Sustainability Tool for Nutrients (FaST) which aims to help all farmers in the EU manage the use of nutrients on their farms (https://ec.europa.eu/info/news/new-tool-increase-sustainable-use-nutrients-across-eu-2019-feb-19_en). The FaST is not yet available for assessment as part of the FAIRWAY project,

however it will be interesting to follow the development, performance and implementation of this DST, as it is the first farm nutrient management DST developed with full EU coverage. The strategies it incorporates to avoid the issues and barriers identified in this study will be of great interest to DST developers and stakeholders in all regions.

These findings are very much in line with the research of Rose and Bruce (2018) and Lundström and Lindblom (2018) who concluded that involvement of stakeholders in the development of a DST is a prerequisite to successful implementation. This prerequisite has not been met in any of the attempts to implement the DSTs in the designed exchange processes reported here. A more logical pathway is to organize exchange and inspiration at the level of the researchers involved, and give them the opportunity to set the timing and approach for incorporation of the intellectual harvest of the exchange into their own scientific and stakeholder communities.

3.4.2 Identification of DST requirements in term of functionality, use, and access

Information on the requirements of DSTs in terms of their functionality (cost, accessibility, data input and output formats, interoperability with other DSTs), use and access was also identified during the testing.

Functionality:

- A DST must be simple (user friendly, self-explanatory application), not too time-consuming and practical for farmers/advisors to use. However, the level of complexity depends on the target users and the objective of the DST. Sometimes more complexity is needed; particularly for DSTs that operate at the catchment scale and if complex environmental interactions are simulated.
- DSTs which can complete complex calculations (e.g. nutrient load calculations, pesticide dosage needs etc.) for the user with minimum data input requirement are useful. However, the DST should still provide some flexibility in order to react to specific situations (e.g. extreme weather events, specific regulation in some areas, etc.) and respect user judgement (e.g. on allocation of nutrients in an agronomically sensible way).
- The DST should support and secure correct advice in regard to e.g. cross-compliance checking.
- Free availability of reliable data and open source formats are important for innovation, development of (new) DSTs etc. Restricted access to farm data (e.g. in Northern Ireland) limits the extent to which DSTs can be applied and new DSTs developed.
- Introduction of new regulations (which are usually more complex) must be supported by providing some assistance for those affected. DSTs to ensure that farmers and other end users comply with legislation are helpful. Furthermore, clear information about the derivation of the outputs produced by the DST should be provided (e.g. data source, assumptions applied etc.). However, it must be simple and easy to see whether the legislation/rules are being followed.
- When new regulations or scientific findings are introduced, DSTs must be updated immediately if they are to retain their relevance and the trust of the end user. A well implemented, simple-to use DST can help to ensure that farmers and other end users comply with legislation.
- Consistency in outputs between different DSTs is important. For example during testing at the Aalborg (DK) case study site, the Environmental Yardstick for Pesticides, SIRIS and the Danish Pesticide tax system all gave different results for the risk from pesticides applied to certain crops. This does not inspire stakeholder confidence.

- Financial support/funding is important to develop, update and implement DSTs. Generally, it is important that DSTs are updated regularly to make sure they comply with the newest rules, scientific knowledge etc. in order to increase trust and thus the adoption rate of a DST. Governments may consider paying for upgrades, development etc. as, farmers will rarely pay for them; however, this depends on the type of DST and the benefits farmers can obtain from it.

Use:

- Advisory assistance is needed in order to encourage farmers to use DSTs, to assist in their application and to interpret their results. Thus, the success of a DST also crucially depends on the skills and experience of the advisor, who should be able to understand both the science and the applicability of the DST.
- An advisory service system is an important requirement in order to establish recognised communication pathways with farmers. On a personal level, one to one talks are often the most powerful form of communication. Additionally, the advisor must have the skills to communicate complex issues to farmers.
- When applying a DST, a user must be made aware of any potential financial or other gains in order to change their behaviour (e.g. increased crop yield; reduced pesticide costs; improved water quality).
- Successful use of a DST is likely if end users and stakeholders to some extend have be involved in the development of the DST, as the DST can be targeted to the needs of the end users.
- Public recognition of success will be beneficial especially for DSTs applied at catchment level i.e. demonstration of best practice.
- Government involvement in getting a DST adopted by farmers may, in some cases, increase its uptake and use. Currently adoption is often decided by market forces.

Access:

- DSTs which are accessible online via PC and mobile apps are likely to have higher take-up, however in some cases poor internet connections may limit the access and lack of technical knowledge may deter some users.
- Some DSTs should be free because they benefit the environment (common good). However, in many cases farmers use them because they gain economic benefits from reducing the pesticide/nutrient load not because they want to reduce the environmental impact. It is recognised that not all DSTs can be free, as commercial developers must get money to continue to produce and improve the DST if there is no public funding available.

3.4.3 Attitudes towards decision support tools and mitigation measures

The attitude of users towards the tested DSTs and the mitigation measures incorporated within them can be summarised as follows:

- A DST must be user-friendly and intuitively designed, i.e. have a clear structure, possibly with a modular design with a stepwise form that helps with fulfilling complex tasks, complying with rules etc.
- The results must be trustworthy and reliable. Thus, the DST must be based on sound evidence/knowledge. Information on data sources used should be provided.
- Supplementary information (manuals and supporting documentation) must be available in the national language or at least in English to answer the most frequent FAQ.

- The DST must be frequently updated to make sure the software complies with the most recent legal restrictions.
- A centralized and holistic approach should be taken, where data only needs to be entered once. There should not be a multitude of DSTs available for a single purpose as this can lead to confusion; integration of 'smaller' DSTs into a single package may be beneficial.
- DST should contain some "reality checks" in order to avoid data input errors.
- It is advantageous, if it is possible, to make easy multiannual analysis of data possible.
- The DST must provide clear results and outputs; graphical representations can be very useful in some cases.
- It can be useful to provide various ways for data to be input and output (web-interface, excel-sheet, pdf, etc.) to suit the user's preferences.

In FAIRWAY Case study no. 3 in the Anglian Region (UK) agronomists, farm advisors and farmers were asked about their general opinion of DSTs. It was clear from this group of respondents, that DSTs encompassed in existing software were deemed most useful. Detailed background explanations of many of the points above can be found in Part 2 of this report.

4. CONCLUDING COMMENTS

Twelve different DSTs were tested or demonstrated at 9 of the FAIRWAY case study sites located across the EU. The selected DSTs were a mixture of farm level tools which aimed to improve on-farm nutrient and/or pesticide management, and catchment/regional level DSTs which aimed to provide:

i) Risk assessment of pesticide applications;
ii) Identify cost-effective measures to reduce nitrate and pesticide loads to water;
iii) Identify cost-effective allocation, location and choice of nitrogen (N) mitigation measures in order to reduce N loads to water,

The findings of the testing process indicated that:

- Most countries have similar DSTs designed to address similar problems.
- Exchange of DSTs between countries is challenging due to various barriers to use e.g. different legislation, input data requirements and regional differences in precipitation, soil types etc.
- All countries were keen to take inspiration from others and to learn from ideas developed by other Member States.
- The consensus opinion was that it was preferable to adopt and enhance existing DSTs or to develop new country-specific DSTs rather than to attempt to adapt a DST developed in a different country.

A model DST that is acceptable to the majority of end users should fulfil most if not all of the criteria summarised in Figure 1.

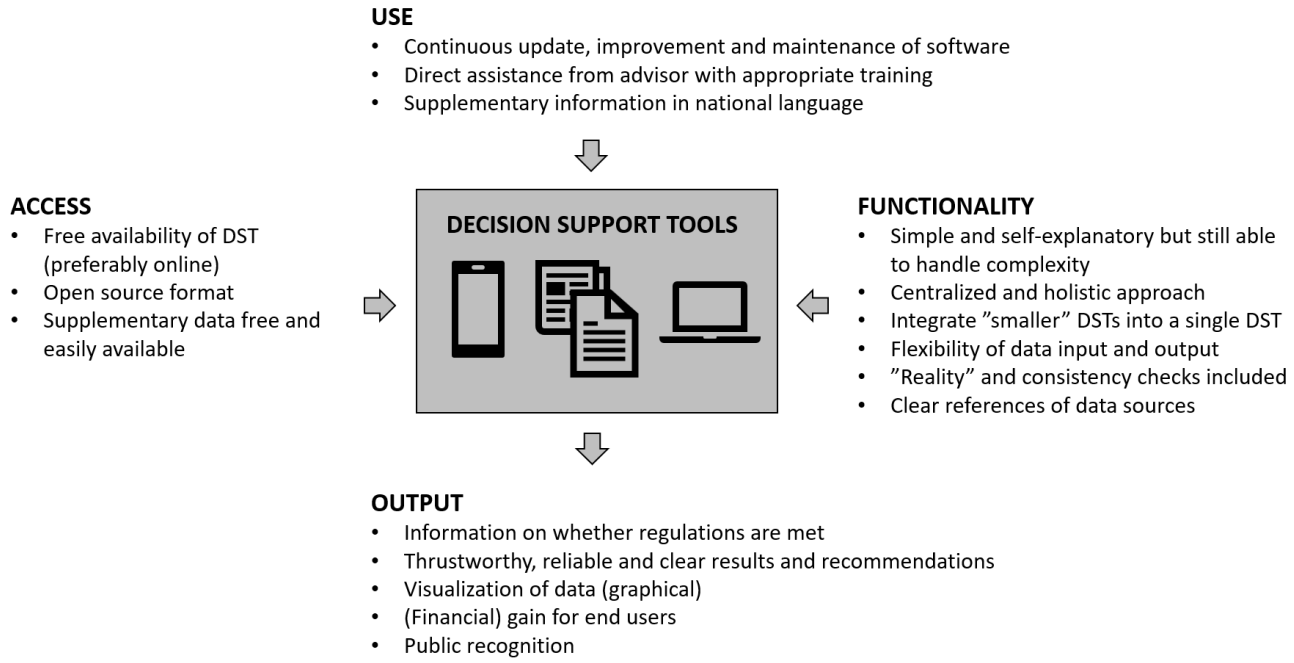

Figure 1. Criteria that DSTs should fulfil.

A DST that fulfils the criteria in Figure 1 and can deliver a range of functions is more likely to be successful, as end users prefer to limit the number of DSTs that they need to use. Additionally, good advisory assistance is important. The DST is only as good as the input data, and therefore support and advice from well-educated and communicative skilful advisors are highly valuable for the end user to make the right decisions.

The main results of Task 5.2 (Part 1 and Part 2 of this report) will, together with the findings in Task 5.1 (Nicholson *et al.*, 2018), be used in the next task (Task 5.3), and especially Task 5.4, where a framework will be established to highlight the ways in which DSTs can be applied successfully to establish and improve awareness of diffuse pollution of vulnerable drinking water resources among farmers and other stakeholders.

Evaluation of Decision Support Tools Part 2 – Case Study Results

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5. FAIRWAY CASE STUDY RESULTS

Part 2 of the FAIRWAY report *'Evaluation of Decision Support Tools'* contains detailed descriptions of the work and findings of the testing of decision support tools (DSTs) in the participating FAIRWAY case study sites. For the overall purpose of the work see Part 1, which also contains a summary of the main findings and a conclusion.

In Part 2, the following sections present the work and results of the assessment, testing and implementation of the selected DSTs for each participating FAIRWAY case study site in the order presented in Table 1 (Part 1).

5.1 DENMARK – AALBORG

The FAIRWAY case study site at Aalborg is located in one of the most vulnerable areas in Denmark with regards to nitrate and pesticide leaching to groundwater. In Denmark, the DSTs MarkOnline and Plant Protection Online are available to support sustainable nutrient and pesticide management at the farm level and are operated within Danish legislative requirements. Thus, it is assumed that these DSTs improve the efficient use of nitrogen and pesticides and by that improve water quality. Based on the findings summarised in evaluation scheme 0 (see Appendix), it was found that the Dutch DST Environmental Yardstick for Pesticides and the French DST SIRIS do the same with regard to pesticide management in the countries for which they were developed. These DSTs were therefore tested and assessed in a Danish context and compared to Danish pesticide tax system, which reflect the risk of the pesticides.

Additionally, the Danish DST TargetEconN was tested to assess how to apply N mitigation measures and where to apply them, to minimize the costs of meeting a nutrient load reduction target (the WFD targets are currently considered). The testing of TargetEconN will continue as part of Task 5.3 "Assessment of cost and benefits for farmers, water companies and society" in Work package 5.

5.1.1 Workplan

The workplan for application of Environmental Yardstick for Pesticides, SIRIS and TargetEconN in the FAIRWAY case study site at Aalborg is summarized in Table 5.

Table 5. Workplan for the FAIRWAY case study site at Aalborg, Denmark.

Action	Action details	Target deadline	Involved partners
Overview of selected DSTs and data requirements	Describe expectations/expected outcome by DST. Use evaluation scheme 1 (See Appendix).	October 2018	SEGES, AU
Secure access and pre-test selected DSTs	Contact the owners of the DSTs and obtain access to DSTs. Pre-test the DST and ask for support if necessary.	November 2018	SEGES, AU
Testing of selected DSTs	Enter own data and run model. Bilateral correspondence with the owners of the DSTs about results and improvements of simulations.	December 2018 – January 2019	SEGES, AU, CLM, BRGM
Describe and evaluate results	Evaluate results and compare with the Danish pesticide taxes and other models.	February 2019	SEGES, AU
Evaluate impact on practical management and implementation in a Danish context	Discuss results with experts and practitioners	February 2019	SEGES, AU
Summarize successes and difficulties		March 2019	SEGES, AU

5.1.2 **Assessment, testing and implementation of selected DSTs.**

In Denmark, farmers are only allowed to use pesticides approved by the Danish Environmental Protection Agency. The chemical agents are tested in the Danish Pesticide Leaching Assessment Programme to provide an early warning of the risk of groundwater contamination when approved pesticides are used in accordance with current regulations. If a pesticide or its degradation products leach to the groundwater, the monitoring results generated by the programme provide a basis for reassessment of the substance by the Danish Environmental Protection Agency.

In the following sections pesticides approved in Denmark for application in maize, potatoes and winter wheat were tested using the Dutch DST Environmental Yardstick for Pesticides and the French DST SIRIS. The results were compared with the Danish pesticide tax.

This is followed by the results of the testing of TargetEconN.

Environmental Yardstick for pesticides

a. Assessment

Environmental Yardstick for pesticides is a Dutch DST applied to quantify the environmental impact of the use of pesticides. For each permitted pesticide in the Netherlands, the Environmental Yardstick for Pesticides assigns environmental impact points (EIP) at the recommended product dose per ha to express the risk to water organisms, the risk of leaching to groundwater and the risk to soil organisms. High EIP (i.e. >1000 EIP) means high risk for the environment and this shows up as red in the Environmental Yardstick for Pesticides. A score of 100 – 1000 EIP shows up as orange and means medium risk, and low risk is green and has 0 – 100 EIP. Based on the EIP, the user can compare agents and choose the least harmful crop protection strategy.

In Denmark, to reduce the use of pesticides, DSTs such as Plant Protection Online and the Agent Database combined with the field experiments in the Nordic Field Trial System (NFTS) form the basis of recommendations to local advisors in relation to the composition of the weeds to be controlled. Agricultural advisors making field visits to farms in the growth season to help evaluate the correct dose are also important.

In winter cereals, a low dose strategy is based on knowledge of the composition of the weed population and early control. Often the weed will be controlled before germination or just after emergence at a very early stage, which requires in depth knowledge of the weed composition at field level. Often, very broad-spectrum spraying agents are used. The farmers and the advisors enter into Plant Protection Online and they fill in their experiences on the weed composition in the current field and the program calculates which pesticides are most effective to use. Based on this Plant Protection Online is a useful DST for advisors and farmers to make the right decisions. Testing the Environmental Yardstick for pesticides in a Danish context is therefore an interesting exercise.

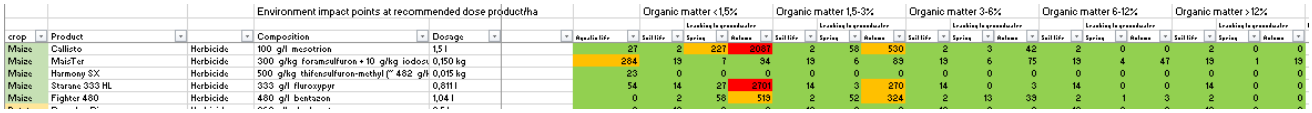
b. Testing

Results of the tests with approved Danish pesticides in maize, potatoes and winter wheat using the Environmental Yardstick for Pesticides are presented in the following sections.

Maize

In the Netherlands, there are 72 different products approved for control of weeds in maize. In comparison, Denmark only have 5 of the approved products available: Callisto, MaisTer, Harmony SX, Starane 333 HL and Fighter 480. These 5 products have been tested using the Environmental Yardstick for Pesticides (Figure 2). The results show that it is better to use the herbicide Callisto in maize than MaisTer, with respect to pesticide leaching to groundwater.

Callisto, MaisTer, Harmony SX, Starane Top (DK Starane 333 HL) and Basagran (DK Fighter 480) are all the same only with different names.



			Environment impact points at recommended dose product/ha			Organic matter <1,5%			Organic matter 1,5-3%			Organic matter 3-6%			Organic matter 6-12%			Organic matter >12%		
						Leaching to groundwater			Leaching to groundwater			Leaching to groundwater			Leaching to groundwater			Leaching to groundwater		
crop	Product		Composition	Dosage		Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn
Maize	Callisto	Herbicide	100 g/l mesotrion	1,5 l		27	2	227	2087	2	58	530	2	3	42	2	0	0	2	0	0
Maize	MaisTer	Herbicide	300 g/kg foramsulfuron + 10 g/kg iodosu	0,150 kg		264	13	7	34	13	6	83	13	6	75	13	4	47	13	1	13
Maize	Harmony SX	Herbicide	500 g/kg thifensulfuron-methyl (= 482 g/k	0,015 kg		23	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maize	Starane 333 HL	Herbicide	333 g/l fluroxypyr	0,811 l		54	14	21	2101	14	3	270	14	0	3	14	0	0	14	0	0
Maize	Fighter 480	Herbicide	480 g/l bentazon	1,04 l		0	2	58	519	2	52	324	2	13	38	2	1	3	2	0	0

Figure 2. Results of testing with approved Danish pesticides in maize using the Environmental Yardstick for Pesticides. Environment impact points at recommended product dose/ha. Green (low risk): 0-100 EIP, Orange (medium risk): 100-1000 EIP and Red (high risk): >1000 EIP.

However, in Denmark farmers often use a combination of 2-3 products. As an example, cranesbill (in Danish: storkenæb) is often a problem in maize and requires a combination of herbicides. Callisto and MaisTer have a low effect on Cranesbill (Table 6), so MaisTer, Callisto and Fighter 480 are used in a combination (Table 7). Therefore, a typical strategy for weed control in Denmark is to mix products in order to control different weed species (Table 7).

Table 6. Effect of herbicides on different weed species in Denmark. It is important to select the right combinations of herbicides. Many stars = high effect. Translation of column headings - DK: Ukrudtsarter = UK: Weed species, DK: Tokimbladet ukrudt = UK: Dicotyledonous weeds.

Ukrudtsarter	Callisto, 0,75 l/ha (mesotrion)	Fighter 480 0,5 l/ha (bentazon)	Harmony SX, 5,6 g/ha (thifensulfuron-methyl)	MaisTer, 75 g/ha (foramsulfuron+iodosulfuron)	Starane 333 HL 0,15 l/ha (fluroxypyr)	Stomp CS, 1,0 l/ha (pendimethalin)	Xinca, 0,5 l/ha (bromoxynil)
Tokimbladet frøukrudt							
Agerkål	****	**	****	*****	-	-	-
Agersennep	*****	***	****	*****	**	-	****
Agerstedmoder	*****	*	**	*****	*	**	*
Alm. brandbæger	-	**	**	*****	**	-	***
Burresnerre	***	***	-	*****	****	-	**
Fliget brøndsel	**	-	-	****	-	-	-
Forglemmigej	*****	-	***	****	****	**	***
Fuglegræs	*****	***	****	*****	***	**	*
Gul okseøje	****	***	*	****	-	-	*
Gulurt	***	-	**	***	-	-	**
Hanekro	*****	*	****	*****	****	-	**
Haremad	-	*	***	-	**	-	**
Hejrenæb	*	****	***	***	*	-	***
Hundepersille	**	-	-	****	*	-	**
Hvidmelet gåsefod	*****	***	****	*****	*	**	****
Hyrdetaske	*****	-	****	*****	-	-	**
Jordrøg	****	-	-	****	*	-	***
Kamille	****	**	****	*****	*	-	***
Kornblomst	***	-	**	***	*	-	***
Kornvalmue	*	-	***	****	-	***	***
Krumhals	**	***	*	*	***	*	-
Liden nælde	***	***	*	****	*	-	-
Nat limurt	*****	-	***	*****	**	-	-
Pengeurt	*****	-	****	*****	**	-	****
Pileurt, fersken	****	**	****	****	****	-	***
Snerlepileurt	****	**	***	***	****	-	***
Sort natskygge	*****	-	*	*****	*	-	****
Spergel	*****	*	****	*****	**	-	-
Spildraps	****	***	****	*****	*	-	***
Storkenæb	*	*****	***	***	*	*	***
Svinemælde	****	-	-	*****	-	-	****
Tvetand	****	*	****	****	**	**	***
Vejpileurt	****	*	***	***	***	-	**
Vikke	****	-	-	*	-	-	**
Vortemælk	-	-	-	-	-	-	-
Ærenpris	****	*	**	*	*	**	**

Table 7. Standard strategy for control of different weed species in maize with herbicides in Denmark. The strategy is developed by SEGES experts based on field trials. Often mixed products and a split application strategy are used in maize fields. Translation of column headings - DK: Skadegørere = UK: Gras & dicotyledonous weeds, DK: Tidspunkt = UK: Time, DK: Løsning = UK: Solution to solve the problem, DK: Dosis pr. hectare = UK: Dose per hectar, DK: Behandlingsindeks (BI) = UK: Treatment Index (TI), DK: Pris = UK: Price/cost.

Skadegørere	Tidspunkt	Løsning	Dosis pr. ha.	BI	Pris
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + MaisTer + MaisOil	(0,4 + 30 + 0,4) - (0,6 + 50 + 0,67)	0,47-0,73	179-281
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	(0,4 + 5,6 + 0,5) - (0,5 + 5,6 + 0,5)	1,14-1,37	359-449
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Callisto + MaisTer + MaisOil	(0,4 + 35 + 0,45) - (0,5 + 50 + 0,67)		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	(0,4 + 5,6 + 0,5) - (0,6 + 5,6 + 0,5)	1,16-1,29	337-388
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Starane 333 HL + MaisTer + MaisOil	(0,15 + 50 + 0,45) - (0,15 + 50 + 0,67)		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hejrenæb, hvidmelet gåsefod, hyrdetaske, kamille, kornblomst, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Fighter 480 + Renol	(0,4 + 0,3 + 0,5) - (0,6 + 0,4 + 0,5)	1,51-1,93	456-577
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Callisto + Fighter 480 + MaisTer + MaisOil	(0,5 + 0,4 + 35 + 0,45) - (0,5 + 0,5 + 50 + 0,67)		
Agersennep, agerstedmoder, bleg pileurt, burresnerre, enårig rapgræs, ferskenpileurt, fuglegræs, hejrenæb, hvidmelet gåsefod, hyrdetaske, kamille, kornblomst, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	(0,4 + 5,6 + 0,5) - (0,6 + 5,6 + 0,5)	1,59-1,92	449-554
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Callisto + Fighter 480 + MaisTer + MaisOil	(0,5 + 0,4 + 35 + 0,45) - (0,5 + 0,5 + 50 + 0,67)		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hejrenæb, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	Før afgrødens fremspiring	Legacy 500 SC	0,05 - 0,075	-	276-414
	Forår på ukrudtets stadium 10-12 (0-2 løvblade)	Callisto + MaisTer + MaisOil	(0,5 + 50 + 0,67) - (0,75 + 75 + 1)		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hejrenæb, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	0,75 + 5,6 + 0,5	1,44-1,71	474-576
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Callisto + MaisTer + MaisOil	(0,5 + 35 + 0,45) - (0,75 + 50 + 0,67)		
Agermynte, agersvinemælk, alm. hanespore, græsukrudt, grøn skærmaks, kvik, kærgaltetand, tokimbladet frøukrudt	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	0,75 + 5,6 + 0,5	2,04-2,21	704-767
	2. sprøjtning 10-14 dage senere	Callisto + MaisTer + MaisOil	0,5 + 75 + 1		
	3. sprøjtning	MaisTer + MaisOil	(50 + 0,67) - (75 + 1)		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hejrenæb, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rød tvetand, snerlepileurt, sort natskygge, storkenæb, vejpileurt	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Fighter 480 + Starane 333 HL + Renol	0,3 + 0,3 + 0,1 + 0,5	1,41	483
	2. sprøjtning 7-10 dage senere, når næste hold ukrudt er spiret frem	Callisto + MaisTer + MaisOil	0,3 + 30 + 0,4		
	3. sprøjtning 10-14 dage efter 2. sprøjtning	Callisto + MaisTer + MaisOil	0,3 + 30 + 0,4		
Agerstedmoder, burresnerre, enårig rapgræs, fuglegræs, hvidmelet gåsefod, hyrdetaske, kamille, korsblomstret ukrudt, pileurt, rajgræs, rød tvetand, snerlepileurt, sort natskygge, vejpileurt, vindaks, ærenpris	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Xinca	(0,5 + 0,2) - (0,75 + 0,4)	1,04-1,65	371-576
	2. sprøjtning 10-14 dage senere	Callisto + MaisTer + MaisOil	(0,4 + 35 + 0,45) - (0,6 + 50 + 0,67)		
Agertidsel, gråbynke, spildkartofler, tokimbladet frøukrudt, vandpileurt	1. sprøjtning, ukrudt max. 2 løvblade	Callisto + Harmony SX + Renol	0,5 + 5,6 + 0,5	1,61-1,71	538-576
	2. sprøjtning 10-14 dage senere	Callisto + MaisTer + MaisOil	(0,5 + 35 + 0,45) - (0,5 + 50 + 0,67)		
	3. sprøjtning	Callisto	0,5		
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The test in maize shows that the Environmental Yardstick for Pesticides is not able to provide advice on which weeds are controlled by which products. This makes the tool less useful at field level. In Denmark, the dose recommended by the producer is not used. Instead lower combination doses based on field trials are used in order to control the exact composition of the weed species (Table 7).

Potatoes

As with maize, the availability of herbicides used on potatoes in Denmark is very limited (Figure 3) in comparison to the Netherlands, where 47 different products are available for potatoes. Additionally, the products are used in very different ways, which makes the Environmental Yardstick for Pesticides not relevant. Because only a few herbicides are available and because they have different effects, this means that there is no need for a DST, which can separate the risk. Only if there are more than 5 pesticides with nearly the same effects does it make sense to use the Environmental Yardstick for Pesticides.

From 2020 Denmark will not be allowed to use Reglone anymore.

			Environment impact points at recommended dose product/ha			Organic matter <1,5%			Organic matter 1,5-3%			Organic matter 3-6%			Organic matter 6-12%			Organic matter >12%		
							Leaching to groundwater			Leaching to groundwater			Leaching to groundwater			Leaching to groundwater			Leaching to groundwater		
crop	Product		Composition	Dosage	Aquatic life	Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn	Soil life	Spring	Autumn
Potatoes	Roundup Bio	Herbicide	360 g/l glyphosat	3,5 l	8	13	0	0	13	0	0	13	0	0	13	0	0	13	0	0
Potatoes	Reglone	Herbicide	374 g/l diquat dibromid (" 200 g/l diqua	4 l	544	33	0	0	33	0	0	33	0	0	33	0	0	33	0	0
Potatoes	Proman	Herbicide	500 g/l metobromuron	4 l	62	24	2740	9340	24	212	456	24	1	2	24	0	0	24	0	0
Potatoes	Boxer	Herbicide	800 g/l prosulfocarb	3,5 l	224	113	0	112	113	0	3	113	0	0	113	0	0	113	0	0
Potatoes	Agil 100 EC	Herbicide	100 g/l propaquizafop	1,25 l	45	1	1	2	1	0	0	1	0	0	1	0	0	1	0	0
Potatoes	Focus Ultra	Herbicide	100 g/l cycloxydim	5 l	1	0	1300	8000	0	650	1650	0	50	100	0	0	1	0	0	0
Potatoes	Fianman	Suspensionscor	400 g/l cyazofamid	0,2 l	13	2	87	62	2	6	6	2	0	0	2	0	0	2	0	0
Potatoes	Shirlan	Fungicide	500 g/l fluazinam	0,4 l	276	24	381	442	24	54	66	24	1	1	24	0	0	24	0	0
Potatoes	Acrobat New	Fungicide	75 g/kg dimethomorph + 667 g/kg manco	1,68 kg	51	81	118	715	81	8	475	81	3	408	81	1	304	81	0	158
Potatoes	Cyperb 100	Insekticide	100 g/l cypermethrin (cis:trans 40:60)	0,4 l	123	2	0	0	2	0	0	2	0	0	2	0	0	2	0	0
Potatoes	Karate 2,5 WG	Insekticide	25 g/kg lambda-cyhalothrin	0,3 kg	300	4	0	0	2	0	0	1	0	0	1	0	0	0	0	0

Figure 3. Results of testing with approved Danish pesticides in winter potatoes using the Environmental Yardstick for Pesticides. Environment impact points at recommended product dose/ha. Green (low risk): 0-100 EIP, Orange (medium risk): 100-1000 EIP and Red (high risk).

Table 8. Standard strategy for control of different weed species in potatoes with herbicides in Denmark. The strategy is developed by SEGES experts based on field trials. Translation of column headings - DK: Skadegørere = UK: Gras & dicotyledonous weeds, DK: Tidspunkt = UK: Time, DK: Løsning = UK: Solution to solve the problem, DK: Dosis pr. hectare = UK: Dose per hectar, DK: Pris = UK: Price/cost.

Skadegørere	Tidspunkt	Løsning	Dosis pr. ha.	Pris
Græsukrudt, tokimbladet ukrudt	1. sprøjtning inden kartoflernes fremspiring	Roundup Bio	1 - 2	50-100
Græsukrudt, tokimbladet ukrudt	1. sprøjtning inden kartoflernes fremspiring	Reglone + Sprede-klæbemiddel	(1,25 + 0,15) - (1,75 + 0,15)	289-403
Tokimbladet ukrudt	Før kartoflernes fremspiring (se bemærkninger)	Proman + Reglone	2 + 1,2	984
Burresnerre, sort natskygge	Efter afgrødens fremspiring	Boxer	2 - 3	360-540
Hvidmelet gåsefod	Forår under gode temperaturforhold	Metaxon	0,03 - 0,1	6-21
Græsukrudt, tokimbladet ukrudt	1. sprøjtning i god tid inden kartoflernes fremspiring. Efterfølgende udføres mekanisk bekæmpelse	Roundup Bio	1,5 - 2	75-100
Kvik	Forår når kvikken har 3-4 blade og er i god vækst	Agil 100 EC	0,75 - 0,8	180-192
Kvik	Forår når kvikken har 3-4 blade og er i god vækst	Focus Ultra + Dash	(1,5 + 0,5) - (2 + 0,5)	303-398

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Winter Wheat

In winter wheat, the recommendations are often complicated because low dose mixtures are often used to ensure high effect and prevent herbicide and fungicide resistance in Denmark. Figure 4 shows the results from the Environmental Yardstick for Pesticides tested with approved Danish pesticides in winter wheat.

crop	Product		Composition	Dosage		Environment impact points at recommended dose product/ha				Organic matter <1,5%				Organic matter 1,5-3%				Organic matter 3-6%				Organic matter 6-12%				Organic matter >12%			
												Leaching to groundwater				Leaching to groundwater				Leaching to groundwater				Leaching to groundwater				Leaching to groundwater		
						Aquatic life	Soil life	Spring	Autumn	Soil life	Spring	Autumn		Soil life	Spring	Autumn		Soil life	Spring	Autumn		Soil life	Spring	Autumn		Soil life	Spring	Autumn	
Wheat	Adimax	Herbicide	600 g/l prosulfocarb + 10 g/l clodinafop-pr	4 l		264	137	10	877	137	2	173		137	0	3		137	0	0		137	0	0		137	0	0	
Wheat	Atlantis OD	Herbicide	30 g/l mefenpyr-diethyl (" 25,5 g/l mefenp	0,75 l		104	5	510	917	5	333	708		5	120	269		5	23	88		5	5	21					
Wheat	Boxer/Fidox/Roxy	Herbicide	800 g/l prosulfocarb	4 l		256	135	0	197	135	0	3		135	0	0		135	0	0		135	0	0					
Wheat	Cossack OD	Herbicide	22,5 g/l mefenpyr-diethyl (" 19,1 g/l mefen	0,33 l		124	9	500	1258	9	332	991		9	133	549		9	41	257		9	10	90					
Wheat	Hussar OD	Herbicide	300 g/l mefenpyr-diethyl (" 255 g/l mefen	0,075 l		39	6	516	1237	6	335	988		6	124	537		6	37	263		6	7	35					
Wheat	Hussar Plus OD	Herbicide	250 g/l mefenpyr-diethyl (" 212 g/l mefen	0,05 l		18	2	280	583	2	181	454		2	64	217		2	17	94		2	3	32					
Wheat	Othello	Herbicide	50 g/l diflufenican + 22,5 g/l mefenpyr-diet	1,2 l		223	8	61	2482	8	51	1564		8	34	645		8	16	153		8	7	42					
Wheat	Primera super / Foxtrot	Herbicide	69 g/l fenoxaprop-P-ethyl (" 63,6 g/l fenox	1 l		22	1	1607	2551	1	1015	1605		1	321	536		1	63	92		1	2	2					
Wheat	Stomp SC	Herbicide	455 g/l pendimethalin	1,0 liter		114	41	0	0	41	0	0		41	0	0		41	0	0		41	0	0					
Wheat	Ally SX	Herbicide	200 g/kg metsulfuron-methyl (" 193 g/kg m	0,002 kg		5	0	1	6	0	1	4		0	1	3		0	0	1		0	0	0					
Wheat	Starane XL	Herbicide	2,5 g/l florasulam + 100 g/l fluroxypyr	1 l		28	5	106	1033	5	78	182		5	53	58		5	28	29		5	9	10					
Wheat	Mustang forte	**Herbicide**	5 g/l florasulam + 180 g/l 2,4-D + 10 g/l ami	0,75 l		14	2	257	5783	2	159	1526		2	82	288		2	42	58		2	14	15					
Wheat	Primus XL	Herbicide	5 g/l florasulam + 100 g/l fluroxypyr	1 l		37	5	201	1133	5	155	264		5	106	115		5	56	58		5	18	19					
Wheat	Tombo + PG 26N (oil)		25 g/kg florasulam + 50 g/kg aminopyralid	0,2 kg		33	2	199	533	2	158	421		2	107	286		2	56	76		2	18	20					
Wheat	Atlantis OD	Herbicide	30 g/l mefenpyr-diethyl (" 25,5 g/l mefenpy	0,3 l		125	6	612	1172	6	339	850		6	144	347		6	35	105		6	6	26					
Wheat	Hussar Plus OD + Mero EC 80 (oil	Herbicide	250 g/l mefenpyr-diethyl (" 212 g/l mefenpy	0,14 l		52	7	784	1648	7	506	1270		7	178	608		7	47	264		7	7	83					
Wheat	Cossack OD + Renol		22,5 g/l mefenpyr-diethyl (" 19,1 g/l mefen	0,33 l		124	9	500	1258	9	332	991		9	133	549		9	41	257		9	10	90					
Wheat	Atlantis OD	Herbicide	30 g/l mefenpyr-diethyl (" 25,5 g/l mefenpy	0,3 l		125	6	612	1172	6	339	850		6	144	347		6	35	105		6	6	26					
Wheat	Comet Pro	Fungicide	200 g/l pyraclostrobin	1,25 l		57	1	0	0	1	0	0		1	0	0		1	0	0		1	0	0					
Wheat	Bell	Fungicide	67 g/l epoxiconazol + 233 g/l boscalid	1,5 l		47	37	1852	2230	37	263	375		37	73	84		37	6	8		37	0	0					
Wheat	Ceando		300 g/l metrafenon	1,5 l		22	83	1	1	83	0	0		83	0	0		83	0	0		83	0	0					
Wheat	Flexity	Fungicide	300 g/l metrafenon	0,5 l		7	28	0	0	28	0	0		28	0	0		28	0	0		28	0	0					
Wheat	Proline EC 250		250 g/l prothioconazol	0,8 l		62	1	0	0	1	0	0		1	0	0		1	0	0		1	0	0					
Wheat	Proline Xpert		80 g/l tebuconazol + 160 g/l prothioconaz	0,75 l		79	28	293	460	28	147	218		28	47	54		28	4	5		28	0	0					
Wheat	Prosaro EC 250		125 g/l tebuconazol + 125 g/l prothioconaz	0,3 l		38	17	183	288	17	92	136		17	29	34		17	2	3		17	0	0					
Wheat	Rubric		125 g/l epoxiconazol	1 l	253	53	100	565	893	100	284	423		100	91	105		100	8	10		100	0	0					
Wheat	Viverda + Ultimate S		50 g/l epoxiconazol + 60 g/l pyraclostrobir	2,5 l	668	92	117	1365	2468	117	319	458		117	91	105		117	8	10		117	0	0					
Wheat	Propulse SE 250 + Comet Pro		125 g/l prothioconazol + 125 g/l fluopyram +	1 l + 1,25 l	135,5	101	16	3376	4125	16	958	1114		16	37	51		16	0	0		16	0	0					
Wheat	Propulse SE 250 + Orius 200 EW		125 g/l prothioconazol + 125 g/l fluopyram +	1 l + 1,25 l	169	217	126	5194	6643	126	1563	2021		126	234	276		126	16	23		126	0	0					
Wheat	Propulse SE 250		125 g/l prothioconazol + 125 g/l fluopyram	1 l	78	44	16	3376	4125	16	958	1114		16	37	51		16	0	0		16	0	0					
Wheat	Viverda + Prosaro EC 250 + Ultimate S		50 g/l epoxiconazol + 60 g/l pyraclostrobin + 140 g/l boscalid & 125 g/l tebucor		474	217	174	2574	3427	174	624	811		174	169	216		174	15	21		174	0	0					
Wheat	Bell + Prosaro EC 250		67 g/l epoxiconazol + 233 g/l boscalid & 12	1,5 l + 1 l	474	173	154	2462	3243	154	569	828		154	172	198		154	14	19		154	0	0					
Wheat	Bell + Proline Xpert		67 g/l epoxiconazol + 233 g/l boscalid & 8	1,5 l + 0,75 l	457	140	134	2242	2904	134	459	665		134	136	157		134	11	15		134	0	0					
Wheat	Viverda + Proline Xpert + Ultimate S		50 g/l epoxiconazol + 60 g/l pyraclostrobir	2,5 l + 0,75 l	717	171	145	2258	2928	145	465	675		145	138	159		145	11	15		145	0	0					
Wheat	Armure		150 g/l difenoconazol + 150 g/l propiconaz	0,8 l	90	130	2	1065	1681	2	534	795		2	172	193		2	14	20		2	0	0					
Wheat	Prosaro EC 250		125 g/l tebuconazol + 125 g/l prothioconaz	1 l	68	125	57	609	959	57	306	454		57	98	113		57	8	11		57	0	0					
Wheat	Karate 2,5 WG	Insektticide	25 g/kg lambda-cyhalothrin	0,4 kg		400	5	0	0	2	0	0		1	0	0		1	0	0		0	0	0					
Wheat	Kaiso Sorbie		50 g/kg lambda-cyhalothrin	0,15 kg		300	4	0	0	2	0	0		1	0	0		1	0	0		0	0	0					
Wheat	Pirimor G	Insektticide	500 g/kg pirimicarb	0,2 kg		235	5	1730	2156	5	323	423		5	14	21		5	0	0		5	0	0					
Wheat	Teppeki		500 g/kg flonicamid	0,14 kg		0	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Cycocel 750	Growth regulato	750 g/l chlormequat-chlorid (" 582 g/l chlo	1,5 l		2	10	1024	4174	10	61	183		10	0	1		10	0	0		10	0	0					
Wheat	Stabilan Extra	Growth regulato	750 g/l chlormequat-chlorid (" 582 g/l chlo	1,2 l		2	8	819	3339	8	49	147		8	0	1		8	0	0		8	0	0					
Wheat	Trece 750	Growth regulato	750 g/l chlormequat-chlorid (" 582 g/l chlo	1,2 l		2	8	819	3339	8	49	147		8	0	1		8	0	0		8	0	0					
Wheat	Moxa		250 g/l trinexapac-ethyl (" 222 g/l trinexap	0,4 l		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Moddus Start		250 g/l trinexapac-ethyl (" 222 g/l trinexap	0,3 l		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Medax Max		75 g/kg trinexapac-ethyl (" 66,7 g/kg trinex	0,75 kg		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Moddus M	Growth regulato	250 g/l trinexapac-ethyl (" 222 g/l trinexap	0,4 l		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Trimaxx		175 g/l trinexapac-ethyl (" 156 g/l trinexapac	0,4 l		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Cuadro NT		250 g/l trinexapac-ethyl (" 222 g/l trinexap	0,4 l		1	0	0	0	0	0	0		0	0	0		0	0	0		0	0	0					
Wheat	Medax Top		300 g/l mepiquat-chlorid (" 229 g/l mepiqu	1,5 l		1	4	225	13500	4	90	2250		4	4	135		4	0	0		4	0	0					
Wheat	Terpal		155 g/l ethephon + 305 g/l mepiquat-chlorid	1,2 l		6	12	183	10380	12	73	1830		12	3	110		12	0	0		12	0	0					

Figure 4. Results of testing with approved Danish pesticides in winter wheat using the Environmental Yardstick for Pesticides. Environment impact points at recommended product dose/ha. Green (low risk): 0-100 EIP, Orange (medium risk): 100-1000 EIP and Red (high risk).

Table 9. Standard strategy for control of different weed species in winter wheat with herbicides in Denmark. The strategy is developed by SEGES experts based on field trials. Translation of column headings - DK: Skadegørere = UK: Gras & dicotyledonous weeds, DK: Tidspunkt = UK: Time, DK: Løsning = UK: Solution to solve the problem, DK: Dosis pr. hectare = UK: Dose per hectar, DK: Behandlingsindeks (BI) = UK: Treatment Index (TI), DK: Pris = UK: Price/cost, DK: Bemærkninger = UK: Remarks.

Ukrudtsbekæmpelse i vinterhvede om efteråret 20-11-2018 SEGES

Skadegørere	Tidspunkt	Løsning	Dosis pr. ha.	BI	Pris	Bemærkninger
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF	1 + 0,075	1,38	421	**Tidlig såning. Tokimbl ukrudt + enårig rapgræs + evt. vindaks.** Opfølgning efter behov forår med f.eks. 0,5 l/ha Cossack OD eller 0,3 l/ha Atlantis OD + 90 g Broadway pr. ha.
	Opfølgning forår	Cossack OD + Renol	0,5 + 0,5			
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, rajgræs, stedmoder, storkenæb, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF	2 + 0,05	2,12	769	**Tidlig såning. Alm. rajgræs, enårig rapgræs og tokimbladet ukrudt.** Opfølgning efter behov med f.eks. 0,14 l Hussar Plus, 165 g Broadway eller 0,6 l Cossack OD pr. ha i foråret.
	2. sprøjtning 14-21 dage senere	Topik + Renol	0,2 + 0,5			
	Evt. opfølgning forår	Hussar Plus OD + Renol	0,14 + 0,5			
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, rajgræs, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF	1,5 + 0,05	2,26	808	**Tidlig såning. Alm. rajgræs, enårig rapgræs og tokimbladet ukrudt.** Opfølgning efter behov med f.eks. 0,14 l Hussar Plus OD, 165 g Broadway eller 0,6 l Cossack OD pr. ha i foråret.
	2. sprøjtning 14-21 dage senere	Adimax + Topik	1 + 0,1			
	Evt. opfølgning forår	Hussar Plus OD + Renol	0,14 + 0,5			
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF	(0,75 + 0,05) - (1 + 0,075)	0,46-0,66	156-211	**Tokimbl ukrudt + enårig rapgræs + vindaks.** Moderat vindaksbestand, 10-40 planter pr. m^2. Højeste dosis DFF ved stor bestand af stedmoder og ærenpris. Dosis af DFF på 0,075 l/ha forebygger resistens hos fuglegræs og kamille.
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF	(1 + 0,05) - (1,5 + 0,075)	0,54-0,80	201-301	**Tokimbl ukrudt + enårig rapgræs + vindaks.** Stor vindaksbestand, >40 planter pr. m^2. Opfølgning mod vindaks efter behov forår. Højeste dosis af DFF ved stor bestand af stedmoder og ærenpris. Dosis af DFF på 0,075 l/ha forebygger resistens hos fuglegræs og kamille.
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, raps, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 11-12	Boxer + DFF + Express SX	(0,75 + 0,05 + 3) - (1 + 0,075 + 4)	0,66-0,93	166-225	**Tokimbl ukrudt incl. mange spildraps + enårig rapgræs + vindaks.** Express/Nuance efterår giver restriktioner for anvendelse af SU-midler forår. Højeste dosis DFF ved stor bestand af stedmoder og ærenpris. Dosis af DFF på 0,075 l/ha forebygger resistens hos fuglegræs og kamille.
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF + Buctril EC 225	(0,75 + 0,03 + 0,35) - (1 + 0,05 + 0,45)	0,56-0,79	224-300	**Kamille + fuglegræs + enårig rapgræs + vindaks.** Moderat vindaksbestand, 10-40 planter pr. m^2. Buctril forebygger ALS-resistens hos kamille og fuglegræs. Højeste dosis DFF ved stor bestand af stedmoder og ærenpris.
Burresnerre, enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + DFF + Xinca	(0,75 + 0,03 + 0,2) - (1 + 0,05 + 0,25)	0,57-0,79	199-266	**Kamille + fuglegræs + enårig rapgræs + vindaks.** Moderat vindaksbestand, 10-40 planter pr. m^2. Xinca/Maya forebygger ALS-resistens hos kamille og fuglegræs. Højeste dosis DFF ved stor bestand af stedmoder og ærenpris.
Enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, kornblomst, kornvalmue, stedmoder, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + Stomp CS + DFF	(0,4 + 0,6 + 0,05) - (0,75 + 0,75 + 0,05)	0,53-0,68	270-378	**Tokimbl ukrudt + valmue + enårig rapgræs + vindaks. Hvor der hyppigt er anvendt SU-midler mod valmue.** Meget bred effekt.
Enårig rapgræs, forglemmigej, fuglegræs, hyrdetaske, kamille, kornblomst, kornvalmue, stedmoder, storkenæb, tvetand, vindaks, ærenpris	Efterår på afgrødens stadium 10-11	Boxer + Lexus 50 WG + DFF	(0,75 + 5 + 0,05) - (0,75 + 8 + 0,075)	0,71-0,99	194-227	**Tokimbl ukrudt + kornblomst + storkenæb + enårig rapgræs og vindaks.** Evt. opfølgning mod kornblomst og storkenæb bør ske med middel med anden virkemekanisme end ALS-hæmmer, f.eks. Mustang forte mod kornblomst og Zypar mod storkenæb.

Often mixed products and a split application strategy are used in winter wheat fields. A combination of herbicides in winter wheat are often recommended. Table 9 shows the SEGES Strategy for control of different weed species in winter wheat with herbicides.

c. Implementation

The Environmental Yardstick for Pesticides focuses on leaching of pesticides to groundwater, and the DST's strength is risk management of pesticides. This is useful if the purpose is to select the most sustainable products from a wide selection. Generally, the Netherlands have more products available for the control of weeds in maize, potatoes and winter than Denmark. Thus, the Environmental Yardstick for Pesticides is much more relevant in the Netherlands than in Denmark.

A combination of the Environmental Yardstick for Pesticides and the Danish DST Plant Protection Online would be a useful DST. To prevent resistance development, it is crucial to use many different products with different mechanisms of action, and this requires the use of complex DSTs.

The Danish DST Plant Protection Online does not visually display the risk effect. In Denmark the risk is controlled by taxes on pesticides, so a high risk means high taxes. The tax is calculated based on factors such as health, environmental behaviour and environmental effect.

SIRIS

a. Assessment

SIRIS is a French DST mainly used by the administration to refine pesticide surveillance programmes. In SIRIS, “Le-rang” defines the risk. A high “Le-rang”-percentage means a high risk of pesticide leaching. SIRIS does not differentiate risks between spring and autumn applications, as does the Dutch DST Environmental Yardstick for Pesticides. However, the leaching potential in SIRIS takes into consideration the organic matter in soil.

b. Testing

SIRIS has, as with the Environmental Yardstick for Pesticides, been tested with pesticides approved in Denmark for application in maize, potatoes and winter wheat.

In the following, the results of a comparison of SIRIS, Environmental Yardstick and the Danish pesticide tax system is presented. The test was based on the expectation that there is the same level of risk for leaching in all countries for each pesticide.

Comparison of SIRIS, Environmental Yardstick for Pesticides and the Danish pesticide tax system

SIRIS and the Environmental Yardstick for Pesticides were developed to test the risk of pesticide leaching to the groundwater. In Denmark, pesticide load data and load index and pesticides are assessed on three different levels:

1. Health (Calculation of the effect of pesticide load on human health)
2. Environmental fate (Degradation in soil, bioaccumulation, mobility in soil)
3. Environmental toxicity (Determined by using several sub indicators in nature)

’Environmental fate’ is the assessment most comparable to SIRIS and the Environmental Yardstick for Pesticides. However, note that it is difficult to compare assessments from the individual countries as they use very different methods and assessments.

In the Danish assessments, Boxer (prosulfocarb) and Stomp (pendimethalin) have high leaching risks. The rest of the examined pesticides had medium-low leaching risk Table 10.

Table 10. Danish risk profiles. Load data and load index for selected products. Red and green indicate the highest and lowest load, respectively. For products, which may be applied to several crops, efficacy and load index for winter cereals are used. In the column 'Environmental fate' a red colour and high number indicate high risk of leaching. Table from Danish EPA - Environmental review no. 2, 2012.

Regnr.	Product	Efficacy (TFI per kg)	Active ingrid. (kg per kg)	Load (L per kg)	IN TOTAL	Health	Environmental fate	Environmental toxicity
		-- (per kg of product) --			-- Load index (L per TFI) --			
FUNGICIDES								
19-144	Opera	0,93	0,18	1,75	1,88	1,24	0,24	0,41
11-29	Rubric	1,00	0,13	1,78	1,78	1,13	0,35	0,30
19-87	Opus	1,00	0,13	1,70	1,70	1,05	0,35	0,30
19-173	Bell	1,20	0,30	1,89	1,57	0,94	0,44	0,19
64-60	Dithane NT	0,50	0,75	0,52	1,04	0,60	0,02	0,42
19-143	Comet	1,00	0,25	0,79	0,79	0,15	0,15	0,49
18-391	Folicur EC 250	1,00	0,25	0,73	0,73	0,58	0,12	0,04
1-4	Tilt 250 EC	2,00	0,25	0,89	0,44	0,21	0,22	0,01
18-473	Proline EC 250	1,25	0,25	0,46	0,37	0,34	0,01	0,02
1-172	Amistar	1,00	0,25	0,24	0,24	0,00	0,18	0,06
HERBICIDES								
19-138	Stomp	0,25	0,40	1,48	5,90	0,40	5,02	0,48
1-211	Boxer	0,29	0,80	0,63	2,22	0,53	1,20	0,50
347-12	M-750	0,50	0,75	0,69	1,38	0,80	0,16	0,42
18-428	Oxitril CM	1,00	0,40	1,31	1,31	0,82	0,01	0,47
396-12	Agil 100 EC	0,67	0,10	0,61	0,92	0,82	0,07	0,03
347-5	Metaxon	0,50	0,75	0,42	0,83	0,25	0,16	0,42
48-29	Roundup Max	0,54	0,68	0,36	0,66	0,43	0,14	0,09
19-74	Basagran M 75	0,40	0,33	0,22	0,55	0,25	0,18	0,11
19-179	Fighter 480	0,67	0,48	0,27	0,41	0,15	0,19	0,07
19-109	Command CS	3,00	0,36	0,90	0,30	0,12	0,14	0,05
48-15	Roundup 3000	0,32	0,48	0,09	0,28	0,00	0,17	0,10
48-16	Roundup Bio	0,24	0,36	0,07	0,27	0,00	0,17	0,10
64-68	Starane XL	1,56	0,10	0,40	0,26	0,24	0,01	0,01
3-168	Ally ST	83,30	0,50	20,99	0,25	0,00	0,23	0,02
18-416	DFF	5,00	0,50	1,20	0,24	0,00	0,19	0,05
64-70	Mustang forte	1,32	0,20	0,25	0,19	0,11	0,04	0,03
3-156	Harmony Plus ST	51,80	0,50	9,55	0,18	0,00	0,17	0,01
1-185	Callisto	0,67	0,10	0,10	0,15	0,00	0,10	0,05
19-93	Focus Ultra	0,50	0,10	0,06	0,12	0,10	0,01	0,01
18-505	Atlantis OD	1,11	0,01	0,14	0,12	0,11	0,01	0,00
3-164	Express ST	66,67	0,50	7,34	0,11	0,00	0,11	0,00
18-442	MaisTer	6,70	0,31	0,63	0,09	0,01	0,01	0,08
48-28	Monitor	45,70	0,80	3,58	0,08	0,00	0,05	0,03
18-493	Hussar OD	10,00	0,10	0,48	0,05	0,01	0,02	0,01
64-69	Broadway	8,20	0,09	0,28	0,03	0,01	0,02	0,01

The Danish legislation uses health, environmental behaviour and environmental impact as parameters and based on this, a pesticide tax is calculated in relation to normal dosage in the treatment index (TI).

"The calculation of the Treatment Frequency Index (TFI), which reflects pesticide use nationally, is based on the standard dose of each product for each crop and the annual sales of pesticides. At farm level, on the other hand, the Treatment Index (TI) reflects the number of times the farmer has treated his land with pesticides in a growing season if standard doses were used. TI and TFI are in many ways one and the same term; application and substitution are done by the farmer whilst the TFI is a statistical average calculation at national level. The calculation of TI is used for individual farms for advisory purposes and to decide on the use of pesticides in a given crop." From The Agricultural Pesticide Load in Denmark 2007-2010

Each crop has a dosage corresponding to 1 TI, e.g. use of Boxer in winter crops have a dosage of 3.5 litres per hectare and a pesticide tax of 26 DKK/litre or approximately 3.5 Euro/litre. This means that if the farmer applies 3.5 litres in the field, there is a tax of 12.2 Euro. This encourages Danish farmers to use low doses of pesticides. There are several levels to test and it is complicated if the farmer uses a mixture of 2-4 different agents, which is very common in Denmark. For this reason,

the dosages can be considered on 4 levels, which also increases complexity when making comparisons:

Four levels:

a. Maximum dosage in the treatment index (TI).
b. Maximum dosage allowed to protect the crop.
c. Dosage used as a single product by the farmer in the field
d. Dosage used in mixtures by the farmer in the field

In this test the maximum dosage in the treatment index (TI) was used.

In the test, the SIRIS ”Le-rang” is compared to Environmental Yardstick for Pesticides (assuming a soil organic matter content of 1,5 - 3% and autumn application), Danish pesticide taxes are based on normal dosage in the treatment index (TI) in the Danish Plant Protection Product Database and the Danish risk profile ’Environmental fate’.

Figure 5 shows a section of the Danish Plant Protection Product Database with approved agents and their dosage for treatment index (in Danish: Behandlingsindeks (BI)) and pesticide taxes.

Figure 5. Round Up Bio as an example of the Danish Plant Product Database. 1 BI (i.e. TI, treatment index) = 3.5 litres in winter cereals (red arrow). Pesticide tax/duty = 26 kr./l = 3.5 Euro/l. (blue arrow). The pesticide is per liter.

The results of the comparison of Environmental Yardstick for Pesticides and the Danish pesticide taxes are presented in Figure 6.

Crop	Danish name	Active substance	Danish normal do	Danish pesticide tax after	Pesticide tax in Euro		CLM-Yardstick. Orgaaic matter 1,5-3%. Autumn
Wheat	Adimax	800 g/l prosulfocarb + 10 g/l clodinafop-propargyl (~ 8,31 g/l	1,87 l/ha	(1,87 l * 124 kr/l) = 231,88 kr	31		173
Wheat	Atlantis OD	30 g/l mefenpyr-diethyl (~ 25,5 g/l mefenpyr) + 2 g/l iodosulfu	0,300 l/ha	(0,30 l * 17 kr/l)= 15,30 kr	2		708
Wheat	Boxer/Fidox/Roxy	800 g/l prosulfocarb	3,50 l/ha	(3,50 L * 124 kr/l)= 434 kr	58		3
Wheat	Cossack OD	22,5 g/l mefenpyr-diethyl (~ 19,1 g/l mefenpyr) + 7,5 g/l iodosu	0,698 l/ha	(0,698 l * 19 kr/l)= 13,26 kr	2		331
Wheat	Hussar OD	300 g/l mefenpyr-diethyl (~ 255 g/l mefenpyr) + 100 g/l iodose	0,1000 l/ha	(0,1 l * 47 kr/l)= 4,7 kr	1		388
Wheat	Hussar Plus OD	250 g/l mefenpyr-diethyl (~ 212 g/l mefenpyr) + 50 g/l iodosul	0,176 l/ha	(0,176 l * 64 kr/l) = 11,26 kr	2		454
Wheat	Othello	50 g/l diflufenican + 22,5 g/l mefenpyr-diethyl (~ 19,1 g/l mefenp	0,698 l/ha	(0,698 l * 38 kr./l)= 26,52 kr	4		1564
Wheat	Primera super / Foxtrot	63 g/l fenoxaprop-P-ethyl (~ 63,6 g/l fenoxaprop-P) + 75 g/l m	1,000 l/ha	(1,0 l*60 kr./l)= 60 kr	8		1805
Wheat	Stomp SC	455 g/l pendimethalin (Forbidden)					0
Wheat	Ally SX	200 g/kg metsulfuron-methyl (~ 193 g/kg metsulfuron) (Forbid	30,0 g/ha	(30 g * 0,181 kr/g)= 5,43 kr	1		4
Wheat	Starane XL	2,5 g/l florasulam + 100 g/l fluroxypyr	0,837 l/ha	(0,837 l * 67 kr/l)= 56,08 kr	8		182
Wheat	Mustang forte	5 g/l florasulam + 180 g/l 2,4-D + 10 g/l aminopyralid	0,759 l/ha	(0,759 l/ha*41 kr/l)=31,12	4		1526
Wheat	Primus XL	5 g/l florasulam + 100 g/l fluroxypyr	0,590 l/ha	(0,590 l/ha*70 kr/l)=41,30 kr	6		264
Wheat	Tombo + PG 26N (oil)	25 g/kg florasulam + 50 g/kg aminopyralid + 50 g/kg pyroxsulo	118 g/ha	(118 g/ha *0,06 kr/g)=7,08 kr.	1		421
Wheat	Atlantis OD	30 g/l mefenpyr-diethyl (~ 25,5 g/l mefenpyr) + 2 g/l iodosulfur	0,300 l/ha	(0,3 l/ha*17 kr/l)=15,3 kr	2		850
Wheat	Hussar Plus OD + Mero EC	250 g/l mefenpyr-diethyl (~ 212 g/l mefenpyr) + 50 g/l iodosulfo	0,1000 l/ha	(0,10 l/ha*47 kr/l)=4,7 kr.	1		1270
Wheat	Cossack OD + Renol	22,5 g/l mefenpyr-diethyl (~ 19,1 g/l mefenpyr) + 7,5 g/l iodosult	0,698 l/ha	(0,698 l/ha*19 kr/l)= 13,26 kr	2		331
Wheat	Atlantis OD	30 g/l mefenpyr-diethyl (~ 25,5 g/l mefenpyr) + 2 g/l iodosulfur	0,300 l/ha	(0,3 l/ha *17 kr./l)= 15,3 kr	2		850
Wheat	Comet Pro	200 g/l pyraclostrobin	1,25 l/ha	(1,25 l/ha*94 kr/l)=117,5 kr	16		0
Wheat	Bell	67 g/l epoxiconazol + 233 g/l boscalid	0,832 l/ha	(0,832 l/ha *271 kr/l)= 225,47 kr	30		375
Wheat	Ceando	300 g/l metrafenon	0,752 l/ha	(0,752 l/ha*240 kr./l)=180,48 kr	24		0
Wheat	Flexity	300 g/l metrafenon	0,500 l/ha	(0,5 l/ha * 86 kr/l)=43 kr	7		0
Wheat	Proline EC 250	250 g/l prothioconazol	0,800 l/ha	(0,8 l/ha *63 kr/l)=50,4 kr	7		0
Wheat	Proline Xpert	80 g/l tebuconazol + 160 g/l prothioconazol	0,893 l/ha	(0,893 l/ha *67 kr/l)= 59,83 kr	8		218
Wheat	Prosaro EC 250	125 g/l tebuconazol + 125 g/l prothioconazol	0,355 l/ha	(0,355 l/ha*68 kr/l)= 64,94 kr	9		136
Wheat	Rubric	125 g/l epoxiconazol	1,00 l/ha	(1,0 l * 253 kr/l)= 253 kr	34		423
Wheat	Viverda + Ultimate S	50 g/l epoxiconazol + 60 g/l pyraclostrobin + 140 g/l boscalid	0,362 l/ha	(0,362 l/ha *267 kr/l) =256,85 kr	34		458
Wheat	Propulse SE 250 + Comet	125 g/l prothioconazol + 125 g/l fluopyram & 200 g/l pyraclostr	Mix				1114
Wheat	Propulse SE 250 + Orius 2	125 g/l prothioconazol + 125 g/l fluopyram & 200 g/l tebuconaz	Mix				2021
Wheat	Propulse SE 250	125 g/l prothioconazol +125 g/l fluopyram	0,889 l/ha	(0,889 l/ha*78 kr/l)= 69,34 kr	9		1114
Wheat	Viverda + Prosaro EC 250	50 g/l epoxiconazol + 60 g/l pyraclostrobin + 140 g/l boscalid	Mix				311
Wheat	Bell + Prosaro EC 250	67 g/l epoxiconazol + 233 g/l boscalid & 125 g/l tebuconazol +	Mix				828
Wheat	Bell + Proline Xpert	67 g/l epoxiconazol + 233 g/l boscalid & 80 g/l tebuconazol +	Mix				665
Wheat	Viverda + Proline Xpert + I	50 g/l epoxiconazol + 60 g/l pyraclostrobin + 140 g/l boscalid	Mix				675
Wheat	Armure	150 g/l difenoconazol + 150 g/l propiconazol	0,417 l/ha	(0,417 l/ha *90 kr)= 37,53 kr	5		795
Wheat	Prosaro EC 250	125 g/l tebuconazol + 125 g/l prothioconazol	0,889 l/ha	(0,889 l/ha*68 kr/l)= 60,45 kr	8		454
Wheat	Karate 2,5 WG	25 g/kg lambda-cyhalothrin	0,300 kg/ha	(0,300 kg/ha*318 kr.)= 95,4 kr	13		0
Wheat	Kaiso Sorbic	50 g/kg lambda-cyhalothrin	?				0
Wheat	Pirimor G	500 g/kg pirimicarb	0,250 kg/ha	(0,250 kg/ha*356kr)= 89 kr.	12		423
Wheat	Teppeki	500 g/kg flonicamid	0,140 kg/ha	(0,140 kg/ha*55 kr)= 7,70 kr	1		0
Wheat	Cycocel 750	750 g/l chlormequat-chlorid (~ 582 g/l chlormequat)	1,23 l/ha	(1,23 l/ha*110 kr)= 135,30 kr	18		183
Wheat	Stabilan Extra	750 g/l chlormequat-chlorid (~ 582 g/l chlormequat)	1,23 l/ha	(1,23 l/ha*88 kr)=108,24 kr	15		147
Wheat	Trece 750	750 g/l chlormequat-chlorid (~ 582 g/l chlormequat	1,23 l/ha	(1,23 l/ha*88 kr)=108,24 kr	15		147
Wheat	Moxa	250 g/l trinexapac-ethyl (~ 222 g/l trinexapac)	0,500 l/ha	(0,5 l/ha*39 kr)= 19,5 kr	2		0
Wheat	Moddus Start	250 g/l trinexapac-ethyl (~ 222 g/l trinexapac)	0,500 l/ha	(0,5 l/ha*25 kr)= 12,5 kr	2		0
Wheat	Medax Max	75 g/kg trinexapac-ethyl (~ 66,7 g/kg trinexapac) + 50 g/kg pro	0,303 kg/ha	(0,303 kg/ha*8 kr)=7,27 kr	1		0
Wheat	Moddus M	250 g/l trinexapac-ethyl (~ 222 g/l trinexapac)	0,500 l/ha	(0,5 l/ha *33 kr/l)= 16,5 kr	2		0
Wheat	Trimaxx	175 g/l trinexapac-ethyl (~ 156 g/l trinexapac)	0,714 l/ha	(0,714 l/ha*36 kr)=25,70 kr	3		0
Wheat	Cuadro NT	250 g/l trinexapac-ethyl (~ 222 g/l trinexapac)	0,500 l/ha	(0,5 l*36 kr/l)=18 kr	2		0
Wheat	Medax Top	300 g/l mepiquat-chlorid (~ 223 g/l mepiquat) + 50 g/l prohexc	1,33 l/ha	(1,33*36 kr)=47,88 kr	6		2250
Wheat	Terpal	155 g/l ethephon + 305 g/l mepiquat-chlorid (~ 233 g/l mepiqua	1,73 l/ha	(1,73 l/ha*46 kr)=79,58 kr	11		1830

Figure 6. Test of Environmental Yardstick for Pesticides and Danish pesticide tax system in winter wheat.

The results of the comparison of the Danish pesticide taxes, Environmental Yardstick for Pesticides and SIRIS are presented in Figure 7.

Riskprofiles				Approved dose to the task	Danish pesticidetax			Leaching to groundwater. Environment impact points EIP						
Crop	Danish name		Composition	Dosage kg or liter	Euro	Load index-Denmark. Groundwater	SIRIS - le rang	Aquati	Soil life	Spring	Autum	Soil life	Spring	Autumn
								1,5% Org			1,5-3% org			
Maize	Callisto	H	Mesotrion	1,5 l	19	0,10	41,45	27	2	227	2087	2	58	530
Maize	MaisTer	H	Foramsulfuron/iodosulfuron-methyl-Na/isoxadifen-ethyl	0,15 kg	2	0,01	55,26	284	19	7	94	19	6	89
Maize	Harmony SX	H	Thifensulfuron-methyl	15 g/ha	2		63,16	23	0	0	0	0	0	0
Maize	Starane 333 HL	H	Fluroxypyr	0,811 l	9	0,01	71,05	54	14	27	2701	14	3	270
Maize	Fighter 480	H	Bentazon	1,04 l	7	0,19	81,58	0	2	58	519	2	52	324
Potatoes	Roundup Bio	H	Glyphosat	3,5 l	12	0,17	82,26	8	13	0	0	13	0	0
Potatoes	Reglone	H	Diquat dibromid	4 l	79		82,26	544	33	0	0	33	0	0
Potatoes	Proman	H	Metobromuron	4 l			91,13	62	24	2740	9340	24	212	456
Potatoes	Boxer	H	Prosulfocarb	3,5 l	58	1,20	59,68	224	119	0	172	119	0	3
Potatoes	Agil 100 EC	H	Propaquizafop	1,25 l	13	0,07	46,77	45	1	1	2	1	0	0
Potatoes	Focus Ultra	H	Cycloxydim	5 l	29	0,01		1	0	1300	8000	0	650	1050
Potatoes	Ranman	S	Cyazofamid	0,2 l	1		22,58	13	2	87	62	2	6	6
Potatoes	Shirlan	F	Fluazinam	0,4 l	7		30,65	276	24	381	442	24	54	66
Potatoes	Acrobat New	F	Dimethomorph/mancozeb	1,68 kg	23		91,13	51	81	118	715	81	8	475
Potatoes	Cyperb 100	I	Cypermethrin	0,4 l	85	0,03	17,74	123	2	0	0	2	0	0
Potatoes	Karate 2,5 WG	I	Lambda-cyhalothrin	0,3 kg	13	0,01		300	4	0	0	2	0	0

Figure 7. Test of SIRIS, Environmental Yardstick for Pesticides and Danish pesticide taxes and risk profiles in maize and potatoes.

The results in Figure 6 and Figure 7 indicate that there is not much similarity between the 3 different leaching risk assessments.

An agent used by all the countries is glyphosate. In this test Roundup Bio (glyphosate 360 g/litre) was assessed to be 82 percent in SIRIS - that is a high leaching risk, while the Environmental Yardstick for Pesticides in the Netherlands indicate low leaching risk on soils with a content of 1 - 3% organic matter. The Danish assessment is low-medium based on the size of the taxes and the level of Environmental fate.

The herbicide Boxer (prosulfocarb) was assessed to have a high risk in Denmark, medium risk in France and low-medium risk in the Netherlands.

The desiccant herbicide Reglone (374 g/l diquat) had a very high risk profile in Denmark and France, but not in the Netherlands. The agent will be banned in the EU from 2020.

The advantages and disadvantages of the Environmental Yardstick for Pesticides and SIRIS are summarized in Table 11.

Table 11. Advantages and disadvantages of the Environmental Yardstick for Pesticides and SIRIS applied in a Danish context.

Advantages		**Disadvantages**	
Environmental Yardstick for Pesticides	**SIRIS**	**Environmental Yardstick for Pesticides**	**SIRIS**
Suitable as an advisory tool for advisors and farmers at farm level	A surveillance program that can handle leaching of pesticides at catchment level.	Designed mostly for single products and not so much for mixtures.	Expert program. Unsuitable as an advisory tool for advisors and farmers.
Very visual tool that is easy to understand and use for advisors and farmers.		Missing the connection/link to the weeds to be controlled at farm level.	The program try to show the connections between the findings in groundwater and the use of pesticides in a specific area
		Lack of calculations in relation to the resistance challenge in weed control, pests and fungal diseases	

c. Implementation

The conclusion of this test is that it will be difficult to implement SIRIS and Environmental Yardstick for Pesticides in Denmark, since the assessments are very different from the assessments behind the Danish legislation concerning pesticide taxes, which are taxes that reflect the risk of the pesticide in several areas.

As the Danish assessments are based on health, environmental behaviour and environmental impact parameters and not just leaching risk, the comparison is not entirely fair. It would be fairer to compare only the leaching risk as this is the only risk assessed in SIRIS and the Environmental Yardstick for Pesticides. In general, the Danish government bans all pesticides with high leaching risk to ensure the quality of Danish groundwater. This is an ongoing process as knowledge increases. The table from The Agricultural Pesticide Load in Denmark 2007-2010 also reflects that most of the pesticides has a medium-low leaching risk.

SIRIS and the Environmental Yardstick for pesticides can be used as inspiration to further develop the Danish Plant Protection Product Database where currently environmental assessments are not transparent. The Environmental Yardstick fro Pesticides is good for visually showing the environmental impact of pesticides while this is hidden in Plant Protection Online for the users. In Denmark, it is assumed that the government removes pesticides with high leaching risks and for this reason the Danish Plant Protection Product Database has focused mainly on helping users to choose the right pesticides for the specific problem in the individual field – i.e. the program is specialised in handling very different weed community compositions and single species with the right dosages in order to lower consumption compared to the recommended dosage on the label.

TargetEconN

a. Assessment

TargetEconN is a Danish model, developed for the Limfjord catchment, where Aalborg is situated. The model is currently set up for all other Danish catchments as well. The model is developed as part of research projects, and is now being used to advise the Danish Ministry of Environment and Food with regard to the implementation of the Water Framework Directive (WFD) with respect to cost-effective choice of mitigation measures, abatement levels and spatial allocation of measures. The model is currently set up for abatement of nitrogen (N) loads to surface water, but will be set up also to include groundwater. The model is furthermore set up for modelling pesticide effect of some of the N mitigation measures in the model, but a full modelling of pesticide reductions have not been implemented in the model.

TargetEconN include field parcel level input for 12 different mitigation measures, for clay and sandy soils, effect of nitrogen abatement in kg N/ha and costs in DKK/ha. The N load reduction targets are set for catchments draining to Limfjorden, and the model is flexible to include smaller (ID15 i.e. catchments of approximate 15 km^2) or larger catchments.

Figure 8 shows the cost-effective distribution of N mitigation measures for fulfilling WFD, and also the distribution of costs, at field parcel level. The model has been used to test how model results are affected by uncertainty on the data and assumptions on the retention of N in the catchment.

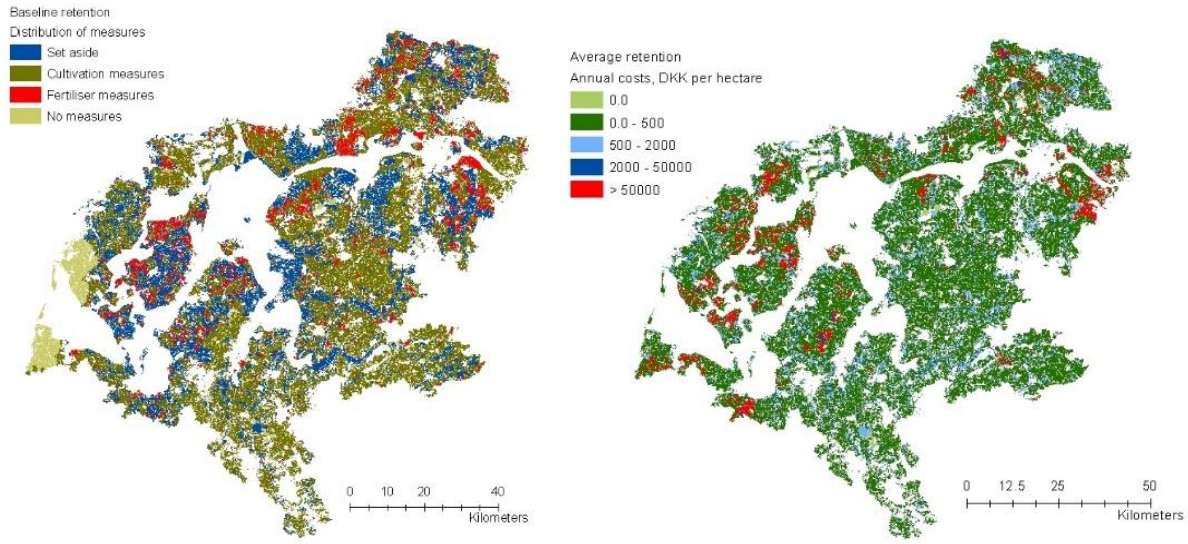


Figure 8. Target Econ N solutions. Left hand side map: Distribution of mitigation measures. Right hand side map: Distribution of annual cost (DKK/ha).

b. Testing

The model has been tested in the Limfjord catchment where Aalborg is situated, and this is the catchment where the model has been developed. The model is set up for Denmark as a whole, as well, divided into 23 catchments and with the ability to subdivide into smaller catchments. The model has not been tested in catchments in other countries. The model will be compared with other Danish cost-effectiveness models (SMART and Norsminde) but the results of these model simulations and tests for the other models are not yet finished. This test will be documented in the FAIRWAY deliverable 5.3. as differences and deviations in cost-effective solutions between these models are analysed.

c. Implementation

TargetEconN solutions have been discussed with the Water Utility Company in Denmark in an interview, and the conclusions from this test is that i) the distribution of mitigation measures on field level is attractive as information for the utility, but ii) the cost-effective solution might be difficult to use in negotiations with farmers about where and how much to implement in terms of groundwater protection. The maps have not been tested on farmers, however.

TargetEconN and the resulting maps and solutions have also been discussed with the Ministry of Environment and Food, and opposite to the Water Utility company the Ministry is not in favour of too spatially detailed information at field level. The Ministry indicates that information on cost-effective solutions is of interest as advise, but also that having information from several sources and models provides results as a range, and that this range is important for trust building in the results.

5.2 UNITED KINGDOM – ANGLIAN REGION

The Anglian Region Case Study covers three areas in Eastern England where surface water pesticides are found in drinking water resources. The case study activity is a social science one. The University of Lincoln (UoL) are co-ordinating surveys of farmers in the three areas to understand how different interactions with the water company, Anglian Water, might result in long term changes in approaches to understanding and responding to issues of surface water contamination with pesticides. The three areas are:

a) 'Limited intervention' (control) – using an area, the Cringle Brook catchment, where there has been little Anglian Water agricultural advisory intervention with the agricultural community;

b) 'Network engagement' using the Louth Canal catchment where for three years the water company agricultural adviser has been working closely with agronomists and others to raise awareness of the challenges of pesticides, particularly metaldehyde (a pesticide used to control slugs in a range of crops) in drinking water resources; and

c) 'Ecosystem services' using 6 reservoir catchments where a payment was made to farmers to change from metaldehyde to alternative products, aiming for 100% land manager engagement.

Following the sentiment for the case study of employing social science observation, and in particular the 'engagement' process mentioned in b) the researchers of UoL were keen to assess whether a Decision Support Tool could be used by agronomists and land managers to enhance knowledge of pesticides that can contaminate drinking water resources. The Environment Yardstick for Pesticides seemed a natural choice.

The Environmental Yardstick for Pesticides provides an overview of the environmental pressures generated by all crop protection agents permitted on the Netherlands market, see the website https://www.milieumeetlat.nl/en/hoe-werkt-het-open-teelt.html. It enables the user to compare these agents and to choose the least harmful crop protection strategy. By paying a subscription the service is unlimited, but it is possible to compare up to three products at no cost. The Environmental Yardstick for Pesticides, first developed in 1990 contains data (pesticide properties and exposure models) from the Dutch Authorisation Board and European authorisation guidelines used to estimate environmental impact. It does not take into account all possibilities but the data includes environmental impact factors such as soil life, water life and groundwater leaching (using regulatory submission), compatibility with Integrated Pest Management (using Koppert data base and Pesticide Property Database) and risk to user (product label information). Variables that can be added are dosage, soil organic matter, season of application and estimate of spray drift risk. Therefore, the The Environment Yardstick for Pesticides gives a risk indication based on European authorisation guidelines.

5.2.1 **Workplan**

The workplan for application of Environmental Yardstick for Pesticides in the FAIRWAY case Anglian Region is summarized in Table 12.

Table 12. Workplan for the FAIRWAY case study site Anglian Region, United Kingdom.

Action	**Action details**	**Target deadline**	**Involvement**
Preliminary survey of DSTs used in Anglian Region	Survey of 30 farmers and agronomists	December 2018	UoL and farmers and agronomists
Overview over selected DSTs and data requirements	Describe expectations/expected outcome by DST with small group of agronomists and an Anglian Water agricultural adviser. Select preferred DST to test.	October 2018	UoL
Define the approach to information gathering and reporting	Internal meetings to agree ways to interview farmers and agronomists in the Anglian Water Region. The England Case Study is a social science one and this study will involve assessing farmer and agronomist attitude to another DST.	November 2018	UoL, ADAS
Access to DSTs	Discuss information requirements to demonstrate the Environmental Yardstick for Pesticides.	December 2018	UoL, CLM
Survey data collection	Collection of data, target 50 farmers and agronomists in total for their expert opinion of effectiveness and likely ways to take up the Environmental Yardstick for Pesticides.	December 2018 to February 2019	UoL, farmers and agronomists
Final evaluation	Report on results and conclusions.	April 2019	UoL

5.2.2 Assessment, testing and implementation of selected DSTs.

Environmental Yardstick for Pesticides

a. Assessment

In England crop production advice is provided by agronomists. The BASIS Certificate in Crop Protection is a legal requirement for anyone advising on or selling pesticides in the UK (red circle in Figure 9). UoL is one of the main providers of the training required to gain and maintain the BASIS Certificate in Crop Protection. UoL also provides occasional alumni days and many of the additional advanced training modules shown below. In addition to agronomists, some farmers also seek to obtain the BASIS Certificate in Crop Production qualification.

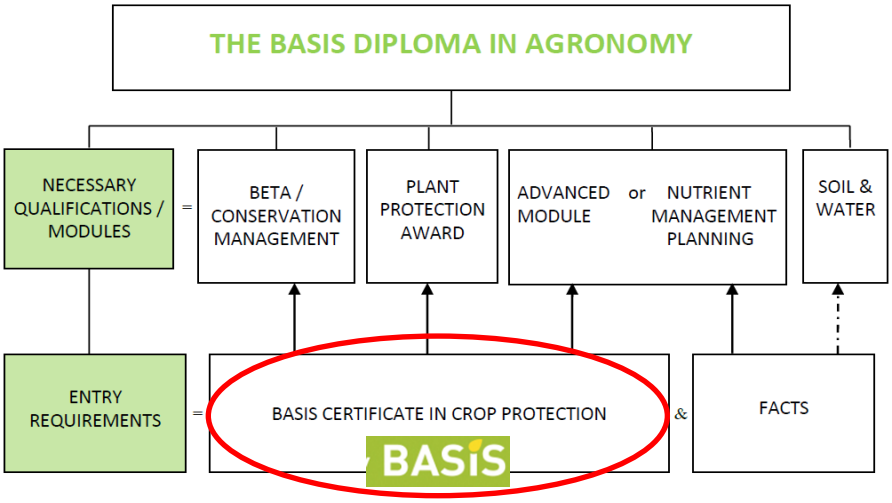


Figure 9. Flowchart showing the BASIS suite suite of courses taught by organisations such as the University of Lincoln. The Certificate in Crop Protection is required by agronomists, and optional advanced modules are shown such as Plant Protection Award and Soil and Water Management.

University of Lincoln researchers were able to access groups of agronomists and farmers who were attending various training courses and events held at the University. Delegates came from a wide area, but mainly from the eastern and east midlands region of England within which our Case Study areas lie. In the following results a BASIS qualified agronomist or farmer is one who has passed the BASIS Certificate in Crop Protection.

As a result of the above backgrounds, we tested the DST by means of

- Phase 1: an initial survey to determine current DST use, asking delegates on 3 advanced BASIS courses, and receiving 22 responses.
- Phase 2: a survey in winter/spring 2019, asking delegates at two events. Some 70 practicing agronomists and BASIS qualified farmers attended an alumni event. A further 50 or so farmers, some BASIS qualified, with their BASIS qualified agronomists attended a training day.

b. Testing

Phase 1: November - December 2018

30 BASIS qualified agronomists and advisors (22) and farmers (7) and others (2) were surveyed to find out which were their preferred existing (in England) DSTs. We asked what they needed from a DST. One person stated they were both farmer and agronomist, 20 were male, 6 were female and 4 did not say.

We provided a choice of nitrate DSTs commonly used in England and asked which ones each person used, and to rate the products they used, where 1 = not at all useful and 6 = extremely useful. The nitrate DST results are shown in Table 13.

Table 13. Average scores for a range of nitrate DSTs commonly used in England.

Broad category of DST	Name	Brief description	Number of respondents who use the tool	Average score for the tool
Bespoke advisory software	Gatekeeper	Commercial online decision suport tool incorporating PLANET and MANNER	12	4.8
	Muddy Boots	Commercial online decision suport tool incorporating PLANET and MANNER	11	5.1
	Own in house	Commercial on line decision support tool	1	6.0
Free nutrient management software	PLANET	Online nutrient management tool, Defra funded	6	5.0
	MANNER	Online manure management tool, Defra funded	4	4.3
	Tried and Tested (T&T)	On line resource for many defra supported DSTs and technical books	7	4.4
	Farm CRAP App	Web and phone based app based on RB209 and Think Manures proving guidance on manure use	8	3.8
Nutrient management Guidance	Nutrient Management Guide RB209	Defra funded recommendations on manure and nutrient planning, funded by defra. Publications and online	30	4.9
	Think Manures	Publication, available online guiding on nutrient value and use of manures	7	4.3
Best management	An Inventory of Methods to Control Diffuse Water Pollution from Agriculture (DWPA) USER MANUAL,	Publication, available online, amined at advisers in catchment advice	1	6.0
	Farmscoper	Online tool expanded from User manual above, aimed at advisers In in catchment advice	1	3.0
	Variable rate, various commercial products	Various sourcs of advice and fee paying services	11	4.4
	Think Soils	Publication, available on line, focusses on reducing soil erosion	10	4.8

Most respondents mentioned the Nutrient Management Guide (RB209), https://ahdb.org.uk/nutrient-management-guide-rb209, a long standing defra and now AHDB funded document, considered to be the authoritative source for information for fertiliser recommendations in England. 22 respondents used 1 or more bespoke advisory software and in general are satisfied with the outputs, giving an average score of 4.8 to 6. Standalone publications (apart from the Nutrient Management Guide) are used by fewer respondents. However, when asked for additional free text comments on such documents these included ‘know, but don’t use’,

'don't use but should' and 'useful but don't use'. Overall the data suggests a move from paper-based to on-line tools.

The responses for pesticides was less clear (Table 14). There appeared to be fewer pesticide tools in the market place.

Table 14. Average scores for a range of pesticide DSTs commonly used in England.

Broad category of DST	Name	Brief description	Number of respondents who use the tool	Average score for the tool
Bespoke advisory software	Gatekeeper, with Sentinel	Commercial online decision suport tool incorporating label and other statutory information on pesticides	12	4.9
	Muddy Boots and related Procheck	Commercial online decision suport tool incorporating label and other statutory information on pesticides	9	5.3
	Own in house	Commercial on line decision support tool	4	5.5
Free pesticide information	Voluntary Initiative	Industry driven website with free tools such as check it out. Repository and source for Environmental Information Sheets	6	4.2
Pesticide management Guidance	Adama Slug aware and water aware	Free commercial App linking soil type, rain forecast and risk of leaching, particularly autumn herbicides and metaldehyde.	8	3.9
	The UK Pesticide Guide	Known as the Green Book. Publication and on line fee paying. Comprehensive searchable database of: mode of action codes, hazard categories, harvest intervals, LERAP classifications of registered pesticides	10 (incl 2 users who did not score their use)	5.1 (excluding the 2 users)
	Advice and reccommendations fom supplier/ manufacturers		5	4.8

Again the most widely used products were bespoke advisory tools, with 25 respondents scoring the products from 4.9 to 5.5 out of 6. The UK Pesticide Guide is an authoritative source of information and two free text comments suggested that there is a shift from such traditionally paper based sources to an online service.

The group was asked for their general opinion in free text of DSTs and this is shown in a word cloud in Figure 10.

Figure 10. Word cloud: Phase 1 respondents' general opinion of Decision Support Tools.

It was clear from conversation and free text within this group of respondents that tools encompassed in software, ideally in existing software were deemed most useful.

Phase 2: February 2019

UoL researchers presented information on the Environmental Yardstick for Pesticides to 120 agronomists and farmers at one BASIS alumni event and at one event organised by a group of independent agronomists for their farmers. The process comprised

1. The speaker showed 6 slides (Figure 11)
2. Then did a live demonstration of the DST using the CLM website, https://www.milieumeetlat.nl/en/bereken-open-teelt.html.
3. Then showed a summary sheet (for potatoes) and
4. Then answered questions.
5. Then everyone was asked to complete a voluntary survey.

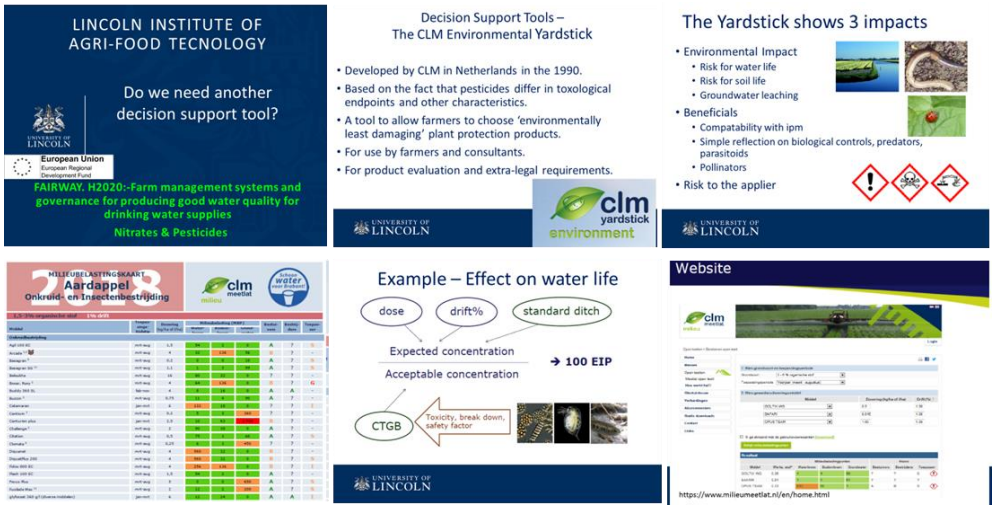
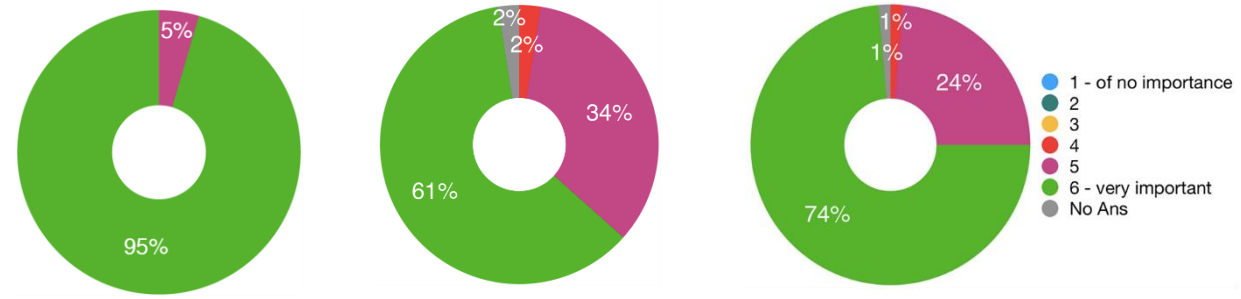


Figure 11. Slides on the CLM Environmental Yardstick for Pesticides used in the Phase 2 presentations.

From the 120 survey forms passed out, 70 forms were returned. Not all respondents answered every question. Therefore the responses below are based on those who responded. Farmers and agronomists were analysed separately in case there were distinct differences. Then an aggregate for all responses including those who did not state whether they were agronomists of farmers, was analysed. Below are the key questions:

Question 1: Please could you rate how important it is for an agronomist to understand the impact of pesticides on water quality Where 1= of no importance and 6 = very important

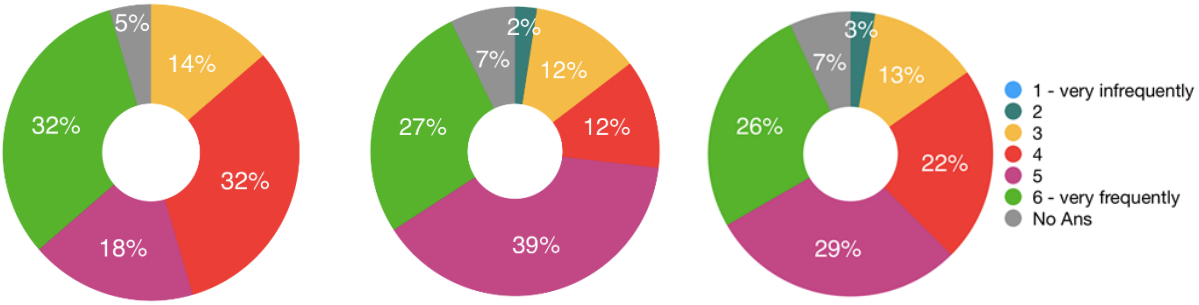
Agronomist response (22 respondents) *Farmer response (41)* *Aggregate response (72)*



Comment: Agronomists who responded showed a clear indication that understanding the impact of pesticides on water is very important. Farmers placed slightly less importance on their agronomists having this understanding.

Question 2: Please could you state how frequently you take into consideration the environmental impact of pesticides on water quality when making (pesticide) recommendations? Where 1 = very infrequently and 6 = all the time.

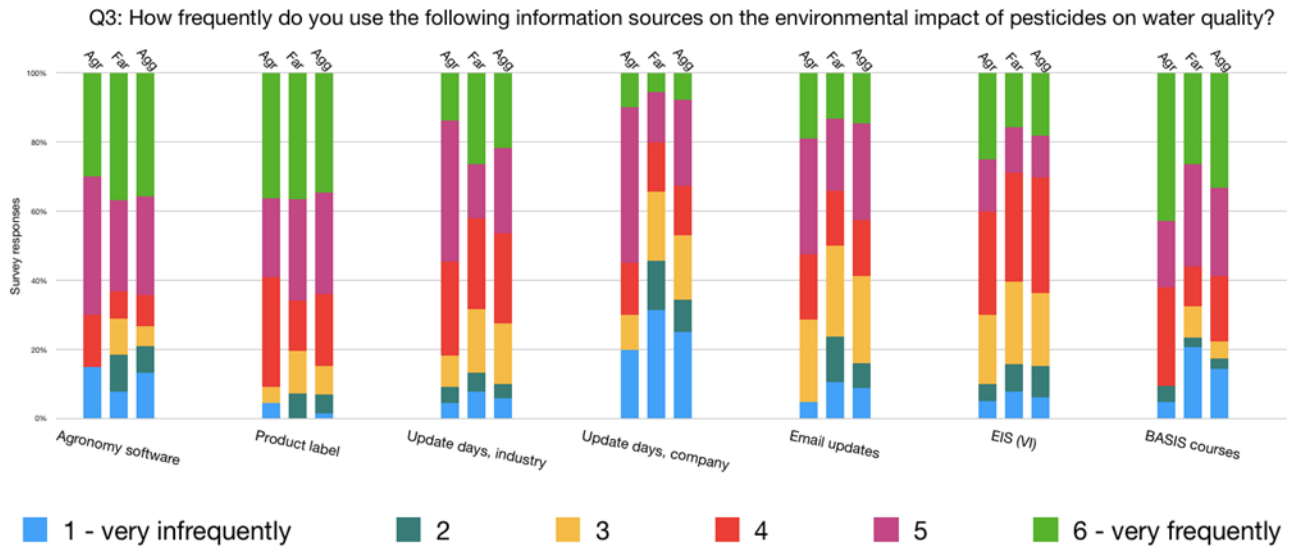
Agronomist response (22 respondents) *Farmer response (41)* *Aggregate response (74)*



Comment: Taking scores 4, 5 and 6 as positive, the difference between agronomists (82%) and farmers (78%) is small.

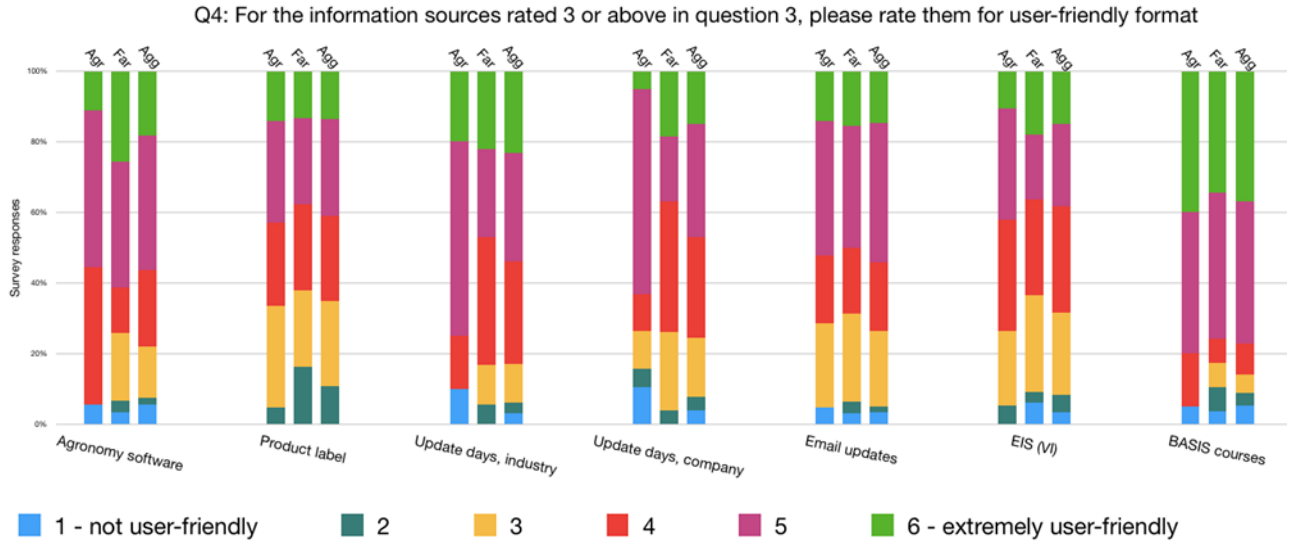
Question 3: Please could you scale how frequently you use the following information sources on the environmental impact of pesticides on water quality? Where 1 = very infrequently and 6 = very frequently.

Agr = Agronomist Far = Farmer Agg = Agronomists + Farmers + those who did not state if they were farmers or agronomists, or other. Nil responses are ignored.



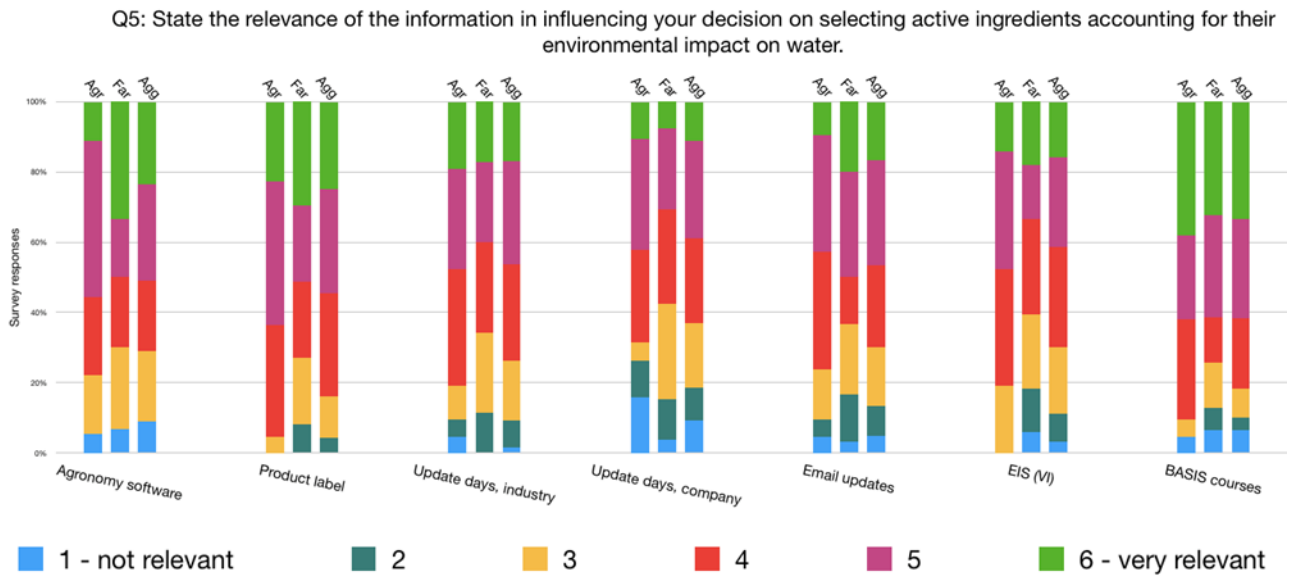
Comment: Most sources identified are positively considered. Taking a score of 5 and 6 as the most positive then agronomy software along with product label are frequently used as a source of information on environmental impact.

Question 4: For the information sources rates 3 and above in question 3, please rate them for user friendly format, where 1 = not user friendly and 6 = extremely user friendly.



Comment: Taking categories 5 and 6 as positive, then it is interesting to note the poorer scores for both the product label and the Voluntary Initiative Environmental Information Sheets. Apart from the recommendation sheet, the label is the main source of information for the sprayer operator and was not valued as highly as other tools. The EIS sheets are a source of similar information (environmental risk, including to water) to Environmental Yardstick for Pesticides but in this survey they are deemed less user friendly than other sources of information. The EIS sheets are held in an online database and so may be hard to make 'like for like' comparisons.

Question 5: State the relevance of the information in influencing your decision on selecting active ingredients accounting for their environmental impact on water. Where 1 = not relevant and 6 = very relevant.

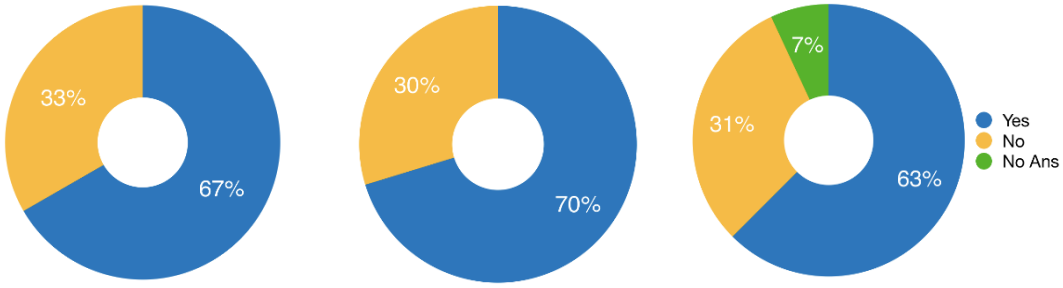


Comments: It is interesting to note that BASIS courses are perceived as most relevant along with product label. For the farmer, bespoke recommendation generated using the agronomy software and sent by the agronomist, is likely to include information on ideal weather conditions for spraying, label restrictions etc.

After demonstrating the CLM Environmental Yardstick for Pesticides we asked the respondents questions on the product as follows

Question 10: Would you use the Environmental Yardstick as a *standalone* decision support tool to inform your decisions on pesticide recommendations if the data was made relevant to UK conditions and products?

Agronomist response *Farmer response* *Aggregate response*



Comments: Two thirds of respondents would consider using the Yardstick as a standalone. This is a curious response since it was clear from written feedback in the free text boxes provided in the survey that many farmers and agronomists would prefer a product that could be built into existing software products. It should be noted that a few of individuals, mainly famers spoke in person to express support for a tool that differentiates products based on environmental impacts and that this had not really occurred to them as a possible concept before.

Question 11: If you answered yes to Q10 please could you list the features which you consider useful?

Free text points that were appreciated and considered useful in the Yardstick, and a wish list of what could be included was as follows

- Keen on the colour coded approach to risk assessment
- Quick access

- Easy to use
- One stop reference point for pesticide selection incorporates all products
- App for smart phone /ipad
- Internet web user friendly
- NOT STANDALONE – integrate into current software such as Gatekeeper
- Include operator safety
- Include soil and water toxicity
- Include risk to the environment
- Include harvest interval
- Include effective dose rate
- Include growth stage
- Include crop type
- Include soil organisms
- Include pollinators
- Include soil moisture/temperature
- Use in conjunction with application technology such as spray drift reduction

Question 12: If you answered no to Q10 please explain your answer.

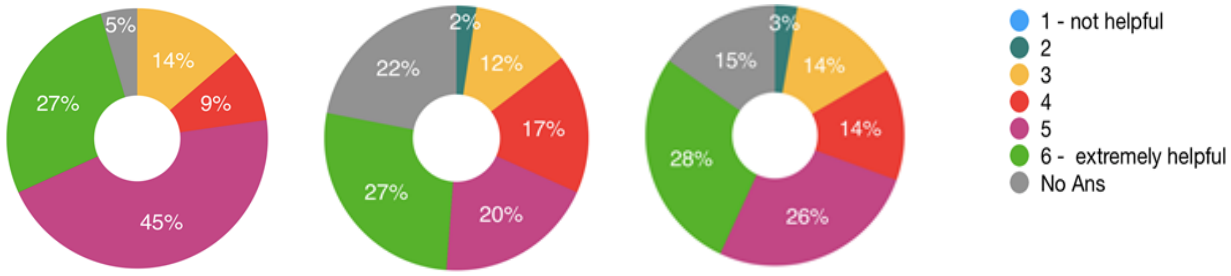
Free text reasons given for not wanting to use the Yardstick as a standalone tool included:

- The system needs to become legislative and incorporated into something like pro-check to ensure best practice.
- Not a big selection of products in vegetables anyway.
- Would you have qualified a 'due diligence' challenge in court? Label is paramount.
- At this point I don't know enough about the Environmental Yardstick for Pesticides.
- Has to be integrated into sentinel.
- Dangerous in hands of uneducated. e.g retailers, environmentalists. Allows the uneducated to make decisions (or think they can).
- Lots of factors need to be taken into consideration but more information is always welcome.
- Not a standalone tool - needs to be incorporated with recommendations.
- It should be part of current software.
- Many other sources of information needed e.g weed, disease pressure etc.
- Would need to be incorporated into other software as time consuming
- It would have to have industry approval before I would consider it the standalone.
- Needs to fit within current systems.
- Too many systems.
- Needs to (be) integrated into existing systems - one stop shop.
- Needs to be on label, incorporate into supermarket PPO requirements / policies.

Comments: Many responses fell into two categories. Several respondents would want the tool to be incorporated into existing DSTs. Others feared that as a standalone product, using the 'traffic light' style colours in the DST, and making it appear that some products might be inferior to others; could cause stakeholders to further restrict an already depleted choice of actives without taking into account other factors such as efficacy, requirement for repeated applications etc.

Question 13: If the information provided by the Environmental Yardstick for Pesticides was incorporated into current DSTs, would this be more useful than a standalone tool to inform your pesticide recommendations with reference to their environmental risk on water quality? Where 1- not helpful at all and 6 = extremely helpful.

Agronomist response *Farmer response* *Aggregate response*



Comment: Agronomists considered it more useful than farmers did to envisage the Environmental Yardstick for Pesticides incorporated into existing software. Overall there is an interest in seeing the Yardstick incorporated into existing information.

Concluding comments on the advantages and disadvantages of the Environmental Yardstick for Pesticides are summarized in Table 15.

Table 15. Advantages and disadvantages of the Environmental Yardstick for Pesticides in an England context.

Advantages that Environmental Yardstick for Pesticides has over existing tools available in the Case Study Area	**Disadvantages and Constraints**
The tool brings together several sources of information in a way not currently thought to exist in England.	Currently the tool is used in NL and new data would need to be added for use in the UK. Label and authorisation data would be available. IPM data might be less easy to find. However the Environmental Information Sheets (EIS) currently held on the Voluntary Initiative website could be a source.
All pesticides are considered together and can easily be compared.	Farmers and agronomists would prefer the tool to be incorporated into existing tools.
The information appears to be more accessible to farmers and agronomists than the EIS Sheets in England.	Concern by a few growers/agronomists, especially in the vegetable sector that any tool that highlights environmental risk could jeopardise use of the products by buyers.
The DST offers information that is of interest to farmers and agronomists including impact on water, soil and beneficials.	Environmental impact is not the only aspect driving product choice – efficacy, harvest interval etc also need consideration.
	The ability to use different products to help avoid resistance build up is important.

c. Implementation

The information required to run the Environmental Yardstick for Pesticides could be found for England, although some of the IPM data might be difficult and it might not be possible for all crops. If this data was found and adaptations made it would face challenges in adoption for a number of reasons including:

- Perception that it is ‘yet another’ tool when there are already tools that farmers and agronomists are comfortable with.
- The Environmental Yardstick for Pesticides currently only supports a few parameters, including rate and risk of drift, but others such as efficacy, need for repeated applications and harvest interval are excluded.
- Whilst the red/amber/green was liked by some, others feared that markets, using selected information, might ask growers not to use ‘red’ products even though the red product might be the best, or only product to use for efficacy or other reasons.
- From a scientific perspective the Environmental Yardstick for Pesticides can only model likely impact – it cannot measure actual impact on water. It is most valuable as an informative tool.
- From a drinking water resource perspective, if using tools like the Environmental Yardstick for Pesticides reduces the range of products applied to farmland then a consequence might be that a particular product is selected more often with the risk that it might then appear in drinking water resources at higher than the Drinking Water Directive limits.

The Environmental Yardstick for Pesticides was considered an informative tool. The survey process high-lighted the popularity of on line and bespoke advisory tools as existing DSTs in the Anglian area, and respondents did like the Yardstick information. If the information were to be incorporated into existing sources such as the product label or advisory software it would appear to be a useful valuable addition. It would be important to ensure that the data provided within the Environmental Yardstick for Pesticides could be seen by land managers receiving and acting on product recommendations, not just to the agronomist making the recommendation. From a scientific development point of view it is possible to foresee that the data in the Environmental Yardstick for Pesticides could be combined with emerging data sets and spatial tools such as geolocation, soil type mapping and weather forecasting although this could take significant development effort. Counter to this, the simplicity of the existing tool makes it easy to make comparisons quickly. For example, if an agronomist is checking a particular product and notes that it has a high environmental impact it is easy using the existing Environmental Yardstick for Pesticides to check what impact alternatives would have. Adding complexity to the data might make it more difficult to do such simple comparisons.

If there was appetite to develop the tool for the UK then obvious organisations to discuss this with in addition to governmental organisations would be the bespoke software developers for products such as Gatekeeper and Muddy Boots, and the Voluntary initiative which hosts the Environmental Information Sheets on its website. This would help ensure that the tool complements or is integrated into existing information provision.

5.3 FRANCE – LA VOULZIE

SIRIS-Pesticides is a DST that allows classification of pesticides according to their potential to reach surface water and groundwater. SIRIS classifies pesticides from ideal to worst. The core system is a penalty grid.

SIRIS-Pesticides helps to organize the monitoring of pesticides in waters at the regional or local scale. It is a software tool developed around a simple interface.

The SIRIS tool was tested on the La Voulzie catchment about 70 km west of Paris. The dominant crops grown are wheat followed by oilseed rape and barley. Wheat and barley are well spread throughout the catchment. To collect the input data, the BNV-d (Banque Nationale des Ventes des distributeurs) database was used. The BNV-d is supplied since 2009 with the declarations of the annual reports of the sales of phytosanitary products by the authorized distributors (https://bnvd.ineris.fr/).

There are many DSTs in France which can perform diagnostics at a farm/field scale, but SIRIS is one of the few tools available for predicting pesticide loss at the catchment scale, but has not yet been tested in the La Voulzie catchment. It is therefore possible, from the results, to coordinate actions on several farms. The lack of mitigation measurement simulations is one of the main limitations for stakeholder use.

5.3.1 Workplan

The workplan for application of SIRIS in the FAIRWAY case study site at La Voulzie is summarized in Table 16.

Table 16. Workplan for the FAIRWAY case study site La Voulzie, France.

Action	Action details	Target deadline	Involvement
Overview of selected DSTs and data requirements	Describe expectations/expected outcome by DST.	October 2018	BRGM, Eau de Paris
Testing of selected DSTs	Test SIRIS with BNV-d database	October 2018	BRGM, Eau de Paris
Collect data	Collect pesticide use specily on La Voulzy	October 2018	BRGM, Eau de Paris
Describe and evaluate results	Compare SIRIS result (BNV-d) with water quality measure (surface and groundwater)	February 2019	BRGM, Eau de Paris
Summarize successes and difficulties		March 2019	BRGM

5.3.2 Assessment, testing and implementation of selected DSTs.

SIRIS

a. Assessment

Parameters are grouped into classes. The class represents the importance of a process compared to the other. Two equivalent parameters are in the same class. Each parameter is affected to one “level” reflecting its contribution to exposure (Table 17).

For example, a substance, with a DT50 (Half-life of the substance representing the degradation) of less than 30 days is classed "o" for this parameter. A substance, with a Koc (Sorption coefficient of the substance representing the sorption on organic carbon of soil) of less than 100 $L.kg^{-1}$ is classed "d" for this parameter.

Table 17. "Level" affected for each parameter for groundwater.

Parameters	o (not unfavorable)	m (moderately favorable)	d (not unfavorable)
Koc (L.kg-1)	----------->500≥----------->100≥-----------		
DT50 (Day)	----------<30≤----------<120≤-----------		
Hydrolyse (Day)	----------<30≤----------<60≤-----------		
Surface	----------<0.04≤----------<0.2≤-----------		
Solubility (mg-1)	----------<10≤----------<200≤-----------		

The penalty grid assigns a score for each possible combination of parameters. The ideal substance has all its parameters at an “o” level and its score is 0. Penalties are attributed to substances that have parameters affected to levels different from “o”.

This grid lists the scores for every possible combinations of levels. Using the grid, the classes and the levels attributed to the parameters, it is possible to suggest which pesticides should be monitored in priority in freshwaters.

b. Testing

To collect the input data, the BNV-d database was used. The data specific to the catchment have not been gathered, the data for the department of Seine-et-Marne had to be used instead. In this web portal, the user can select when and where data are needed. A specific SIRIS export format is available. An average of the quantities provided over the period 2008-2017 has been used for this test.

Table 18 shows results from SIRIS using the BNV-d input data. The table was adjusted from the original to make it easier to understand for this report. For instance, a level column for each parameter has been included to make the level explicit. Atrazine was added for comparison even though it is no longer sold. Only the top 25 substances with the highest scores are presented.

Table 18. Results from SIRIS using BNV-d input data for the La Voulzie catchment.

INERIS
maîtriser le risque pour un développement durable

FICHIER DES EAUX SOUTERRAINES

Nom utilisateur : FAIRWAY
Territoire considéré :
Surface de ce territoire (ha) : 19000
Période : 2008-2017

Substance	Koc (mL.g-1)	Level	DT50 (Day)	Hydrolyse	Level	Amount		Level	Solubility (mg.L-1)	Level	Rank	Rank
chlorate de sodium	10	d	200	stable	md	6900.745	0.36	m	790000	d	47	75%
fluroxypyr	66	d	51	TS	md	3193.5122	0.17	m	6500	d	47	75%
imidaclopride	225	m	174	TS	2d	2303.846	0.12	m	610	d	44.5	71%
Atrazine	*29*	*d*	*100*	*TS*	md	9999	0.53	m	35	*m*	43	68%
mesosulfuron-methyl	92	d	77.3	TS	md	281.37838	0.01	o	483	d	39.5	63%
thiamethoxam	56.2	d	52	TS	md	192.42431	0.01	o	4100	d	39.5	63%
piclorame	87	d	180	stable	md	0.0001888	0.00	o	560	d	39.5	63%
chlorsulfuron	35	d	60	inst	md	2.205E-06	0.00	o	31800	d	39.5	63%
clethodime	40	d	2	TS	d	1334.2311	0.07	m	5450	d	39	62%
fosetyl-aluminium	0.1	d	0.04	TS	d	859.14621	0.05	m	110000	d	39	62%
2,4-d	56	d	9.9	TS	d	5885.0113	0.31	m	23180	d	39	62%
dimethachlore	63	d	16.5	TS	d	6924.3234	0.36	m	2300	d	39	62%
dichlorprop-p	44	d	19	TS	d	1969.1716	0.10	m	590	d	39	62%
clomazone	286.5	m	45.1	TS	md	1306.7188	0.07	m	1102	d	37	59%
chloridazone	199	m	36.5	TS	md	3361.7194	0.18	m	422	d	37	59%
imidaclopride	225	m	36.5	TS	md	2303.846	0.12	m	610	d	37	59%
beflubutamide	10	d	103	TS	md	177.27222	0.01	o	5.03	o	33.5	53%
florasulame	22	d	8.5	TS	d	103.05357	0.01	o	6360	d	32	51%
iodosulfuron-methyl-sod	45.3	d	8.389	TS	d	146.31272	0.01	o	25000	d	32	51%
metsulfuron-methyl	39.5	d	31.97	stable	d	103.15767	0.01	o	2790	d	32	51%
sulcotrione	36	d	10.1	TS	d	257.56667	0.01	o	1670	d	32	51%
imazamox	58.7	d	14.3	TS	d	163.75058	0.01	o	626000	d	32	51%
hydrazide maleique	45.15	d	5.75	TS	d	172.60095	0.01	o	144000	d	32	51%
dichlormide	36.75	d	8	TS	d	159.55244	0.01	o	5000	d	32	51%
thifensulfuron-methyle	28	d	10	TS	d	124.05968	0.01	o	2240	d	32	51%
metribuzine	37.9	d	12	TS	d	151.48519	0.01	o	1050	d	32	51%

Table 19 shows all the pesticides detected at least once in spring water. For the FAIRWAY project, data from several springs were analysed. In this report, data from the Durthein spring are presented. The analyses analysis records for the La Voulzie springs are generally too short to be assessed.

The first column shows the names of the products, the second column shows the number of detection instances between 2008 and 2017, and the last column indicates if the product has a rank above 30. Pesticides above rank 30, according to SIRIS, could reach the ground water. In the La Voulzie case study, 88 pesticides (out of 280) had a rank above 30.

Table 19. Comparison between pesticides detected in water and pesticides with highest ranks assigned by SIRIS. (Molecules that are no longer sold are written in grey).

Match	Parameter	*Number of detection in water*	Rank	Siris list rank >30	Match	Parameter	*Number of detection in water*	Rank	Siris list rank >30
	Atrazine déséthyl	*74*				*Sebuthylazine 2-hydroxy*	*3*		
(Yes)	**Atrazine**	**74**	43	(Yes)		Metamitrone	3	23	
	2-hydroxy atrazine	*47*				Isoproturon	2	21	
	Simazine	**40**			Yes	dimethachlore	2	39	Yes
	Oxadixyl	**37**				Diflufenicanil	2	16.5	
	Atrazine déisopropyl	*31*			Yes	Imidaclopride	2	44.5	Yes
	Atrazine déisopropyl déséthyl	*31*				Lenacile	2	19	
	Bentazone	30	24.5			Cyproconazole	2	27.5	
Yes	Chloridazone	15	37	Yes		Metazachlore	2	23	
	Ammonium	10				Tributylétain cation	2		
	Boscalid	10	22			*Métolachlore NOA 413173*	*2*		
	Epoxiconazole	9	16.5			*Metolachlor OXA*	*2*		
	Terbuthylazine hydroxy	*8*			Yes	Nicosulfuron	1	32	Yes
	Metolachlor ESA	*8*				Carbendazime	1	19	
	Diméthachlore CGA 369873	*8*				Tebuconazole	1	12.5	
	Diméthachlore-ESA	*8*				**Bromacil**	1		
	Métazachlore ESA	*8*				Flusilazole	1	12.5	
	Dinoterbe	**7**			Yes	Metribuzine	1	32	Yes
Yes	Metsulfuron-methyl	7	32	Yes		**Hexazinone**	1		
	Chlortoluron	6	27.5			Ethofumesate	1	27.5	
	AMPA	*5*				*Ethyleneuree*	*1*		
	Métazachlore OXA	*5*				Quinmerac	1	24.5	
	Glyphosate	3	20.5			*Propazine 2-hydroxy*	1		
	Biphenyle	3				s-metolachlore	1	23	

A concordance between the concentrations actually observed and the results of the SIRIS tool are shown in Table 19. Explanations of the mismatch between the SIRIS forecasts and the measurements in groundwater include:

1) Some products have only been measured for a few years so it is difficult to make comparisons. For instance, in La Voulzie spring water, fluroxypyr was measured only 15 times in 4 years (between 2008 and 2017).
2) There is delay between pesticide application and measurement of the pesticide in groundwater. Many of the products detected are not sold anymore. The French researchers made a study on the site and calculated that the travel time for water is 7 years. It is known that the travel time for pesticides is always longer than for water.

Table 20 summarizes the advantages and disadvantages of SIRIS used in a French context.

Table 20. Advantages and disadvantages of SIRIS seen in a French context.

Advantages	Disadvantages
The model is suitable for working at the watershed scale.	The working scale of the model is not suitable for farmers
The tool is very easy to use and in France, the input data are easy to obtain thanks to the BNV-d database.	Input data is easily available in France from the BNV-d database, but the total amount of pesticides is difficult to obtain at smaller scale.
The tool is very easy to use. It is possible for a manager, non-specialist modeller, to use it quickly.	The BNV-d + SIRIS association is not able to simulate the impact on water of unauthorized products and metabolites.
The tool identifies some of the pesticides that must be restricted.	The tool is very easy to use but knowledge relating to the transfer of pesticides is necessary. For instance, notion on pesticide sorption (Koc) and degradation (DT50) could be needed to understand the tool.
	Comparisons between the measured data and the predicted data show differences that are difficult to explain
	Some features of the model systematically prevent it from correctly reproducing the behaviour of certain pesticides (for example, products with high sorption always have low ranks)
	Apart from the reduction of doses, no mitigation measures can be tested

c. Implementation

SIRIS was easily applied on the catchment area using the data from the BNV-d. It can easily be applied on other basin watersheds in France. There are two opportunities to use it: a) by using the quantities actually applied or b) using pesticides doses (approved doses). This information is usually available (at least the approved doses).

SIRIS only allows classification of the products, and its minimal scale of operation is the watershed. The tool does not propose mitigation measures at the farm scale or across the basin watershed. Because of this, it may not be used for creating scenarios where practices are changed. The possibility to change the doses is not really usable because SIRIS react by threshold (e.g. parameter surface). It is possible to multiply or divide the dose by three and see no impact if one remains in the same level (Table 17), whereas a minimal change in the dose can have effects if it allows to pass a level ("o" towards "m" for example).

Basin watershed managers and water company managers could use SIRIS but it would be for farmers to access. For managers, it can help to select plans for monitoring, for animators; it can be used to know which products to reduce. By slightly modifying the original output template to make table appear clearer (o m d, see Table 17), it is easier to know why each product gets its ranking. Adding a column showing the threshold value will determine if the product will see its rating change with a small change of input data.

5.4 GERMANY – LOWER SAXONY

The German case study site is located in southwest Lower Saxony. The production on the farms is exclusively arable with a focus on wheat, canola and sugar beet. In particular, bread (milling) wheat production comprises 45-60 % of cropping on arable land. Compared to the average farm size in the region, the test farms cultivate a land area which is above average (150 – 350 ha) with favourable soils. Fertilizer practice is based on mineral fertilizers. Application of manure is mainly restricted to some biogas residues and (in some cases) organic manure (pig slurry, poultry solid manure) imported from the western region. However, the results here represent arable farms only and do not consider famers in the western part of Lower Saxony where a lot of animal production (especially pig and poultry farming) takes place.

In Germany, the amendment of the fertilizer legislation (DüV 2017) requires the documentation of crop fertilizer needs at the field level. Increases or decreases to this plant specific nitrogen (N) need are based on soil nutrient contents (mineral N (Nmin) in spring, and available phosphorus (P)), precrop and catch crops, fertilizer history and yield level. In our case study and in many parts of Lower Saxony we currently work with the software Düngeplanung. This software goes beyond the legal requirements by creating individual fertilizer plans (incl. the specific fertilizers used) before fertilizer application takes place. Usually farm advisors and famers work together to fine-tune the individual fertilizer strategies. Within task 5.2 the researchers were interested to see how fertilizer planning in other countries works and how the DSTs are designed. The criteria on which the selection of DST was based is described in section 5.4.2.

We selected the Danish tool Mark Online and the Irish Teagasc NMP Online which are used for fertilizer planning. Unfortunately, the Irish software developers did not provide access for Teagasc NMP Online despite several requests.

In addition, we selected the Dutch DST NDICEA, which is an advisory tool to, among others, estimate N-mineralization in the soil during the growing period. Thus, it can be used to additionally adjust fertilizer plans. In Germany, similar software called ISIP (also described in the report of task 5.1) is available. A second Dutch program called ANCA could not be tested since its use is restricted to dairy farms only which do not exist within our case study area.

5.4.1 Workplan

One focus of the testing was to present the DST to the farmers, and directly discuss the results and the potential implications with them. This included four farm visits and discussion of the results of the tool and its implications with the farm managers based on their individual data. We only carried out farm visits if it was certain that the farmers could benefit from the results of the tool (e.g. get an idea how fertilizer management works in Denmark, compare their agricultural management with those of their European colleagues). The Dutch tool NDICEA unfortunately only uses live-weather data from the Netherlands or Flanders, England, Denmark and Spain, and so the calculated N-mineralization was not realistic for site conditions in Lower Saxony. Therefore, the farm visits focussed primarily on the results of Mark Online. The workplan for both Mark Online and NDICEA is listed in Table 21.

Table 21. Workplan for the FAIRWAY case study site in Lower Saxony, Germany.

Task	Action title	Action details	DST	Information source	Comments/difficulties	Targeted deadline
0	Installation, access to software	Softwark installation, licence	*Mark Online*	SEGES, IT-department of LWK	security settings, provision of license	01.09.2018
			NDICEA	Louis Bolk Instituut, IT-department of LWK		
1	Overview	Legal background and structure of software	*Mark Online*	DST workshop in Cambridge, publications, articles, software developers/administrators	language, complex legal system , continous development of legal system and DST	01.10.2018
			NDICEA		language, live climate-data not available for Lower Saxony	01.10.2018
2	Test dataset	Compiling available data, supplementing information	*Mark Online and NDICEA*	data of *Düngeplanung* , direct information of farmers, Lower Saxony administration for fertilization	conversion of data necessary (soil data, nutrient contents in soil); climate conditions vary to some extent	01.11.2018
3	Data input	Crop rotation (inkl. yields) conversion of soil data data on use of org. fertilizers fertilization practice	*Mark Online and NDICEA*	data of *Düngeplanung* , direct information of farmers, Lower Saxony administration for fertilization	conversion of data necessary (soil data, nutrient contents in soil); climate conditions vary to some extent; specific restrictions in Denmark	15.01.2019
		Crop rotation (inkl. yields) conversion of soil data data on use of org. fertilizers fertilization practice	*Mark Online and NDICEA*		conversion of data necessary (soil data, nutrient contents in soil); live climate-data not available for Lower Saxony	15.01.2019
4	Plausibility checks	Verify entered data with farmers/SEGES	*Mark Online*	direct information by farmer (farm visits) material by SEGES check by SEGES-advisor	technical difficulties (web access) time-intensive	01.03. - 01.04.2019
5	Results	Compilation of results (mapping of some key points which are directly comparable)	*Mark Online*	information by SEGES	comprehensive results numbers of farms tested still too small (4 farms) testing up to now mainly restricted to arable farms with high soil quality	07.03. - 01.04.2019

5.4.2 **Assessment, testing and implementation of selected DSTs.**

When selecting DSTs to be tested, it was a priority to select tools, which could be potentially integrated into our advisory work (so they should be of interest to the farmers).

Hence, we applied the following criteria:

- It should be a DST dealing with fertilizer management, which indirectly reflects on nitrate leaching. The Lower Saxony case study provides a feasible dataset and the test results could be compared with the results of Düngeplanung directly.
- The DST should be applicable at farm-level and consequently directly illustrate and/or influence farmer's management practices.
- The DST should originally come from a case study site with comparable climate, soils and agricultural structure.
- The DST should have the possibility to integrate and assess both obligatory and voluntary measures/environmental restrictions.

Mark Online

a. Assessment

Mark Online is the most widely used DST for fertilizer planning, optimization and documentation in Danish crop production. It covers all aspects of crop management including soil tillage and crop protection. It is a modularly built and web-based software and is maintained by SEGES, the most important test and research organization in Denmark.

The Danish agricultural system is generally known to be quite restrictive with respect to fertilizer practices but has been proven to show very positive environmental effects. The effects of such strict limitations on N fertilization on farming (like decreasing protein contents in winter wheat) have been discussed on a quite emotional basis within Germany. However, details about the legislation and its implementation are not widely known among German farmers. Hence, it was very interesting to assess the on farm-level implications in the German case study area if farmers had to follow Danish law. We were especially eager to know how implementation of Danish law with the help of Mark Online looks in practice. The SEGES staff were very helpful providing free software access in the context of this project. Danish farmers pay a yearly fee amounting to about 200 EUR/year.

Beforehand and while testing the software, some challenges had to be tackled:

- Since Mark Online always reflects prevailing law, we also had to pay attention to the specific legal frame conditions in Denmark in order to be able to interpret the results in a sensible way.
- Denmark designates some sensitive areas with additional restrictions concerning animal rearing, catch crop establishment and/or phosphorus application. For our German test farms, we assumed that they are not located in any of these specific areas.
- Climate and soil conditions in Denmark and parts of Lower Saxony are only comparable to a limited extent. Especially in the farms located in the very south of Lower Saxony, agri-environmental conditions can deviate (continental instead of maritime climate).
- The software is only available in the Danish language; hence exploring some of the software details was very time-consuming.
- On one of the test farms, no stable web access was available.

b. Testing

In total, we mapped four farms in our case study in southwest Lower Saxony with Mark Online. All the farmers were very interested to get to know the tool and were supportive with the provision of data and additional information. Within individual farm visits, we discussed details of crop production and compared recent cropping and fertilizer practices to legal requirements in Denmark and Lower Saxony.

Qualitative findings mainly concerning the manageability or Mark Online are described in the following. Generally, our test famers appreciate the well-structured way Mark Online is built. The modular design in particular helps to stepwise tailor farm management to the complex rules. In addition, it is web-based and continuously updated, hence when using Mark Online, farmers can be sure, they are working with the most recent software covering most recent legal restrictions. Furthermore, information has to be only entered once (and not repeatedly into a number of different applications). Therefore it is possible to easily produce long-term analysis of data (e.g. concerning yields, fertilizer used, expenses, etc.). However, our test farmers criticised the fact that they had to expend much effort to first enter the relevant data and further maintain the documentation since many bureaucratic requirements already exist. In addition, worries concerning data security were expressed in this context. Due to the software's complexity, farmers confirmed, they would need the help of an advisor. Especially the integration their own measurements (which can sometimes differ a lot from general numbers) was found to be difficult to handle.

Table 22. Advantages and disadvantages of the application of Mark Online on German test farms.

Advantages	**Disadvantages**
User-friendly design, clear structure	Very complex, help of advisor needed
Supplementary information provided (manual Vejledning om gødsknings og harmoniregler) to answer the most frequent FAQ	Entering and maintaining of data is time-consuming
Centralized and holistic approach, data has to be only entered once	Concerns about data privacy
Software is always up-to-date (Farmers can rely on information provided within the software)	Infrastructure (Stable and fast web-access has to be available)
Multiannual analysis of data easily possible	Relies very much on general numbers
Graphical illustration of some elements provided (green check marks, management of manure within a tank, etc.)	Software has to be tailored to conditions in Lower Saxony (climate, legal system, language, etc.)
Various ways for data output (Excel-sheet, pdf, etc.)	No freeware

In order to produce and interpret some of the quantitative test results, the different legislation and its execution in both Denmark and Lower Saxony (Germany) had to be considered. Since the Danish system is very comprehensive, we had to limit our focus to some selected legal requirements (farm level) that could be compared between the two countries and which are of greatest interest to the farmers. This is most feasible for the:

- N-quota according to the Danish system,
- limits for P-fertilizer use and
- additional environmental requirements .

The results from our four test farms are summarized below. However, we must stress that these test results should not be extrapolated to farms beyond the case study area. For this, a more comprehensive analysis is needed, e.g. including farms with different site conditions (e.g. poor soil quality) and different focus of agricultural production (dairy, pig farming, etc.).

Calculation of farm-specific N-quota

Both Mark Online and Düngeplanung attribute specific N-needs as nutritional demand for different crops (Grundnorm in Danish, N-Bedarfswert in German) which are legally binding. Both systems allow an increase of this value, if a higher than average yield level can be proven for a specific crop (5-year's average in Denmark, 3-year's average in Germany). In the German system, obligatory reductions have to be made if the average yield level falls below the standard value. In the Danish system, the expected yield level is closely linked to soil texture, and thus to soil quality, which is not the case in Germany. Therefore, soil analysis data available for the farms was used to classify the soils accordingly.

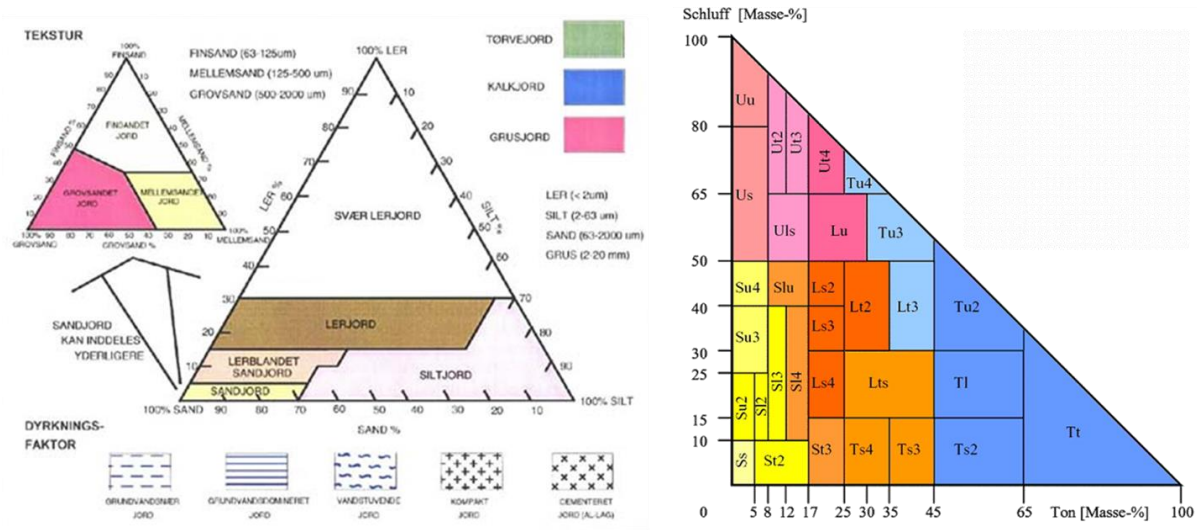


Figure 12. Classification of the soil texture according to the Danish (left hand) and German classification (https://www2.skovognatur.dk/udgivelser/2000/jordbund/jordtyper.htm and Bodenkundliche Kartieranleitung (2006)).

Depending on the preceding precipitation and crop growth during winter, the amount of mineral nitrogen in the soil (Nmin) at the start of vegetative growth can vary substantially. In the Danish system, this effect is accounted for by tailoring the crop N-need to the soil type. In addition, in early spring the so-called N-prognose for the whole of Denmark's territory is published in order to correct values on a regional level. The N-prognose is based on both climatic data and several field trials. In contrast, Lower Saxony requires that soil Nmin is directly subtracted from the calculated plant N-need. To come up with appropriate values, so-called soil climate zones (Bodenklimaräume) are defined. Within each zone, reference soil samples for different crops are taken and analysed for Nmin (0-90 cm depth). The individual farmer can take either their own samples or use the published Nmin-values.

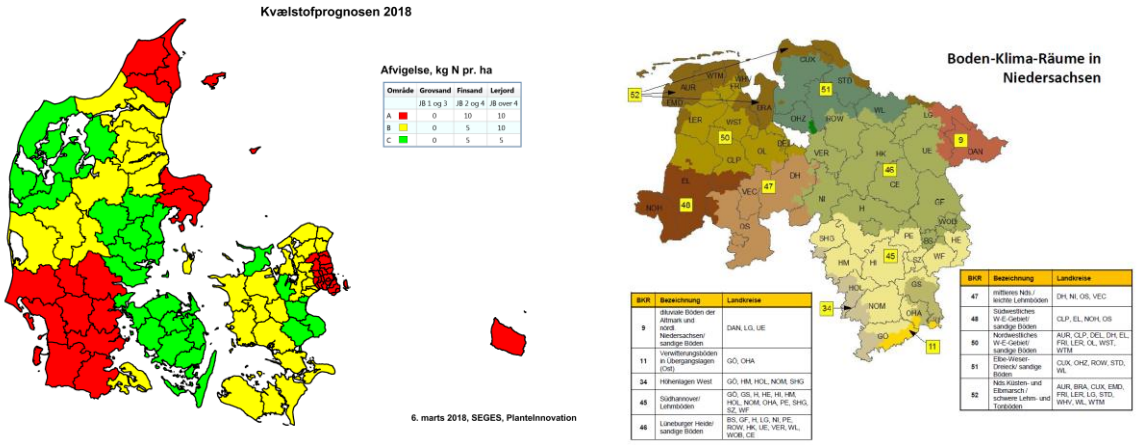


Figure 13. N-prognose for Denmark 2018 and designation of soil climate zones in Lower Saxony.

Both, the Danish and the German system account for the effect of the precrop including catch crops; however, values differ. Accounting for fertilizer history (e.g. application of manure for many years) differs between the countries.

Moreover, in the Danish system the N-quota can be further reduced, if specific environmental regulations (like a defined share of catch crops) are not met. Based on this information, Mark Online calculates a farm-specific N-quota, i.e. the amount N a farmer is legally allowed to purchase. In contrast to the German system, retailors of mineral fertilizers have to report sales of fertilizers directly to the authorities.

Below, the average result of the four farms tested is graphed (Figure 14).

- Column 1 represents the N-quota calculated according to the more restrictive Danish agricultural legislation for the year 2015. The average amount of ca. 200 kg/ha N is further reduced by the average N-prognose (orange) and by some further reduction attributed to N-mineralization of previous catch crops.
- Column 2 represents the change in the legislation (with higher N-Grundnorms) since 2016. Consequently the average N-quota standardized by hectare increased by about 20 kg/ha.
- Column 3 represents the average maximum amounts of N in the four test farms that are allowed to apply according to current German law. The maximum amounts of N to be applied in autumn (crosshatched light yellow) is added to the maximum fertilizer applied in spring and summer (light yellow). The average Nmin-contents in early spring are subtracted (orange).
- Column 4 represents the average amount of fertilizer the four test farms purchased during winter 2017/18 and spring/summer 2018. Data originates from sales accounts and individual farm records.

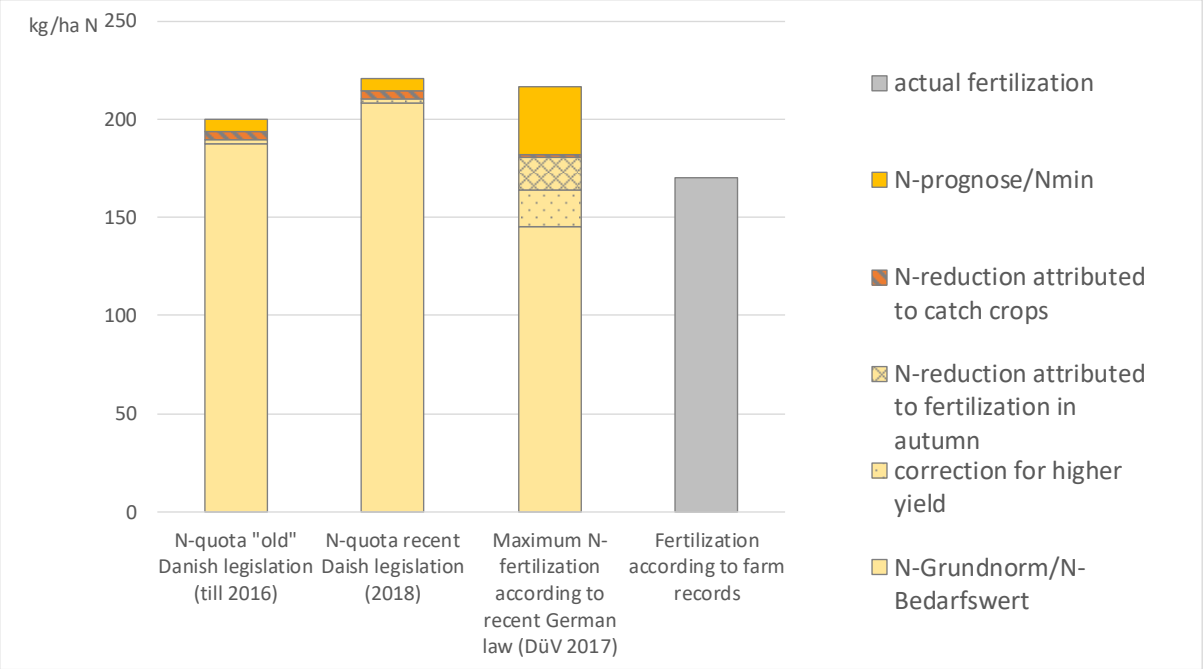


Figure 14. Average result of four test farms for the year 2018.

The results show that the four test farms were able to comply with the Danish N-quota, both for the “old” and recent regulation. Compared with the recent Danish legislation, the four farms purchased only 78 % of the N they would have been allowed to. This corresponds with 87 % for the “old” Danish legislation.

Farm-specific limits for P-fertilization

Both the Danish and the German systems aim at establishing a balance between P-fertilizer inputs and P export from the field. The Danish system defines a limit of 30 kg/ha P-fertilizer on-farm average (corresponds to ca. 68 kg/ha P_2O_5) for arable farms. If manure is used, this threshold is slightly increased, depending on the type of livestock farming. Furthermore, some P-sensitive areas are mapped, and in these P-fertilizer is even more restrictive. In contrast, in Germany, soil analysis is considered and fields with high P-contents will receive only the amount of P which will be exported by harvest.

The four test farms complied with both systems. On farm-average P-application was 22-30 kg/ha P. Since they primarily apply expensive mineral P-fertilizers such as triple superphosphate or di-ammonium-phosphate, the total amount of P applied is limited and does not exceed plant P-uptake. In regions with intensive livestock production and high amounts of P in organic fertilizers, results could deviate.

Environmental demands

Both countries, Denmark and Germany, define some additional environmental targets in order to fulfil good agricultural practice. This includes the diversification of cropping systems, i.e. number of crops produced on the farm should be at least three, and the share of the two most important is restricted (Krav om flere afgrøder in Danish). The crop rotation of our test farms involved 4-6 different crops.

Furthermore, both systems force farmers to manage some area in an especially environmental-friendly way (Miljøfokusområder in Danish, Ökologische Vorrangfläche in German). For both countries this areas should be about 5 % of the farmed area (only arable in Germany, both arable and grassland in Denmark). Measures to comply with this request include e.g. provision of fallow areas or buffer strips or establishment of catch crops. Depending on the individual farm structure, in both countries farms can choose which fits best for them.

In Denmark, however, depending on the number of animals kept and on the location of the farm, some additional area has to be attributed for the establishment of catch crops, fallow land, multiannual crops for energy production, etc. The test farms, which neither keep animals nor are located in environmentally vulnerable areas (designated by the Danish system) hence have the obligation to establish catch crops on at least 10 % of their summer-harvested crop area (Pligtige efterafgrøder). Depending on the number of animals kept and on the location of the farm, the share of obligatory and voluntary catch crops can also be substantially higher. Again, the share of catch crops can be replaced by alternative measures. Three out of four of our test farms complied accordingly. However, some of the measures the farmers applied (e.g. buffer strips with flowering plants) are financially reimbursed in Lower Saxony (payments for agri-environmental measures). Without these compensation payments, the respective areas would be probably substantially smaller. Since none of our test farms keeps animals, regulations concerning the storage of manure (Lagerreglen) are not relevant in the frame of the testing.

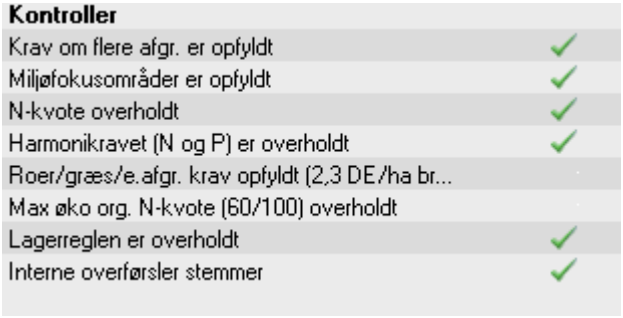


Figure 15. Example of the graphical output of the results of one of our test farms in Mark Online;
"Krav om flere afgr. er opfyld" = diversification of crops is met;
"Miljøfokusumråder er opfyld" = Specific environmental valuable agricultural area is provided;
"N-kvote overholdt" = N-quota is respected;
"Harmonikravet (N og P) er overholdt" = The land size for applied N and P fertilizer is sufficient.;
"Harmonikravet (N og P) er overholdt" = The land size for applied N and P fertilizer is sufficient.;
"Lagerreglen er overholdt" = Sufficient storgae capacity is provided
"Interne overførsler stemmer" = internal nutrient flows are correct.

c. Implementation

Generally, testing was very successful, although some difficulties occurred. Some elements of Mark Online could be integrated easily into the German system, although the legal framework conditions certainly have to be respected. Mark Online creates clear overviews of the four test farms which helps considerably in advisory work. However, this advisory session would have to be an individual session in order to cope with the complexity of the software.

The tested farms of the case study almost completely meet the requirements concerning fertilizer use and environmental-friendly crop rotations. Admittedly, these are comparatively large arable farms with favourable soil conditions. Hence, ideas on how to implement Mark

Online are deduced from the results of these farms only. For livestock farms and/or farms with poor soils additional aspects could be relevant.

In the Danish system a lot of information is linked (fertilizers sales accounts, transport of manure, number of animals, etc.). In addition, it is based on numbers, which can be crosschecked (amounts of fertilizers, numbers of animals, etc.). For that reason, it is much easier for the authorities to control if a farmer meets the requirements. Most information of that kind is also available for Lower Saxony but not linked in the same way. The establishment of the Danish system in Lower Saxony may risk violating data privacy rights; however, it would make fertilizer regulation much more transparent. A farm-specific N-quota can limit the total amount of fertilizers to be applied (and thus better control the risk of reactive N being emitted to the environment) but at the same time rely on farmer's expertise when it comes to allocation of nutrients in an agronomically sensible way. The way this is realized within Mark Online looks very promising. By linking the yield level to the soil type (and thus to the assigned N-demand), N-quotas are closely linked to the individual nutrient need of farms. In contrast, in the German system the influence of different mineral soil types on field-level is largely disregarded.

Some technical issues hamper the one-to-one implementation of Mark Online. The language of the software is Danish, and many terms are abbreviated which complicates the situation further, especially for details such as the classification of a certain crop. Furthermore, the software is calibrated on the basis of Danish site conditions. Numbers are derived with the help of climatic measurements in Denmark and field trials on Danish research sites (e.g. N-prognose, yield levels etc.). Before implementing, it would have to be harmonized with the German site conditions and numbers. Moreover, the software would need to be continuously updated and maintained.

NDICEA

a. Assessment

The software NDICEA stikstofplanner provides an integrated assessment of the nitrogen availability in the soil. It goes beyond simple nitrogen budgeting for each crop since it accounts for the complex interaction of the soil-crop-management system. By integrating live weather data, the most variable influence factor for crop development is also factored in.

In Germany, a comparable system is used, which is part of the web-based platform Integrated Plant Production System (ISIP), also mentioned in the task 5.1-report. It estimates nitrogen availability to crops in order to optimize N-fertilizer use and hence improve N-efficiency. Although the German model produces clear graphical representations of N-availability to crops, measured values and field observation sometimes substantially differ from model predictions. Certainly, high spatial variability of precipitation events are a big challenge since they have a large influence on model performance. In addition, the data input into the ISIP system may not be sufficiently comprehensive, e.g. the effects of soil tillage are not accounted for. Since NDICEA also considers a lot of additional information on soil properties and soil tillage, it might be more precise in assessing N-dynamics in the soil.

During first assessment, some basic challenges arose:

- Integration of live weather data is only possible for the Netherlands, Flanders, England, Denmark and Spain. Even if the software developer added some

German weather stations subsequently, the problem of the high spatial variability of precipitation events would remain.

- Output crucially depends on the quality of the input data. For our test farms site-calibrated descriptions on soil structure in top- and subsoil was unfortunately not available.

b. Testing

During the testing phase, we first compiled some data for our test farms. Since NDICEA needs information for at least five years of cropping in order to provide output, this a comparatively comprehensive task. Management of the software was quite convenient (see screenshot below) and in most cases no paper guidance was needed to use NDICEA. However, not all types of mineral fertilizers applied by our test farms were listed.

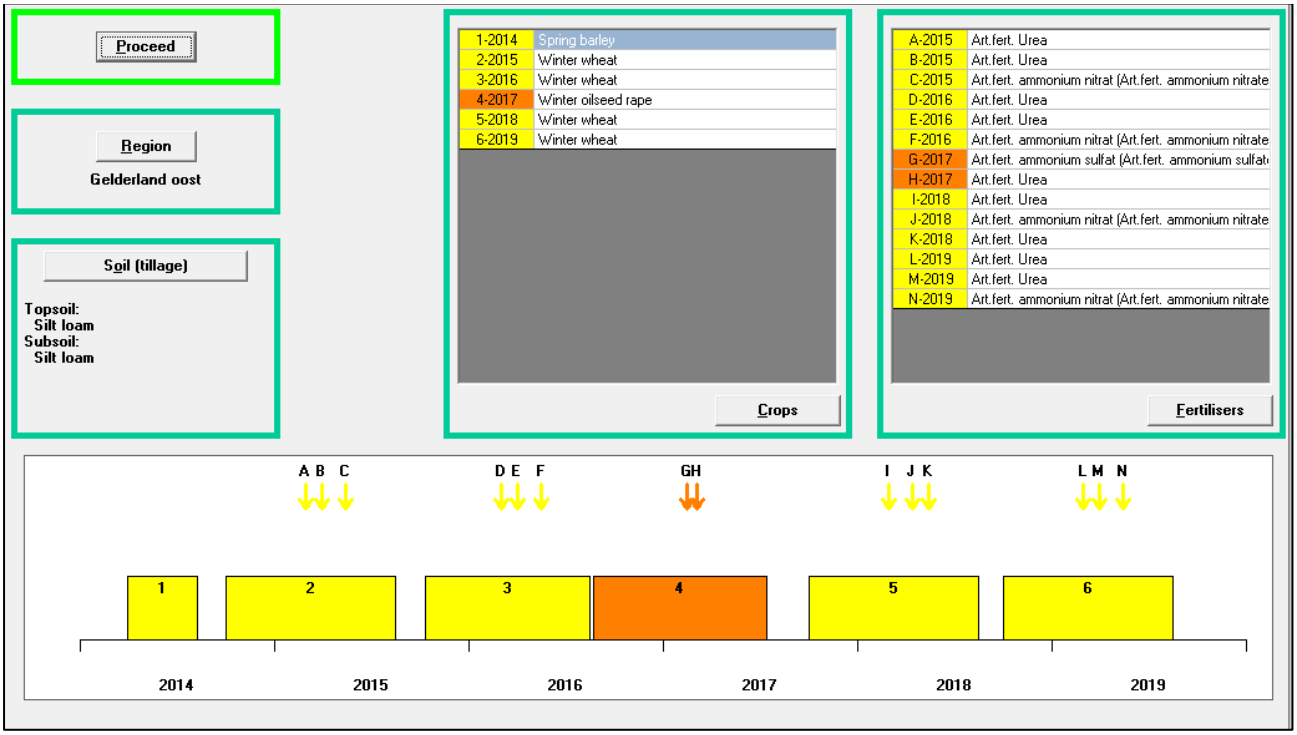


Figure 16. Software interface of NDICEA visible in the example of a winter wheat-canola crop rotation for one of our test farms.

NDICEA calculates plant available N and crop N-uptake for five years of simulation (Figure 17). From the drop-down menu of NDICEA, we chose the Dutch weather station Gelderland-Oost, since it is the one which is closest to our test field (ca. 300 km distance). Although climate conditions here on average resemble those in the south eastern part of Lower Saxony, they are too inaccurate to provide reliable results.

The calculated plant N-uptake by NDICEA of 210 kg/ha N in the year 2018 was somewhat below the results estimated by ISIP (240 kg/ha N-uptake; Figure 17).

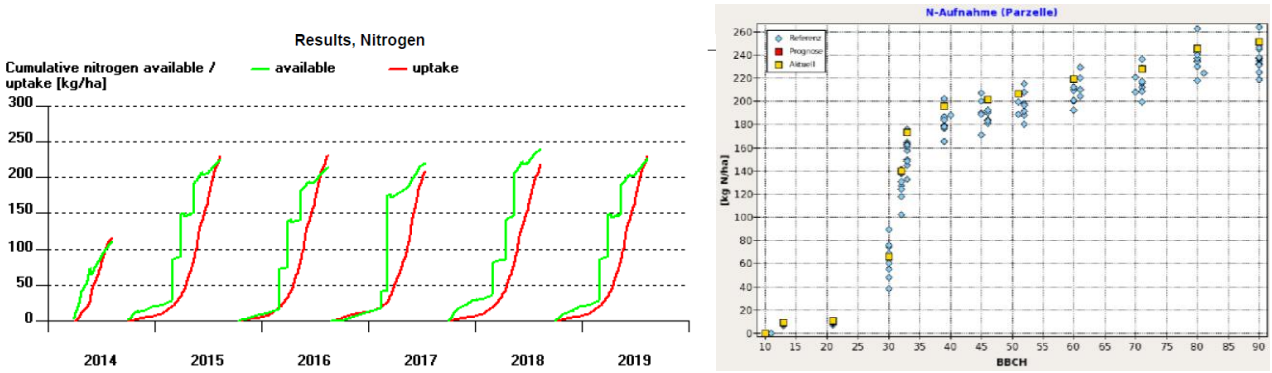


Figure 17. Left chart: Plant available N and cropplant N-uptake on one test field from 2014-2019 calculated by NDICEA; right chart: Calculated crop N-uptake by ISIP in the year 2018 (yellow mark).

Table 23. Advantages and disadvantages of the use of NDICEA to estimate nitrogen mineralization in the soil.

Advantages	**Disadvantages**
User-friendly design, self-explanatory application, additional dialogue boxes provided	No additional information on assumptions made
Many influencing factors are considered	Comprehensive data input needed (at least five years of cropping)
Own data (soil analysis, crop quality, etc.) can be optionally be integrated (if not, default values are used)	Calibration needed
Clear graphical representation provided	No availability of local weather data
Freeware	

c. Implementation

NDICEA is an advisory tool to provide additional information on N-availability to crops. The level of adoption by farmers depends on the quality of the calculated result. Unfortunately, in the latest version input data (especially live weather data) is much too inaccurate to use for fertilizer recommendations.

Even if the software could be locally calibrated for our test farms, the model results should be continuously verified by measurements in the field (optical and colorimetric measurements). For that reason there is no potential for the implementation of NDICEA on the test farms at present.

5.5 IRELAND – DERG CATCHMENT

The Agri-Food and Biosciences Institute (AFBI) in Northern Ireland have evaluated three DSTs in the context of the Derg Catchment case study (No.7). The Derg is a 384 km^2 sub-catchment of the Foyle river system located in the north west of the island of Ireland (Figure 18). The catchment is cross-border, with headwaters in the Republic of Ireland (RoI) and drinking water abstraction at the outlet, in Northern Ireland (NI), for treatment and supply of between 16 and 28 ML day^{-1} to the NW region.

Figure 18: Derg case study catchment (384 km^2) draining to Lough Foyle in the NW of Ireland. Catchment outlet and abstraction point are indicated (black star).

5.5.1 Workplan

The work plan for evaluating the 3 selected DSTs; (1) Farmscoper, (2) Phytopixal, and (3) SCIMAP is presented in Table 24.

Table 24. Workplan for the FAIRWAY case study site Derg Catchment, Northern Ireland.

Action	Action Details	Target Deadline	Involvement
Review DSTs	Review websites and publications for each of the three DST	1st Dec 2018	AFBI
Access to DSTs	Download and install the relevant software for each DST	1st Dec 2018	AFBI
Collate datasets	Collate available datasets to evaluate the DST. Where data is not available within the Derg case study catchment, data from other similar catchments will be utilised. Data gaps, software licensing, storage and resolution issues will be identified.	31st Dec 2018	AFBI
Stakeholder Engagement	A workshop with key stakeholders will be held to discuss the potential implementation of the DST in the Derg catchment. This will involve representatives from stakeholders groups such as; catchment officers, water utility companies, non-governmental organisations, and technical expertise in catchment management and GIS. Stakeholders will be asked to contribute to the evaluation of the DSTs based on Evaluation scheme 1. In addition the discussion will focus on the practical constraints that need to be overcome if the DSTs are to be utilised by the stakeholders in the future	28th of Jan 2019	AFBI, NI Water, Irish Water, The Rivers Trust
Test DSTs	Each DST will be tested using the best available datasets. Where possible sensitivity analyses will be undertaken to evaluate the limitations of input resolution and data accuracy on results.	18th Feb 2019	AFBI
Evaluation of Results	The results of each DST will be evaluated against existing data and indictors.	18th Feb 2019	AFBI
Reporting	Based on the outcomes of the stakeholder engagement and testing of the DSTs, the challenges and benefits of their future use will be reported on.	28th Feb 2019	AFBI

5.5.2 Assessment, testing and implementation of selected DSTs.

Farmscoper, Phytopixal and SCIMAP

a. Assessment

In Northern Ireland (NI) and the Republic of Ireland (RoI) there is considerable concern about MCPA (2-methyl-4-chlorophenoxyacetic acid) contamination of natural waterbodies. The herbicide is widely used in the control of rushes (*juncus* spp.) and other weeds commonly found in managed grasslands. MCPA usage is of particular concern because rushes grow well in the poorly drained, clay soils common in the Derg catchment and the herbicide is highly mobile in the water phase. Although much progress has been made in updating pesticide usage practice in both NI and the RoI, through the implementation of action plans for sustainable pesticide use (DAFM, 2018), and compulsory training and tighter control on sales, significant concentrations of MCPA are still observed in river water and in drinking water supplies (NIEA, 2017, EPA, 2017). Frequent exceedances of the Drinking Water Directive threshold of 0.1 µg L^{-1} have been detected during regulatory compliance monitoring by the water company at the abstraction point (Figure 18) while 37% of sub-daily sampling undertaken by the INTERREG VA Source to Tap project (www.sourcetotap.eu) between April and November 2018, also exceeded this threshold.

A better understanding of MCPA export and mitigation can be achieved through the application of quantitative mathematical models of pesticide load or spatial models to identify areas where the risk of pesticide export is highest. The DSTs tested in the Derg case study cover both pesticide load modelling and spatial assessment of source and transport risk:

1. Farmscoper (http://www.adas.uk/Service/farmscoper) is an advanced export coefficient model which estimates diffuse losses of P, N, sediment and pesticides from single or multiple farms and quantifies the expected impacts and economic costs of mitigating losses to water and air (Gooday et al., 2014). The models can be upscaled to catchment scales by aggregating data for all farms within a specific catchment (Zhang et al., 2012). Parameters of interest, such as soil type, rainfall and farm type have been pre-defined in the model and are based on conditions in England and Wales, the region for which the model was developed.

2. The **Phytopixal protocol** (Macary et al., 2014) generates a spatial risk assessment based on a small number of physical catchment characteristics (slope angle, soil propensity to cause overland flow and proximity (as linear distance) to a waterbody) and a measure of pesticide usage (e.g. frequency of pesticide application or mass of pesticide applied to particular land use types). The user is allowed considerable freedom in selection of the data sources used, allowing for customisation of the protocol presented in Macary et al (2014). The protocol was developed in France.

3. SCIMAP (http://www.scimap.org.uk) is a diffuse pollution risk mapping tool (Lane et al., 2006, Milledge et al., 2012, Reaney et al., 2011) that generates a spatial risk assessment based on hydrological connectivity. Using topographic information the model predicts, for each point in the landscape, the probability of overland flow being generated, and therefore providing a pathway for contaminants export to the river network. Soil erosion potential is the only contaminant considered explicitly, but the operator can use expert knowledge to explore the risk associated with nutrients, sediment, pathogens or pesticides. The user is allowed considerable freedom in selection of the data sources used, allowing for customisation of the protocol. The latest version of this model is hosted on an online platform and covers only Great Britain (England, Scotland and Wales), but an archived version bundled as a toolbox within the open source SAGA GIS software will remain available and can be customised for other

regions (available to download from (http://www.scimap.org.uk/2016/02/x64-scimap-for-saga-gis-february-2016/).

b. Testing

Farmscoper

The Farmscoper DST is a series of Microsoft Excel spreadsheets with macro-driven databases that has been designed to allow the generation and customisation of individual farm systems, based on on-farm data or using available census data on livestock, cropping and manure management (exemplar screen shots of the input data sheets are shown in Figure 19. Outputs to water and air are modelled for a range of atmospheric and waterborne contaminants including nutrients, pesticides and sediments (a full list is provided in Table 25). Predictions are based on well-established models which have been used in the UK, including NEAP-N for nitrate (Anthony et al., 1996) and PSYCHIC Davison et al., 2008; Strömqvist et al., 2008) for phosphorus and sediment; MACRO Tool (Jarvis, 1995) and SWAT for pesticides. Contaminant losses are apportioned across source (e.g. dairy, beef, arable products, grass products), pathway (e.g. runoff, preferential flow, leaching) and timescale (short to long term) within the model. Soil types in the model are represented based on soil permeability, and classified based on the requirement for artificial sub-surface drainage (e.g. pipe drains). Three drainage classes are available and used as the basis for generating contaminant export coefficients for farming systems on different soils. Three workbooks in the model (Evaluate, Prioritise and Cost) are used to estimate the environmental impact and cost-effectiveness of

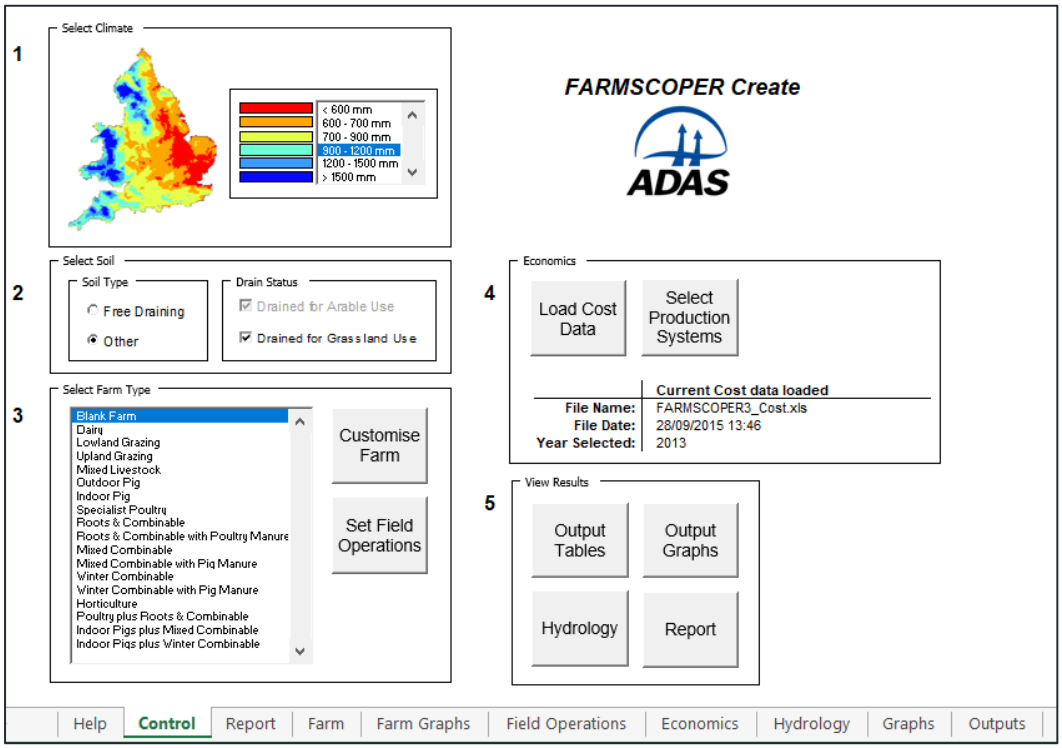
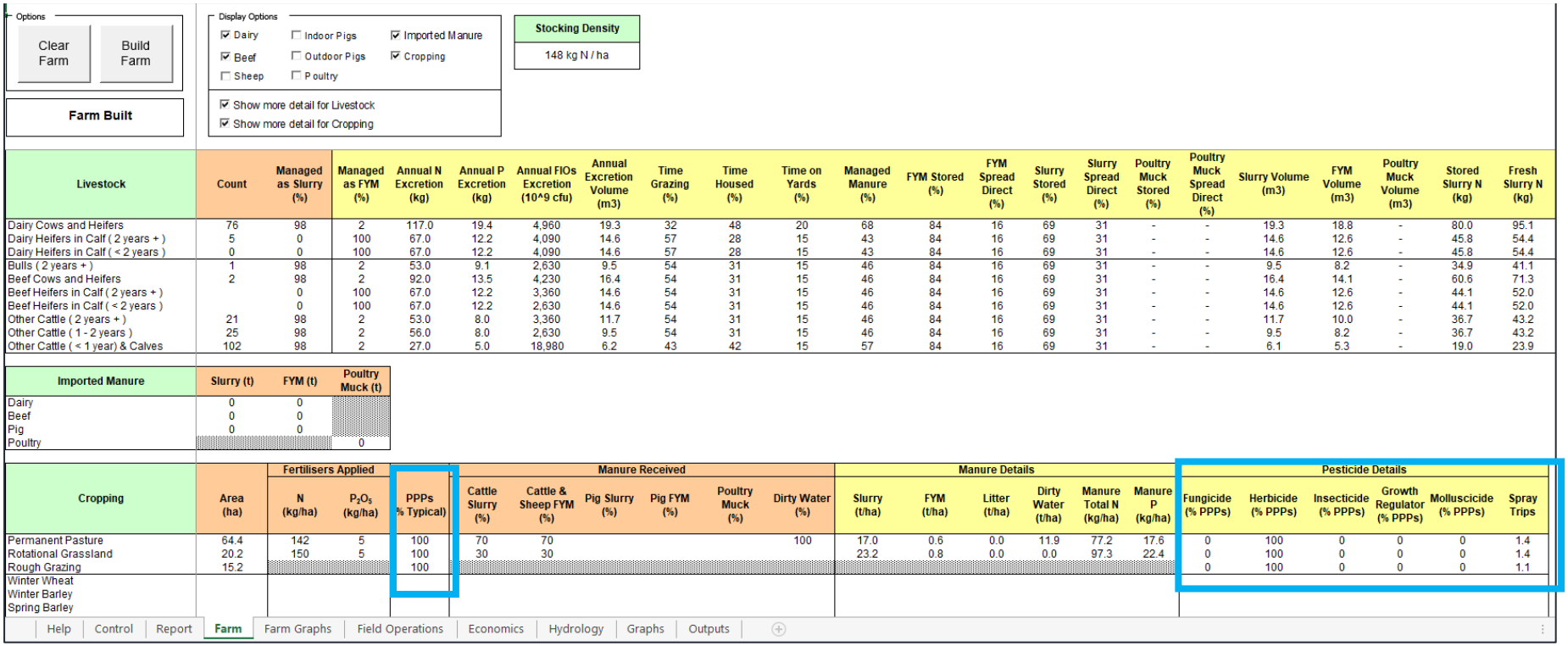


Figure 19. Initial control sheet for selection of soil and climate types and initial farm set up, including options to select from a set of template farms (based on UK census data) or a fully customised farm (based on actual data).

Figure 20. Example of the graphical output generated for the model, showing apportionment of contaminants by land use and source type.



Options: Clear Farm | Build Farm

Farm Built

Display Options: Dairy, Beef, Sheep, Indoor Pigs, Outdoor Pigs, Poultry, Imported Manure, Cropping, Show more detail for Livestock, Show more detail for Cropping

Stocking Density: 148 kg N / ha

Livestock	Count	Managed as Slurry (%)	Managed as FYM (%)	Annual N Excretion (kg)	Annual P Excretion (kg)	Annual FIOs Excretion (10^9 cfu)	Annual Excretion Volume (m3)	Time Grazing (%)	Time Housed (%)	Time on Yards (%)	Managed Manure (%)	FYM Stored (%)	FYM Spread Direct (%)	Slurry Stored (%)	Slurry Spread Direct (%)	Poultry Muck Stored (%)	Poultry Muck Spread Direct (%)	Slurry Volume (m3)	FYM Volume (m3)	Poultry Muck Volume (m3)	Stored Slurry N (kg)	Fresh Slurry N (kg)
Dairy Cows and Heifers	76	98	2	117.0	19.4	4,960	19.3	32	48	20	68	84	16	69	31	-	-	19.3	18.8	-	80.0	95.1
Dairy Heifers in Calf (2 years +)	5	0	100	67.0	12.2	4,090	14.6	57	28	15	43	84	16	69	31	-	-	14.6	12.6	-	45.8	54.4
Dairy Heifers in Calf (< 2 years)	0	0	100	67.0	12.2	4,090	14.6	57	28	15	43	84	16	69	31	-	-	14.6	12.6	-	45.8	54.4
Bulls (2 years +)	1	98	2	53.0	9.1	2,630	9.5	54	31	15	46	84	16	69	31	-	-	9.5	8.2	-	34.9	41.1
Beef Cows and Heifers	2	98	2	92.0	13.5	4,230	16.4	54	31	15	46	84	16	69	31	-	-	16.4	14.1	-	60.6	71.3
Beef Heifers in Calf (2 years +)		0	100	67.0	12.2	3,360	14.6	54	31	15	46	84	16	69	31	-	-	14.6	12.6	-	44.1	52.0
Beef Heifers in Calf (< 2 years)		0	100	67.0	12.2	2,630	14.6	54	31	15	46	84	16	69	31	-	-	14.6	12.6	-	44.1	52.0
Other Cattle (2 years +)	21	98	2	53.0	8.0	3,360	11.7	54	31	15	46	84	16	69	31	-	-	11.7	10.0	-	36.7	43.2
Other Cattle (1 - 2 years)	25	98	2	56.0	8.0	2,630	9.5	54	31	15	46	84	16	69	31	-	-	9.5	8.2	-	36.7	43.2
Other Cattle (< 1 year) & Calves	102	98	2	27.0	5.0	18,980	6.2	43	42	15	57	84	16	69	31	-	-	6.1	5.3	-	19.0	23.9

Imported Manure	Slurry (t)	FYM (t)	Poultry Muck (t)
Dairy	0	0	
Beef	0	0	
Pig	0	0	
Poultry			0

Cropping	Area (ha)	Fertilisers Applied: N (kg/ha)	Fertilisers Applied: P_2O_5 (kg/ha)	PPPs % Typical)	Manure Received: Cattle Slurry (%)	Manure Received: Cattle & Sheep FYM (%)	Manure Received: Pig Slurry (%)	Manure Received: Pig FYM (%)	Manure Received: Poultry Muck (%)	Manure Received: Dirty Water (%)	Manure Details: Slurry (t/ha)	Manure Details: FYM (t/ha)	Manure Details: Litter (t/ha)	Manure Details: Dirty Water (t/ha)	Manure Details: Manure Total N (kg/ha)	Manure Details: Manure P (kg/ha)	Pesticide Details: Fungicide (% PPPs)	Pesticide Details: Herbicide (% PPPs)	Pesticide Details: Insecticide (% PPPs)	Pesticide Details: Growth Regulator (% PPPs)	Pesticide Details: Molluscicide (% PPPs)	Pesticide Details: Spray Trips
Permanent Pasture	64.4	142	5	100	70	70				100	17.0	0.6	0.0	11.9	77.2	17.6	0	100	0	0	0	1.4
Rotational Grassland	20.2	150	5	100	30	30					23.2	0.8	0.0	0.0	97.3	22.4	0	100	0	0	0	1.4
Rough Grazing	15.2			100													0	100	0	0	0	1.1
Winter Wheat																						
Winter Barley																						
Spring Barley																						

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Figure 21. Farm sheet which allows customisation of farm, crop, livestock and nutrient management. Data are from an anonymised exemplar NI farm. Pesticides are represented in the model as % of typical use for crop type based on published national statistics for Britain (blue boxes).

Table 25. Modelled outputs from the Farmscoper model (example based on anonymised input data for a NI farm). Pesticides are given in "dose units" to equate to the standard units of whichever pesticides are used under "typical practice". These vary by crop.

	Units	Area (ha)	Value (units/ha)	Drainage (mm)	Concentration	Units
Nitrate	kg NO_3-N	100	26.213	580	4.52	mg NO_3-N/L
Phosphorus	kg P	100	1.512	580	0.26	mg P/L
Sediment	kg	100	323.459	580	55.79	mg/L
Ammonia	kg NH_3-N	100	38.761			
Methane	kg CH_4	100	238.891			
Nitrous Oxide	kg N_2O	100	11.086			
Pesticides	Dose Units	100	0.001	580	108.95	Dose Units/L
Faecal Indicator Organisms (FIOs)	10^9 cfu	100	115.103	580	19.85	10^{15} cfu /L
Soil Carbon	t CO_2	100	141.742			
Energy Use	kg CO_2	100	1,462.933			
Production	£	100	2,055.015			

one or more mitigation methods, from a library of over 100 options. Model evaluation can be undertaken at farm level or upscaled to catchments, through aggregating individual model output for all farms in a catchment.

In this report, the testing of Farmscoper in the Derg case study focusses on pesticides, as it is the primary contaminant causing breaches of the Drinking Water Regulations limits in the catchment. Potential applications for nutrients and sediment, however are also of interest.

Key issues covered in an assessment of suitability/utility included:

1. Differences in pesticide usage between Ireland and England/Wales (for which the model was developed)

2. Geo-climatic differences between Ireland and England/Wales

3. Data requirements and data deficits

4. Mitigation measure options and costs

1. Differences in pesticide usage between Ireland and England/Wales

Pesticides are represented in Farmscoper as a % of typical plant protection products (PPP) used, based on pesticide surveys and mode of application. Output Table 25 is predicted as a dose unit per litre of whichever pesticides are used as standard on the specified crop type. For England and Wales the dosage of pesticides for a particular land use is based on the Pesticide Usage Surveys for GB (Garthwaite et al., 2005, 2006), which provide the average usage amounts of herbicide, fungicide etc. on different crop types.

Usage practice in Northern Ireland and Ireland differs from that in GB as a result of climate, soil types, crops grown and the advice delivered by pesticide companies and advisors. In NI for example, over 94% of land area is grass and in extensively farmed areas rough grassland is regularly treated, primarily with MCPA to kill rushes. Often MCPA is not applied for agronomic reasons but rather to ensure land remains eligible for the Single Farm payment. In the Farmscoper model rough grassland areas do not produce a loading of pesticides so adaptations will be necessary to represent this practice in NI.

Statistical reports on pesticides are available for NI (2016 for arable crops and 2017 for grasslands (https://www.afbini.gov.uk/articles/pesticide-usage-monitoring-reports)) and Ireland (2012 for arable crops and 2013 for grasslands (http://www.pcs.agriculture.gov.ie/sud/pesticidestatistics/)) and can be provided as kg/ha values for each crop type. However, access to the database component of Farmscoper is required (currently restricted) in order to identify what adaptations are necessary to account for "typical" Plant Protection Product (PPP) use on grassland crops (including rough grazing) in Ireland.

A query has recently been submitted to the developer (19/02/2019) and we are awaiting the response (as of 09/05/2019).

2. Geo-climatic differences between Ireland and England/Wales

Six climate zones (ranging from <500 to >1500 mm yr^{-1}) are defined in Farmscoper based upon the range of long-term average rainfall across England and Wales for 1961-1990. Annual average rainfall in NI over the 1971-2000 period ranged between 700 and 2200 mm, and was highest in the west where the case study catchment is located. The >1500 mm climate zone in Farmscoper is the most applicable option to represent the high rainfall in the case study catchment. However, in the model the annual rainfall value is then distributed into a monthly rainfall pattern which was originally set for England/Wales, and which differs in NI/RoI. This distribution was used when the background PSYCHIC model was run during development (Davison et al., 2008; Strömqvist et al., 2008) and, as such, cannot be adjusted. This has the potential to lead to over/under estimation of drainage flow compared to that observed.

An evaluation was undertaken using data from a monitored catchment in the east of NI, where an input rainfall range of 900-1200 mm generated a modelled drainage flow in Farmscoper (defined as combined runoff + preferential flow + groundwater recharge) of 580 mm yr^{-1}. This drainage flow estimate was verified against local monitoring data on rainfall and evapotranspiration. Rainfall for the 2015 and 2016 hydrologic years (Oct-Sept) at a representative location in the study catchment was 1138 and 1225 mm yr^{-1}, respectively. Evapotranspiration is estimated at ~ 44% for this area which indicates that a runoff of ~662±25 mm yr^{-1} (14% higher than modelled) is more accurate for the catchment. Future application of the model, particularly if it is to be used by non-specialists, would require modifications to account for these differences through adjusting flow partitioning within the model. A specialist could apply a manual correction to the model output values to allow for the differences in the interim.

In the landscape, soil type and geology are the principal controls on determining the pathways of effective rainfall over the ground surface or at depth within shallow sub-surface or deeper groundwater flow. In Farmscoper these combined characteristics are represented by three defined soil drainage classes, according to the probability of having artificial sub-surface drainage under different crop types. These include:

1. Free draining soils that do not require sub-surface drainage
2. Slowly permeable soils that require sub-surface drainage for arable crops
3. Slowly permeable soils that require sub-surface drainage for both arable crops and grassland.

For each type, contaminant apportionment among pathways is based on pre-calculated values derived for English and Welsh soil types and the 6 climate zones from NEAP-N for nitrate (Anthony et al., 1996) and PSYCHIC (Davison et al., 2008, Strömqvist et al., 2008) for phosphorus and sediment; MACRO Tool (Jarvis, 1995) and SWAT for pesticides. Thus there

is no option for the user to modify the model for areas which are outside of the categories for which the model was originally developed.

Partitioning of drainage flow (which is defined in Farmscoper as the sum of runoff + preferential flow + groundwater recharge) between runoff and infiltration (preferential flow + groundwater recharge) in the model is an area requiring further evaluation. Farmscoper runoff estimates are lower than would be expected in NI catchments. For monitored field-scale plots on the AFBI CENIT site (Cassidy et al., 2017, Doody et al., 2010, Watson et al., 2007) annual runoff (as overland flow) can account for 40% of the total effective rainfall. This is primarily due to the steep slopes and clay-rich impermeable soils which typify the glacial depositional landscapes that dominate ~43% of the NI landscape. Before Farmscoper can be used for real management scenario analysis in an Irish context, this issue needs to be examined further. For pesticides this may require MACRO and SWAT to be re-run for some scenarios, in collaboration with the model developer.

3. Data requirements or data deficits

In addition to the representation of geo-climatic factors within the model the availability and accuracy of on-farm data is crucial, and pose the greatest limitation to practical use of the model for pesticides in the Derg case study catchment.

Farm level data required to populate the “CREATE” Farm spreadsheet in the model are not freely available for NI or RoI. All farm data submitted to the departments of agriculture (DAERA in NI and DAFM in RoI) are confidential and cannot be used without consent. Census data for an area or by farm type can be accessed but still requires an agreement with the agriculture departments. For electoral districts with fewer than 10 farms (RoI)/5 farms (NI) this data is not available, affecting use in extensively farmed areas similar to the headwater areas of the Derg case study catchment. These data do not routinely record pesticide usage so it would be less applicable than for nutrients, which are recorded on farm as part of the Nitrates Action Programme and Phosphorus Regulations.

Individual farm data can therefore only be acquired by visits to farmers and on-site survey which would require significant investment in staff time. To correctly represent pesticide use in the Derg catchment it would be necessary to survey farmers and supply them with a table of “typical” pesticide use for their crop types and for them to express how their actual use compares.

4. Mitigation measure options and costs

Farmscoper’s evaluation of the costs and environmental benefits of each selected mitigation measure (examples of those relating to pesticides are shown in Table 26) uses options provided in English and Welsh agricultural schemes and costs correct at the time of development (Figure 22). The mitigation options for pesticides would be generally applicable to NI but costs will need to be updated to reflect inflation and differences in pricing structures between Britain and NI. The Source to Tap project that is currently being carried out in the Derg catchment is collecting data on the costs of implementing mitigation measures for MCPA. Following the completion of the Source To Tap project in 2021 data may be available to inform the modification of this component of the model. It may also be possible to add additional mitigation options to the list, such as weed wiping or lime applications to inhibit weed growth.

Table 26: Mitigation measures (8 out of a total of 105 options) which are specifically targeted at pesticide use (PPP) in Farmscoper Evaluate module.

Mitigation measures (from 105 options listed)
Calibration of sprayer
Fill/Mix/Clean sprayer in field
Avoid PPP application at high risk timings
Drift reduction methods
PPP substitution
Construct bunded impermeable PPP filling/mixing/cleaning area
Treatment of PPP washings through disposal, activated carbon or biobeds
Leave residual levels of non-aggressive weeds in crops

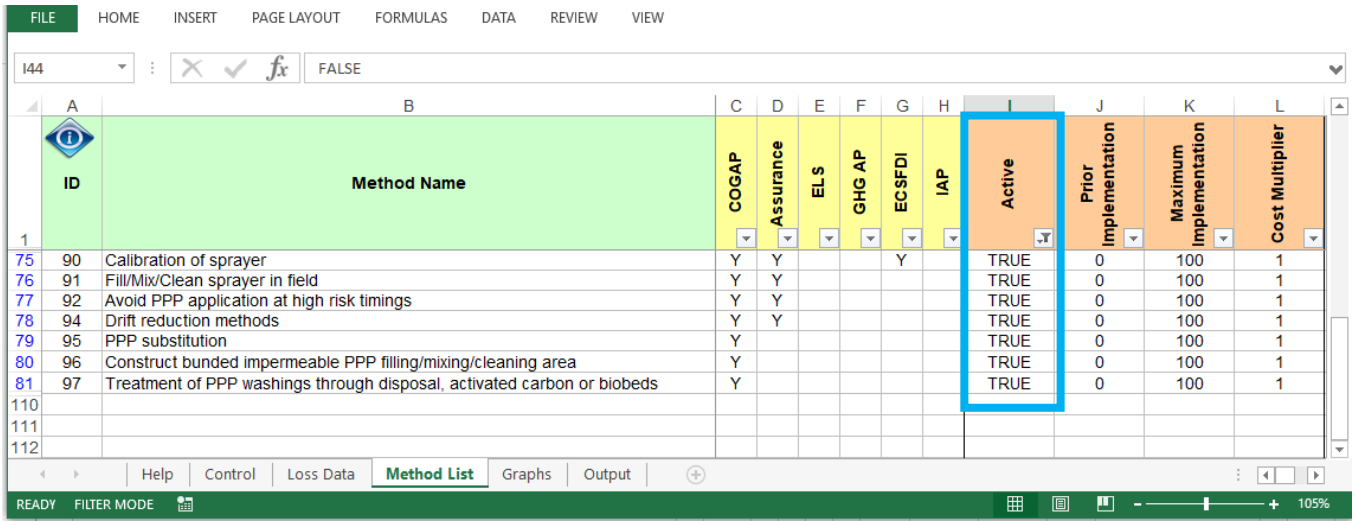


Figure 22: The EVALUATE worksheet in Farmscoper showing mitigation measures relating to reducing pesticide usage. To include a measure in the evaluation of impact and costs the ACTIVE tab (Blue box) for each measure is set to TRUE.

Phytopixal

Phytopixal is a GIS protocol proposed by Macary et al. (2014) to evaluate the risk of diffuse pesticide contamination of the rivers located in the Corteaux de Gascogne region of south-west France. The protocol is used to generate a spatial risk assessment for pesticides based on a number of physical characteristics such as *inter alia* slope, land use and proximity to waterbodies. Slope was derived from a 5 m high resolution digital terrain model (DTM), whilst land use was taken from the CORINE (2012) dataset and the location of waterbodies was taken from the OSNI and OSi mapping databases. Proximity to the waterbody was classified into three risk level (< 30m, 30m - 100m and > 100m) based on the straight-line distance between pixel and waterbodies. These distances were chosen as a first assessment of the impact of distance on the likelihood of fast flow reaching the waterbody. An in-depth analysis of the catchment would require an evaluation of local characteristics. Soil maps were drawn from the Irish National 1:250,000 Soil Map (Irish Soil Information System, 2015) and the General Soil Map of Northern Ireland map (AFBI, 2009), which were merged, and the Standard Percentage Runoff (SPR) (the proportion of rainfall that contributes to the increase in surface runoff) for each soil type in Northern Ireland was adopted. Expert knowledge was used to determine appropriate SPR values for soils in the RoI. All data not presented as a raster dataset was converted to a raster grid by overlaying the non-raster dataset with an empty raster grid that had the same dimensions as that of the

DTM. The value to be used in each cell in the blank raster was taken as the most common value in the underlying layer.

A risk profile was developed for each catchment characteristic (Slope, land use, proximity to a waterbody and SPR) through use of expert opinion and the scientific literature. Slope angle was divided into 5 classes based on the Natural Breaks (Jenks) technique (the “Goodness of variance fit”). This technique seeks to group data in such a way that variance in values within a class is minimised, whilst the variance between classes is maximised (Seamon et al., 2013, ESRI, 2016). Land use risk was determined through calculation of the mass of MCPA added to each land use identified in the catchment, based on the national trends reported in the Pesticide Usage surveys for Northern Ireland 2016 (arable) and 2017 (grassland) (Lavery et al., 2017, Lavery et al., 2016).

The weightings used for each parameter are shown in Table 27 and their distribution across the catchment are shown in Figure 23.

Table 27. Risk category bandings for all input data. Higher values pose greater risk.

Slope angles	Risk category
< 3% (1.72°)	1
3 – 7% (1.72° – 4°)	2
7 – 12% (4° – 6.84°)	3
12 – 25% (6.84° – 14.04°)	4
> 25% (> 14.04°)	5

Buffer distance	
Distance from waterbody	Risk category
> 100m	1
30 – 100m	2
< 30m	3

Soil type	
Standard Percentage Runoff values (% of rainfall)	Risk category
< 2	1
2 – 29.2	2
29.21 – 39.70	3
39.71 – 48.40	4
> 48.40	4

Land use	
Land use	Risk category
Coniferous woods	1
Moors and heathland	1
Sparsely vegetated	1
Transitional woodland/scrubland	1
Unexploited bog	1
Discontinuous urban fabric	2
Natural grassland	2
Complex cultivation patterns	3
Good pasture	3
Mixed Agriculture/natural	3
Mixed pasture	3
Non-irrigated arable land	3
Poor pasture	3

Figure 23 (A) shows that, whilst there are steeper slopes distributed across the catchment, there is a higher concentration of these slopes in the headwaters of the catchment. Figure 23 (B) indicates that higher risk soil categories are distributed across the catchment, but particularly in the west and in the headwaters of the catchment. Figure 23 (C) demonstrates the extensive network of streams and waterbodies across the catchment to which buffer zones of < 30m, 30m – 100m and >100m have been applied. These equate to areas of high risk for contamination of water body, moderate risk and low risk respectively. Figure 23 (D) illustrates the distribution of land use across the catchment. This data suggests that the highest risk activities are located in the centre and the east of the catchment, in the lowland areas of the catchment. There are also some moderate risk land uses at the very top of the catchment.

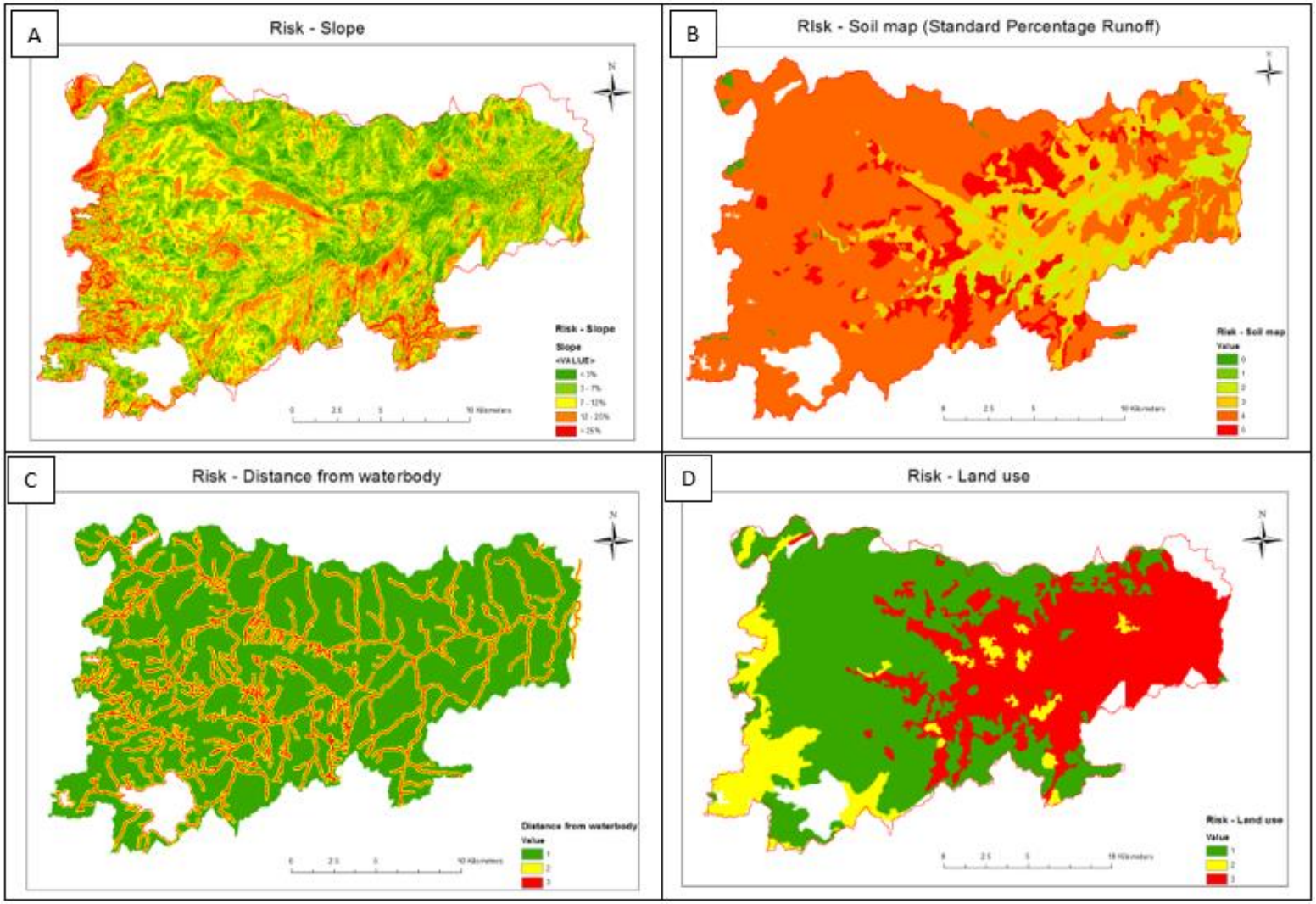


Figure 23: The risk weightings associated with each of the three physical catchment characteristics and land use once weightings have been applied in Phytopixal. Images A, B and C show the risk categories used for slope, soil type and distance of a point from a waterbody respectively and D shows the risk categories assigned to individual land uses. Blank areas within the catchment outline represent either a lack of data or the presence of waterbodies.

The risk assessment calculation was carried out according to Eq. 1 for each cell within the raster grid and the results are shown in Figure 24.

$$Risk = (S + B + So) * L \qquad \text{Eq. 1}$$

Where

S is Slope risk

B is Buffer zone risk

So is Soil association risk

L is Land use risk

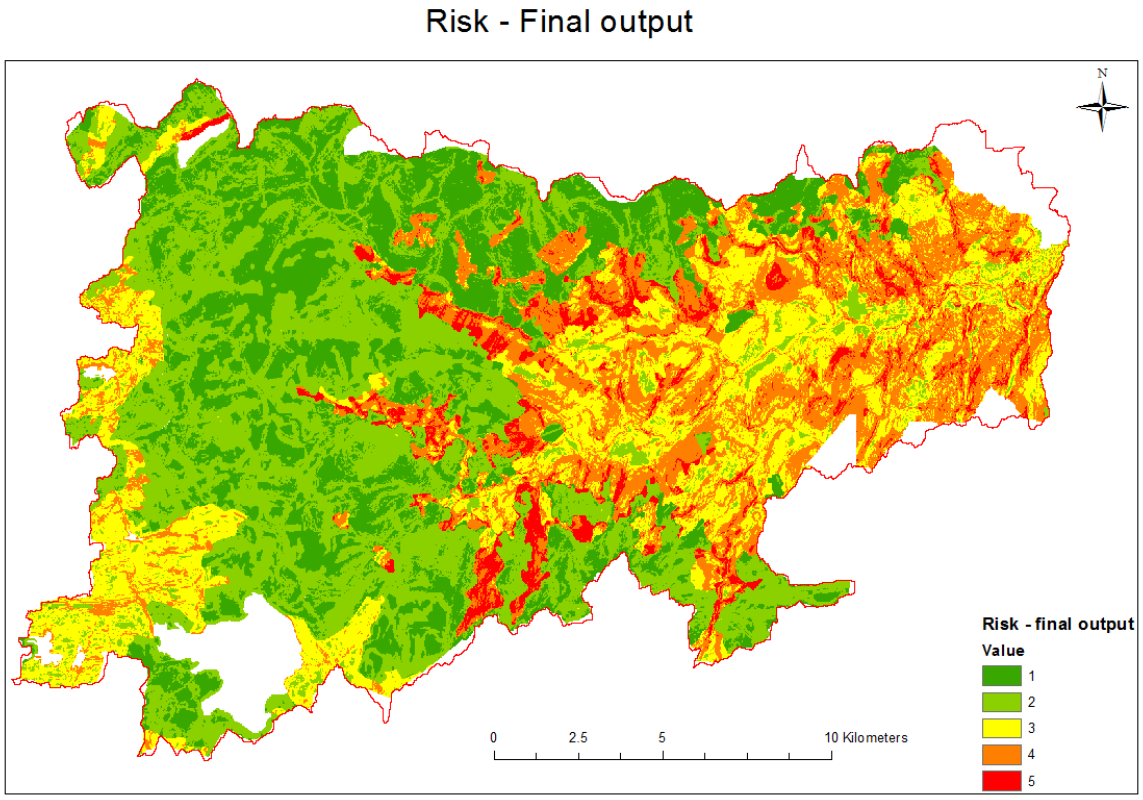


Figure 24: The final risk category assigned to each pixel in the Derg catchment is shown. There is a considerably greater risk of pesticide contamination of water in the east of the catchment and, further west, along the main water courses.

The areas of highest risk (categories 4 and 5) are predominantly located in the east of the catchment, particularly close to the larger watercourses. Although urban areas were given a relatively high risk weighting in land use because of the low levels of domestic user training associated with garden centre bought herbicides, the area around Castlederg (the largest urban area in the catchment) still returned a moderate risk value indicating that agricultural use is of greater significance. The importance of land use in this protocol can also be seen in the west of the catchment where there are areas of intermediate to high risk (3 – 5) identified.

The presentation of the data may also be altered to better suit the target audience, as is illustrated in Figure 25 (A) and (B). Figure 25 (A) shows the Derg catchment divided into 10 sub-catchments according to the location of a spatial grab sampling regime carried out in the catchment in 2018. The risk of pesticide contamination in each sub-catchment is calculated according to Eq. 2

and the resulting cumulative weighting values may then be ranked. In this case the results suggest that the most-downstream sub-catchments are the most risky with respect to MCPA contamination of water and that the central sub-catchments are at moderate risk.

$$Risk\ (sub-catchment)\ = \frac{\sum r}{A} \qquad \text{Eq. 2}$$

where

r is the risk value for each cell within the sub-catchment

A is the area of the sub-catchment

Figure 25 (B) shows the impact of re-sampling the original data to a cell of 250 000 m^2, using Eq. 3.

$$Risk\ (500m\ cell) = \frac{\sum r}{a} \qquad \text{Eq. 3}$$

where

r is the risk value of the 5m cells within the new 500m raster

a is the area of the 500m raster cell

Figure 25 (B) retains a slightly more spatially explicit presentation of the data in that the importance of land use remains visible in the central area of the catchment, but the fine detail is smoothed out in favour of a broad-brush presentation of the data.

A higher resolution map of land use in the NI section of the catchment was developed, based on a visual analysis of 2015/16 aerial Imagery (Figure 25 (C)) that allowed the assignment of land use to individual fields. The categories of land use and their associated risk class are shown in Table 28. The risk analysis in Eq. 1 was then repeated in order to determine if the increased resolution of land use data would significantly alter the final output (Figure 25 (D)).

Whilst the overall pattern of risk is unchanged by the adoption of higher resolution data, it is clear that this approach can identify smaller areas of land that pose a threat and so facilitate the more focussed selection of targets for the deployment of mitigation strategies.

Table 28. Land use classifications and associated risk classes used for the high resolution land classification process.

Description	Risk
Bog/Reedbed/Ineligible Rush	1
Forestry/Woodland	1
Not in Agricultural Use	1
Scrub >50%	1
Extensive grassland - Shrubs 0-5%	2
Extensive grassland - Shrubs 21-50%	2
Extensive grassland - Shrubs 6-20%	2
Rough Grazing	3
Rough grazing - Rush - 0-5% Ineligible	3
Rough grazing - Rush - 21-50% Ineligible	3
Rough grazing - Rush - 6-20% Ineligible	3
Grassland	4
Arable Land	5

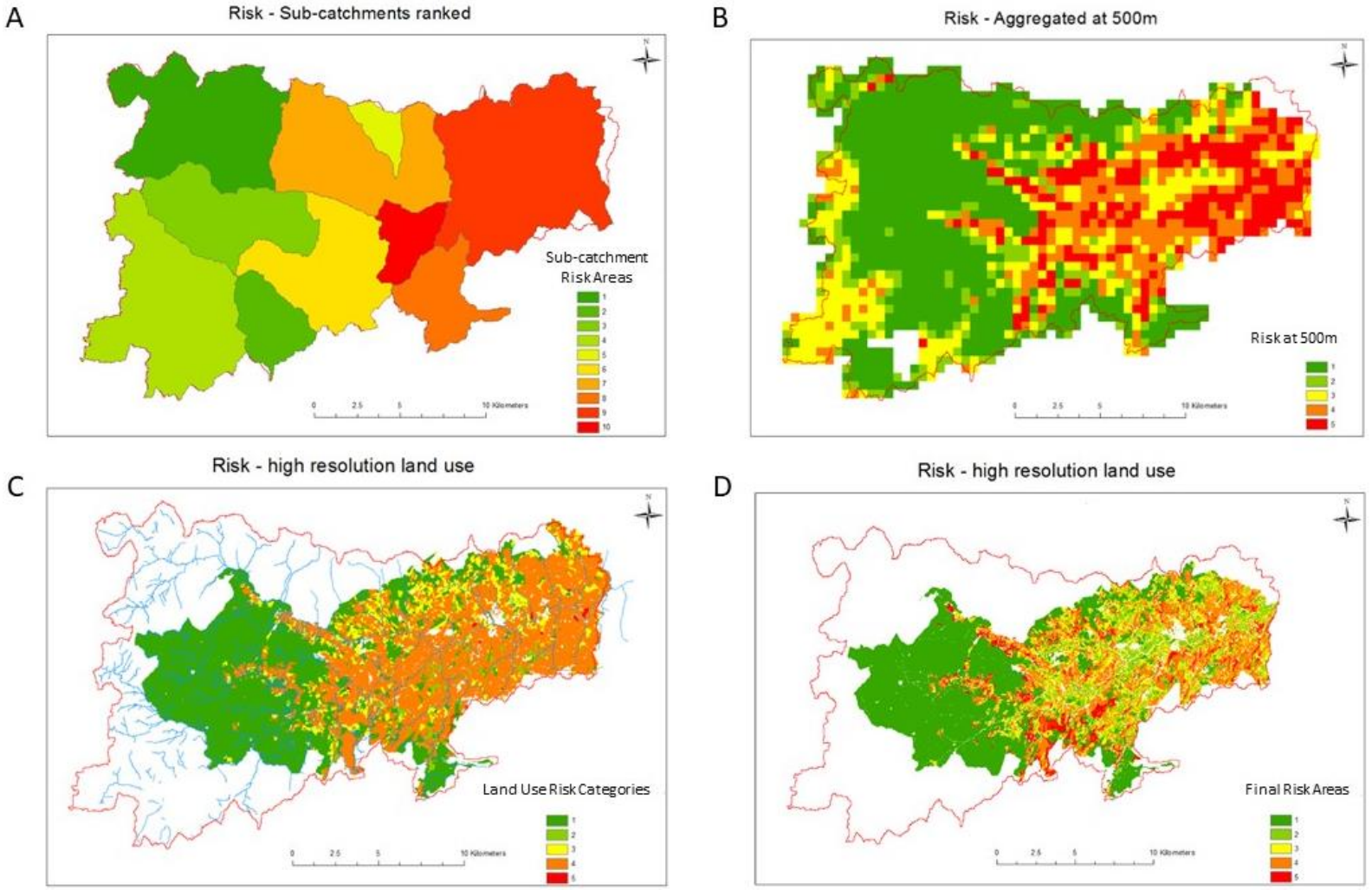


Figure 25: (A) *The Derg catchment has been sub-divided into 10 sub-catchments based on the location of spot-flow sampling locations across the area. The risk value of each 5m cell within each sub-catchment was summed and then divided by the area of the sub-catchment. The total for each sub-catchment was then ranked with the smallest risk value being awarded rank 1. (B) The risk map may also be presented at a lower spatial resolution than that used in Figure 24. In this case a raster cell size of 250 000 m^2 was chosen, but any cell size may be used that is appropriate for the catchment and the audience. (C) High resolution determination of land use using the same categories as outlined in Table 28. (D) The final risk output map based on the same data as outlined in Table 28, except for the high resolution land use shown in (C).*

SCIMAP

SCIMAP uses topographic data to model, for each point in a landscape, the probability of overland flow being generated and a pathway to the river network. With connectivity comes a risk that contaminants such as nutrients, sediment, pathogens or pesticides will be entrained and transferred.

Although SCIMAP was originally developed as an open source desktop application for non-commercial use under a Creative Commons license, development effort has now moved to an online format (http://www.scimap.org.uk/, Figure 26) which is not available for catchments outside Great Britain. The older GIS-packaged software remains available and it was this version of SCIMAP that was used in this analysis.

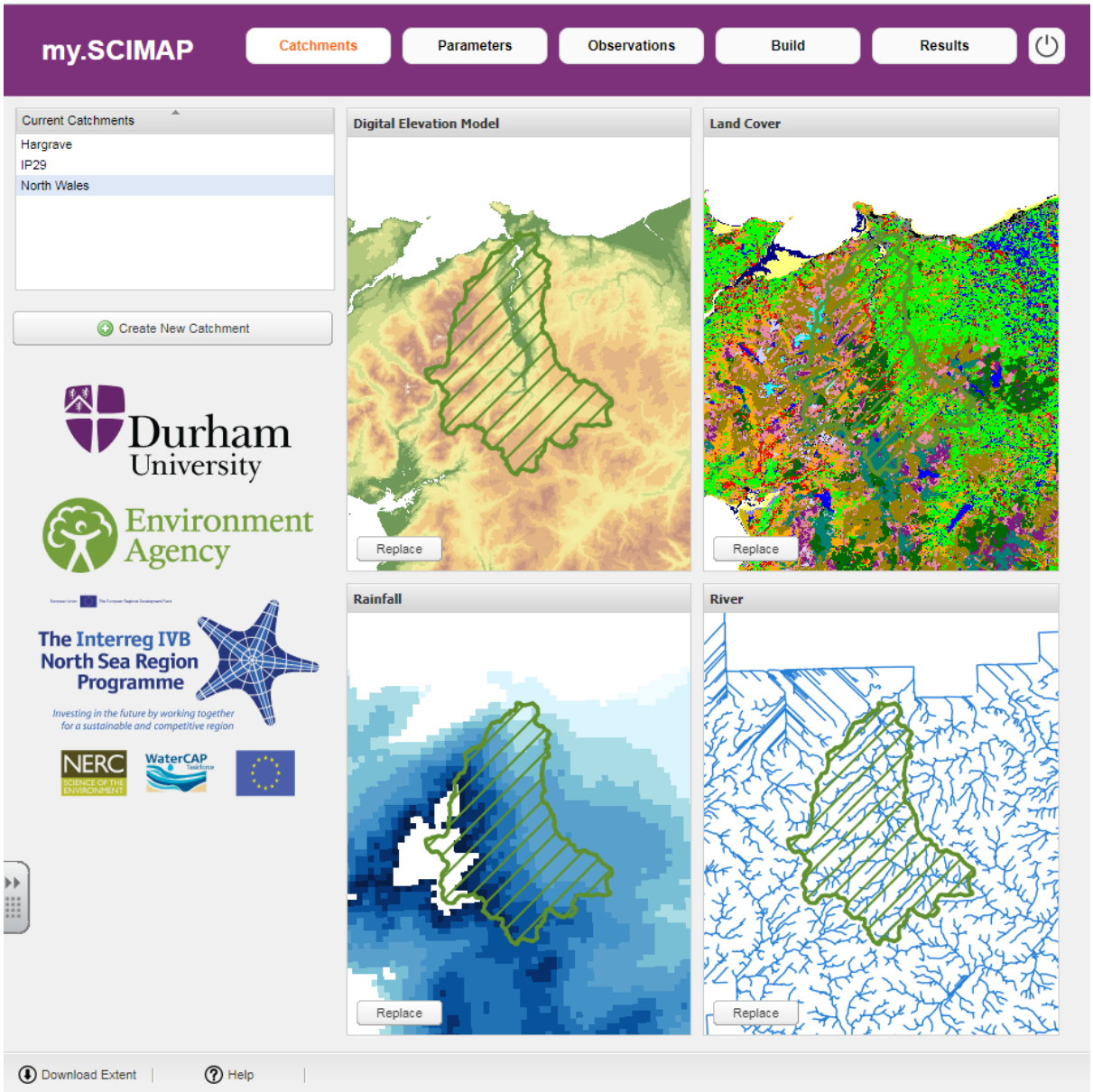


Figure 26: The SCIMAP online portal showing set-up for a catchment in Wales, UK, for which online datasets are available.

The basic data requirement of the approach is a DTM to which other data sets such as the digitised drainage network (used to hydrologically correct the DTM to remove bridges etc.), land use and rainfall for the area of interest are added.

For the Derg catchment, hydrological connectivity (based on the Topographic Wetness index (TWI) (Beven and Kirkby (1979)) was calculated using a 5m DTM (Figure 27.A) that was hydrologically corrected by 'burning' the drainage network (Figure 27.D) into the elevation model to remove bridges and other obstacles to downslope movement of water in the model. The TWI was then calculated based on the slope and flow accumulation from upslope areas to every point in the raster grid (Figure 28 – for clarity only the 10% highest risk areas are shown).

Land use data was drawn from the CORINE (2012) dataset (Figure 27.B). Average rainfall values were taken from Met Eireann (Irish Meteorological Office) long term rainfall averages from 1981 – 2010 (Figure 27.C) and the location of waterbodies was taken from the OSNI and OSi mapping databases. Subsequently, this analysis was repeated with a higher resolution field-scale land use map defined from high resolution aerial imagery (Figure 27 (C)).

Topography is steepest in the headwaters of the catchment in the west and north (Figure 27 (A)) and becomes flatter as the river widens into the flood plain in the lower catchment. Figure 27 (B) illustrates the distribution of land use across the catchment, with risk categorisation for MCPA apportioned to each CORINE land class based on average pesticide applications rates calculated from the Northern Irish pesticide usage surveys (Lavery et al., 2017, Lavery et al., 2016). The highest risk activities, with respect to MCPA usage, are located in areas of poor soil and less intensive agriculture in the centre and west of the catchment, whilst lower risk activities are more common in the peatland and mountain areas in the uplands. Rainfall in the catchment is highest in the mountains in the west of the catchment (~2700 mm yr^{-1}) and approximately 50% lower in the east (Figure 27 (C)).

The model uses the information provided in Figure 27 (B) and Figure 27 (C) to weight the TWI and identify those parts of the catchment that are most likely to act as source of contamination with pesticides – i.e. where source and pathway intersect. An area with a high land use risk, coincident with high TWI poses a greater relative risk to water quality and would be a prioritised target for mitigation.

As previously discussed the CORINE (2012) dataset uses a resolution of 1 km and this is coarser than field scale at which management is undertaken in this part of the island - typical field sizes in Ireland are between 0.3 and 1 ha (Figure 25 (C)). The SCIMAP protocol was re-run with this higher resolution dataset available for the NI section of the catchment and the results (Figure 29) indicate that there are only very small, highly dispersed parts of the agricultural catchment that pose the greatest risk of contributing flow via surface pathways.

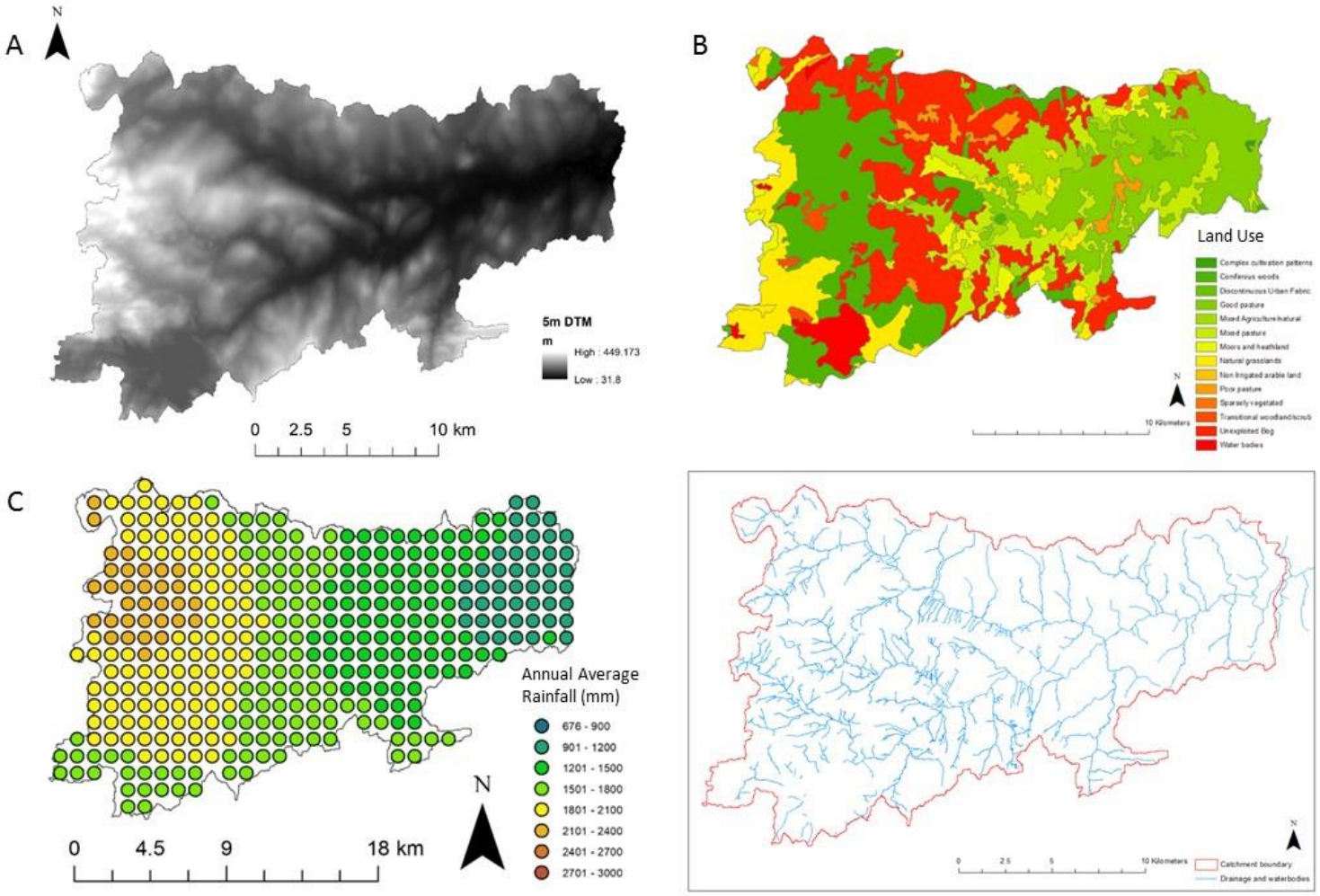


Figure 27: Input data used by SCIMAP. (A) DTM of the Derg catchment at 5m resolution. (B) CORINE (2012) land use classification map. (C) Rainfall rate represented as a spatial distribution, based on data gained from the Castlederg rain gauge (ID, Owner). (D) Surface flow pathways of water through the Derg catchment, based on data presented in the DTM in (A).

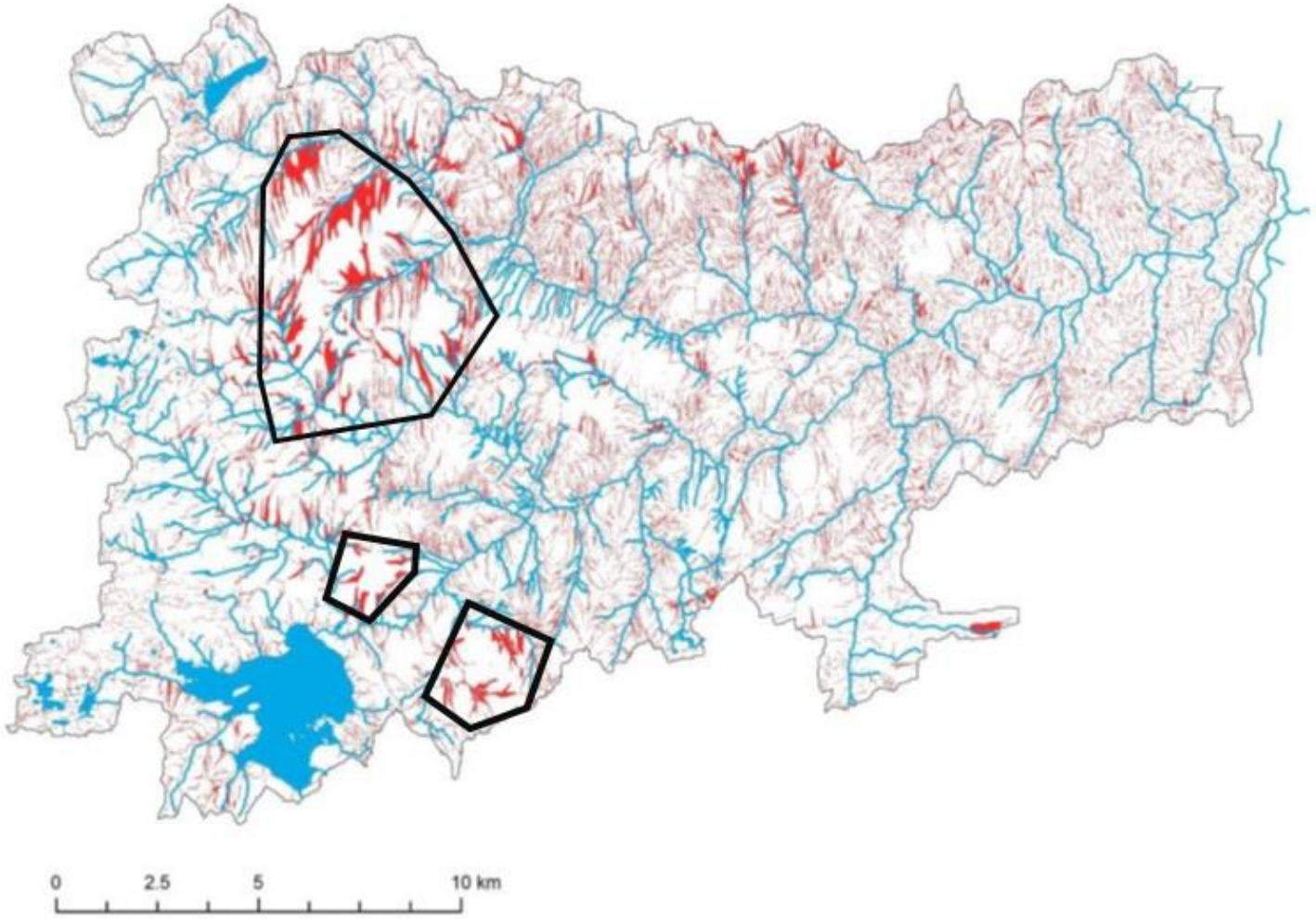


Figure 28: Topographic wetness index (TWI) for the Derg catchment restricted to show the 10% area with the highest risk indices. DTM resolution and accuracy is limited in the west of the catchment (black boxes) where dense coniferous forest stands precluded ground definition by the Satellite Aperture Radar used. In these area the topography is artificially smoothed and hydrological connectivity extends over unrealistically large areas.

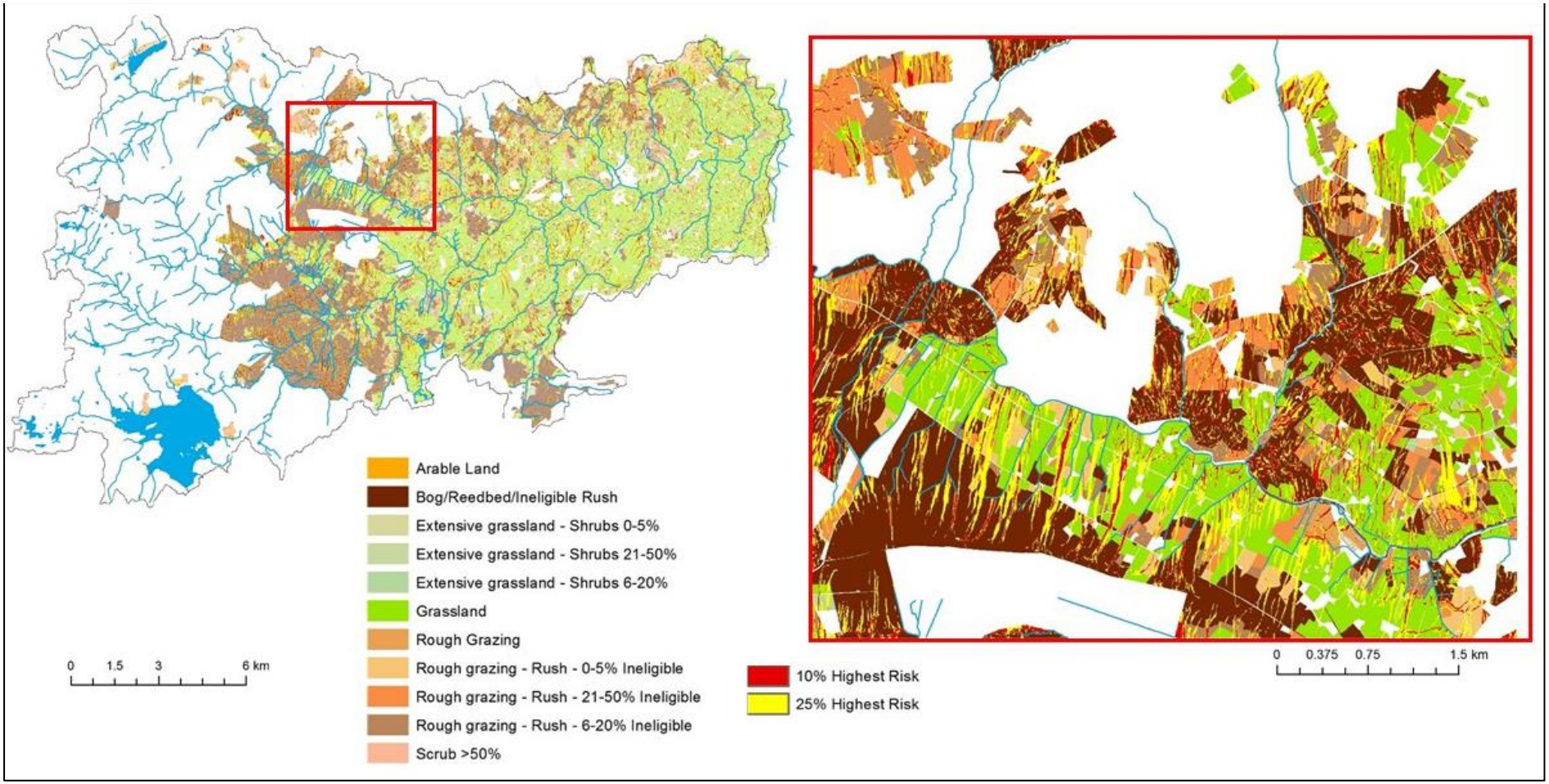


Figure 29: Agricultural land use at field scale with 10% and 25% highest TWI risk areas overlain, for the Derg catchment (left) and a sub-area (at right).

c. Implementation

Stakeholder assessment of the DSTs

A consultation was undertaken with representatives from water companies in NI, the Rivers Trust and catchment officers from the INTERREG VA “Source to Tap” project (http://www.sourcetotap.eu) who have daily interactions with farmers and local authorities and NGOs in the catchment.

Both the water companies and Rivers Trust are involved in catchment management across Ireland and are currently implementing a pilot Land Incentive Scheme (LIS) to address MCPA pesticides, colour and turbidity in the Derg case study catchment. Farmers receive financial support to implement a number of mitigation measures, with the expectation that the measures will serve to reduce exceedances of colour and pesticide limits in the raw drinking water supply from the catchment.

At the meeting, an overview of each of the DSTs were presented to the stakeholders and their opinions on the utility of the DST were discussed. The outputs of these discussion are synthesised with the results of testing undertaken in–house by AFBI.

Farmscoper

In practice, is the DST suitable for your case study area?
Farmscoper provides an advanced modelling approach to estimate diffuse losses of contaminants from single or multiple farms and farm systems up to catchment scale and quantifies the expected impacts and economic costs of mitigation on those losses to water and air. As such it is a potentially powerful tool to support water managers in prioritising the most effective mitigation options in drinking water catchments. In the consultation with stakeholders all expressed an interest in using the DST and requested that we obtain information on modifications necessary to make it applicable to NI/RoI.

If the DST proved useful, please outline the benefits delivered for your target application.
In the Derg catchment water companies must treat drinking water at abstraction to remove pesticides (involving an expensive filtration system). As the cost of water treatment increases as contamination increases water companies are considering providing incentives for farmers to improve pesticide practice and use alternatives. In managing a limited budget the water companies need to identify which target groups (e.g. farm types) and mitigation options will deliver the greatest impact on water quality. Farmscoper allows multiple scenarios of mitigation options to be trialed on different farm types and provides a quantitative output as to the costs and environmental impact of those options.

How did it compare to what was previously available in your case study area?
There are currently no similar DSTs available for this region. There is a gap for such a DST in this region, not just for pesticides but for all diffuse contaminants.

Any issues affecting DST utility in your case study area? What steps would be necessary to remove this obstacle to application?
Testing identified issues relating to climate, soil and land use practices which will need to be addressed if the model is to be applied in this region.

Key issues covered in an assessment of suitability/utility included:

1. Differences in pesticide usage between Ireland and England/Wales
   The database behind Farmscoper will need adaptation to the pesticide applications and usage statistics for NI/RoI. The database in Farmscoper is locked so the developer would have to be

involved in modifying this, and may require funding to do so. However, the practical element of making these changes would not be difficult and all data required are available in NI/RoI.

2. Geo-climatic differences between Ireland and England/Wales
   Climate, topography and soil type in the case study is markedly different from England and Wales where the model was developed. Ireland has, in general, higher runoff rates and monthly rainfall and evapotranspiration figures differ from England/Wales. Most of these coefficients are pre-calculated for Farmscoper and would require MACRO and SWAT to be re-run for some scenarios, in collaboration with the model developer.

3. Data requirements and data deficits
   Farm level data for pesticide use is not routinely collected in farm surveys and general farm data is not freely available in NI or RoI. Negotiations with government departments (who hold such data) would be necessary to allow access for potential users, such as water companies. However, farm census data for various farm types could be used, although the pesticide usage component of such data is limited.

4. Mitigation measure options and costs
   The mitigation options and costs for the case study area need updating to account for local pricing structures and to allow for the effects of inflation since the model was developed. In addition a number of alternative mitigation measures that are being trialled by the water companies and NGOs could be included in the model options. This is relatively straightforward but would need the developer's permission and assistance.

Overall, to bring Farmscoper into use in the case study catchment, investment would be necessary to facilitate the developer (ADAS) to make the necessary adaptations. This is something the water companies would consider. We have requested but to date not received feedback from the developer.

Phytopixal and SCIMAP

As SCIMAP and Phytopixal are similar in approach their implementation is considered jointly.

In practice, is the DST suitable for your case study area?
SCIMP and Phytopixal are both GIS-based and so their applicability to an area is determined by the availability and quality of data the user inputs. Whilst this is a point that we return to later, in principle both Phytopixal and SCIMAP are suitable for implementation in NI/RoI.

If the DST proved useful, please outline the benefits delivered for your target application.
In both cases SCIMAP and Phytopixal allow for the visualization of risk across the area of interest, based on the spatial data provided. This means that it is possible to identify areas of the catchment that pose the greatest threat to water quality and thus targeted mitigation measures (both physical and educational). This approach also generates visual imagery which may be more readily accessible to a wider audience than tabulated data.

SCIMAP and Phytopixal also both offer approaches to modelling the catchment that require only basic GIS skills and catchment information. Phytopixal allows the user more latitude in selecting the input data and thus to optimise the output towards their contaminant of interest.

How did it compare to what was previously available in your case study area?
As GIS is a well-established technology Phytopixal and SCIMAP have not provided significant technological advance over previous approaches as the same GIS tools are used as would previously have been adopted by the analyst. The advantage of these approaches is, however that

SCIMAP and Phytopixal both provide a documented approach using standardized inputs and thus should ensure that results between studies are more easily compared.

Any issues affecting DST utility in your case study area? What steps would be necessary to remove this obstacle to application?

1. Applicability to the Irish landscape

Spatial risk mapping for nutrients and sediment risk in overland flow has been modelled and tested extensively in an Irish context (e.g. Thomas et al., 2016a, Thomas et al., 2016b, Thompson et al., 2013) so both approaches would be easily adapted to the case study area.

The models are both focussed on surface water/erosion potential and so neither is suitable for use in areas where groundwater contamination is a serious concern. However, these models may be helpful in all areas to identify regions of the landscape where surface water pools and so where the water may be potentially passing to groundwater.

In areas where surface water movement is important, both models may be used to differentiate areas by risk through the use of simple catchment parameters that are likely to be available at the start of a project. In the case of NI/RoI, the biggest challenges to model quality currently is the quality of input data. Satellite derived elevation models tend to be less accurate and at a lower resolution than LiDAR datasets, but are cheaper to generate. No national LiDAR datasets are available in NI or RoI, unlike other EU States.

The author of SCIMAP have confirmed that, whilst the online version of the software is the focus of their development efforts, this will only cover Great Britain (England, Scotland and Wales). The previous version of SCIMAP that was bundled with SAGAGIS remains available, but will no longer be supported. Going forward this may impact on the applicability of this approach to the NI/ROI area.

3. Data quality

During this exercise the modellers noted that the quality of the DTM was not the same across all parts of the Derg (Figure 28). In the upland areas utilised for forestry, it was noted that the topography was presented as being very flat, whilst similar, but unforested parts of the catchment were more rugged. This is an artefact of DTM preparation that will adversely impact on the quality of slope angle calculations.

The fact that the Derg is a cross-border catchment also posed problems during the analysis as the Northern Ireland and Republic of Ireland datasets do not always record the same parameters and obtaining the data can incur considerable costs.

Interest around Phytopixal and SCIMAP was focussed on the potential of these approaches to simulate risk in a catchment using already available data, and thus before projects undertook extensive fieldwork campaigns to gather very high resolution data. Stakeholders did raise concerns, however, about the vulnerability of both approaches to low quality data currently available and the time and cost that would be associated with developing higher quality data. Of particular concern was land use as the CORINE dataset does not represent Irish land use patterns well (Cawkwell et al., 2017).

Will you be able to implement the DST in practise? Or elements of it? Which elements?

Overall this investigation has shown that both Phytopixal and SCIMAP are suitable for implementation in NI/RoI and that the results are useful in developing an increased understanding of the threat of diffuse pesticide pollution. However, currently their utility is significantly limited, by the quality of the available data.

It has also been shown that both models are appropriate for use at a variety of scales as the output is spatially explicit and can be managed to suit the audience. It was noted that if the methodology used to divide the calculated risk value into risk categories was altered to percentiles (e.g. the top 20% of risk values assigned to risk category 5, the next 20% of risk values to 4, and so on) and if the same risk profiles were used, then comparison of results between sites would be possible. However, these approaches use subjective assessment of risk, rather than observed data and so will always be advisory in nature.

Whilst SCIMAP makes explicit mention of pesticides, the user does have the opportunity to award different risk weightings to individual land uses if required which allows for expert knowledge to be used to increase the impact of high risk land uses. This is essentially analogous to the way in which land use risk is managed in Phytopixal.

Overview of the advantages and disadvantages of the protocols explored during this exercise

The advantages and disadvantages of Farmscoper, Phytopixal and SCIMAP are summarized in Table 29, Table 30 and Table 31 respectively.

Table 29. Advantages and disadvantages of Farmscoper in an Irish context.

Farmscoper	
Advantages	**Disadvantages**
The capability to evaluate cost-benefits of combinations of mitigation measures is a potentially powerful tool to support water managers in drinking water catchments	Greater emphasis on nutrients than pesticides, which is the case study issue. Pesticide usage is simplified and based on UK statistics – different from NI/RoI.
User-friendly Excel-based interface. Outputs as clear graphics and tables.	Climatic and soil components of the model are based on England/Wales. RoI/NI are different (e.g. higher runoff rates) so adaptation necessary for further use.
Functionality from single farm to catchment scales.	Farm level data availability is limited in NI/RoI due to farm confidentiality.
Strong scientific basis to the model export coefficient approach	Mitigation measures and costs need to be updated for NI/RoI

Table 30. Advantages and disadvantages of Phytopixal in an Irish context.

Phytopixal	
Advantages	**Disadvantages**
Input data (quality and parameter) selected by user.	Land use data is of low resolution in NI/ROI – time intensive to improve
Spatial presentation of results	Soil classification map is of low resolution in NI/ROI.
Results can be re-sampled for lower resolution data presentation	Digital Terrain Models are of lower resolution in NI/ROI
Data needed is likely to be available at the start of the project	Protocol, rather than a GUI so knowledge of GIS required

Table 31. Advantages and disadvantages of SCIMAP in an Irish context.

SCIMAP	
Advantages	**Disadvantages**
Input data quality selected by user	Land use data is of low resolution in NI/ROI – time intensive to improve
Spatial presentation of results	Soil classification map is of low resolution in NI/ROI
Data needed is likely to be available at the start of the project	Digital Terrain Models are of lower resolution in NI/ROI
Desktop version bundled with SAGA GIS (Freeware)	No explicit mention of pesticides - Expert knowledge needed
	Web version not currently available outside Great Britain

5.6 THE NETHERLANDS – OVERIJSSEL

The FAIRWAY case study site at Overijssel deals with nitrate leaching to groundwater and how dairy farmers within the capture zone of vulnerable drinking water resources can improve their mineral management with less N-losses to the soil.

This case (project) covers five regions in the Provence of Overijssel (Eastern sandy soil in the Netherlands): Archemerberg, Hoge Hexel, Wierden en Herikerberg/Goor, with 16 participating dairy farmers. The drinking water wells were indicated susceptible to agricultural pollution due to the hydrogeological situation (deep draining, sandy soils) and due to land use (dairy farming and arable farming). Each of the five abstractions use groundwater. The soils are characterized by a shallow anthropogenic layer with an organic matter content of 3-5% overlaying a deep layer of yellow sand, very low in soil organic matter.

The main focus in the case is on the reduction of nitrate leaching from concentrations in the upper metre of groundwater in the range of 80-100 mg/l to lower than 50 mg/l. Measures are implemented at 16 farms. The effectiveness of measures are evaluated on the basis of the N surplus on the soil balance (kg/ha), the mineral N content in the upper soil layers in autumn and monitoring of nitrate concentrations in the upper meter of groundwater. Measures that are considered most relevant are: improving the grazing strategy, preventing grazing in autumn, undersow of Italian Ryegrass in maize, improving soil quality and optimizing fertilization and spreading of manure.

The relevant stakeholders are: Province of Overijssel, Vitens (water abstraction company), Dairy farmers participating in the project, Contractors that carry out a part of the practical work on farms, EU and national government. These are the basis of the awareness that more strict legislation may follow if the problem with elevated nitrate concentration is not solved. Farm advisors that visit the farm also feed suppliers.

5.6.1 Workplan

For Task 5.2, WUR tested and evaluated the German software Düngeplanung 1.6. The workplan for application of Düngeplanung in the FAIRWAY case Overijssel is summarized below:

This assessment and tests were conducted by researchers involved in the case and discussed with farm advisors and with stakeholders that are also the founders of the project Overijssel (Table 32). We were interested in exploring the applicability of Düngeplanung because in the case of Overijssel optimized distribution of organic and mineral fertilizers over crops and fields are of significant importance for preserving ground water quality in dairy farming regions. Moreover we feel that in the Netherlands knowledge valorisation on optimized fertilization could be improved. We discussed the assessment with professionals in Germany that developed Düngeplanung and apply it in their region. We tested application of Düngeplanung on the experimental farm De Marke and on one commercial farm in the region. This process was reported and discussed with the farmer.

Table 32. Workplan for the FAIRWAY case study Overijssel, The Netherlands.

Action	Action Details	Involved
Define expected value	The needs of the case were confronted with the DSTs offered for exchange and the expectations of the selected DST were defined.	WUR
Access to software	Download and install Düngeplanung	WUR/LWK Niedersachsen
Develop user skills	Learn to work with the software	WUR/LWK Niedersachsen
First Assessment based on simple dataset	Conduct a first assessment of in- and output based on a simple dataset	WUR
Evaluating differences with current tools and systems	The fundamental and practical differences between Düngeplanung and the Dutch fertilizer recommendations and the PerceelsVerdeler (Dutch DST) developed for dairy farming were analyzed.	WUR/LWK Niedersachsen/Farm advisors involved in case Overijssel
Assess potential for implementation	The characteristics of the tool were discussed with key stakeholders. The potential of short implementation on the short term in Overijssel was discussed. The potential of further exchange beyond the case Overijssel was discussed with researchers on the field of crop science and in particularly those involved in the establishment of fertilization recommendations.	WUR/ Farm advisors involved in case Overijssel/Provence of Overijssel/Vitens/Experts on fertilizer recommendations
Reporting	Based on the outcomes of the stakeholder engagement and testing of the DSTs, the challenges and benefits of their future use will be reported on.	WUR

5.6.2 **Assessment, testing and implementation of selected DSTs.**

Düngeplanung

a. Assessment

Implementing the software and getting it running was time-consuming process in spite of accurate and effective assistance and guidance by the developers of the software in Germany. This was possibly caused by safety settings that were incorporated in the software. It also took some time before we developed the skills needed to work with Düngeplanung. Language problems could be overcome rather easily by the researchers involved, but this may not hold for practical implementation on farms. Another aspect is that the interface, although well organized, is quite comprehensive.

b. Testing

Data requirements and outputs

To operate Düngeplanung data the following should be supplied:

- Manager of the farm/address and location of the farm
- Fields on the farm including
    - Agricultural areal per field (ha)
    - Crops and precrop per field (species)
    - Soil data including soil type, organic matter content, pH and P, K, Mg status
    - Nutrients or nutrient carrier applied, including composition

Some data are not used in the Netherlands, e.g. indicators for P status deviate from the parameters used in the Netherlands. The indicators that are commonly used in the Netherlands could possibly be converted to the indicators used as input in Düngeplanung. However, checks are required on the consequences of such conversions. The categories used to indicate soil type are also used in the Netherlands, e.g. lehmiger sand corresponds to lemig zand. However, before implementation further analyses is required to check whether or not the classification is based on the same criteria in terms of composition of texture classes.

Data input is user-friendly. There are options to import data from data systems that are available for German users. These, of course, do not match with the data systems that are used in the Netherlands. Default settings can be used, but these can be specified if desired.

The Düngeplanung produces a practical fertilization plan, expressed in kg total material applied per ha, ready to use for who carries out the Fertilization. Moreover, it produces information on N and P balances of the crop production per field. If a user allocated fertilizers to fields and crops, a report can be printed that shows how much of a fertilizer type will be distributed according to the plan. This way the user can cross-check if the planned spreading of manure matches with the amount that is produced or bought. The same holds for mineral fertilizer.

Functionality within the Dutch context

A major characteristic of Düngeplanung is that it integrates the fertilizer requirements of fields defined on a farm into a fertilizer plan at farm level. It addresses:

- specific fields with their crop history and their soil characteristics
- a great variety of crop species
- The characteristics and chemical composition of organic materials functioning as carrier for specific nutrients
- Residual effects of organic fertilization applied in previous years

The added value is not so much in the total absence of these aspects in the Dutch recommendations but more in the integration of these recommendations with adequate accuracy and precision to specific farms and their fields. This can explained by a short description of the agricultural context.

Until the 1950’s most farms in the Netherlands where integrated meaning that farmers used their land as basis for crops, dairy and/or meat production. Farmers needed to be skilled in both animal management and crop management. However, since the 1950s agricultural production was

increasingly based on specialized arable production on the one hand and specialized dairy and meat production on the other hand. This trend resulted in disintegrated knowledge development and different cultures in the arable sector and the dairy production sector. In the dairy sector the major focus was on herd management at cost of a gradual decline of focus on soil and crop management. Management skills on crop production ceased over time and dairy farmers adopted relatively simple and robust approaches of crop production, based on only grassland and silage maize and with low appreciation of accurate planning of fertilization. As a consequence the accuracy and precision of Dutch fertilizer recommendations, with a scientific and empirical basis that is more or less similar to the German fertilizer recommendations, is not fully reflected in the daily practice of dairy farming.

Fertilizer recommendations are established for the relevant nutrients: N, P, K, S, Mg etcetera, whereas a large share of the nutrients are brought to the field in the form of organic carrier material such as farm slurry. To comply with fertilizer recommendations the variability in composition of those nutrients in farm slurry must be addressed. Moreover, the land use history, i.e. the crops cultivated in preceding years should be addressed as well as the soil characteristics and soil fertility. This farm specific information should be integrated to convert fertilizer recommendations into tailor made farm specific fertilizer plans. Many dairy farmers consider this conversion too complex and work according to tacit knowledge or simply use farm quota for N and P rates (i.e. the amount of N and P that can be applied within the legal application standards) as a basis for fertilization.

Also farm quotas for the use of N and P rates to farmland that came into force in 2006 affected practical farm management. These quotas limit both organic and mineral fertilizer N and P input rates to soil which urges intensive dairy farmers to export part of the manure produced by cattle from their farm as the animal production exceed the fertilizer N or P quotas. In fact these quota are crop specific application standards, but farmers are free to decide on the distribution over crops and fields on their farms. Since the implementation of the quotas farmers tend to tune their fertilizer application rates not to recommendations but to the allowed quotas for maize and grass without paying much attention to differences between fields in production capacity and expected yields, soil characteristics and land use in earlier years. This practice lacks precision which causes high risks of nitrate leaching. To improve this there is an urgent need for more accuracy in fertilization in dairy farming and the PerceelsVerdeler was developed to support this accuracy (Oenema et al., 2017).

The PerceelsVerdeler has some similarities to the Düngeplanung. However, the PerceelsVerdeler only addresses grass and maize. Therefore the PerceelsVerdeler falls short where other crops are integrated into crop rotations. In spite of the specialized character of arable production and dairy production crop rotation in which arable crops, e.g. potatoes, grains or beets are alternated with grassland occurs regularly where dairy farmers rent parts of their farmland to arable farmers. In addition, advantages of Düngeplanung are the wider range of nutrients addressed as compared to the PerceelsVerdeler (looking at only N, P, K), the more systematic and formal way to incorporate soil data and the easy way to build up sound records of crop history for specified fields on the farm.

The Düngeplanung does not address N fertilizer quotas but considers crop fertilizer N requirements as threshold for maximum N rates in the fertilizer plans. Rates of organic and mineral fertilizer N and P are limited in the Dutch regulation. On the basis of these limits (specified per crop) expressed in kg per ha and the areal of each crop on the farm a farm budget for N and P is established. This budget can be freely allocated to the crops and parcels of the farm. Thus farm fertilizer plans should respect the farm N quota, and when N quota are lower than the fertilizer recommendations, they should suggest an optimal distribution of the N and P quota. The PerceelsVerdeler uses the quota as a starting point to recommend optimal distribution. As far as we see, the Düngeplanung does not refer to quota set by regulation. In this respect Düngeplanung seems, similar to the approach in Dutch fertilizer recommendations. It is a rational approach for

distribution of N as long as farm N quota are not exceeded. But when recommended N rates exceed the level of farm N quota farmers need to know on which fields and on which crops they apply a discount to the N rates in order to be meet the farm N budgets. For these circumstances it would be helpful if Düngeplanung would address farm N quota based on regulation as the PerceelsVerdeler does. For P Düngeplanung tunes to equilibrium fertilization on fields with high soil P status. Therefore, for P the recommendations are well in agreement with P quota in the Netherlands that also are based on P equilibrium fertilization.

The current systems developed to support fertilizer plans for arable famers do address crop history but do not support evaluation of the cropping system in terms of the N and P surplus (kg/ha) on the soil balance, whereas Düngeplannung does. This functionality is relevant for the case Overijssel because in the nearby future the case will be elaborated to arable farmers in drinking water abstractions. In the evaluation of the environmental pressure caused by arable farming the N surplus is one of the relevant indicators.

The assessment of Düngeplanung for Dutch circumstances are summarized in Table 33.

Table 33. Advantages and disadvantages of the use of Düngeplannung as a basis for fertilizer plans.

Advantages	Disadvantages
User-friendly interface, systematic and consistent design	Comprehensive data input needed
All relevant crop species are incorporated	Conversion of some parameters e.g. P status needed
Integration of relevant farm data on fields, soil fertility, crops and crop history and organic nutrient carriers with their specific composition	N quota on farm level are not addressed
Production of a practical list for fertilziation	Check on recommendations or adaptation to Dutch recommendations needed
	Minor problems concerning software implementation and language need to be solved upon implementation

c. Implementation

Discussions with the project managers, farm advisors, researchers and farmers involved in the case Overijssel resulted in the conclusions that it is not recommended to implement Düngeplannung directly in the case Overijssel for the following reasons:

- Input data used in Düngeplanung are different from the parameters used in the Netherlands.
- Without additional tests and comparisons there is too much uncertainty about the applicability of the German fertilizer recommendations under Dutch circumstances.
- It is important to address the distribution of the N quota on a farm, also indicated as N budget, over the fields of the farm.
- It is important to benefit from data supplied by ANCA. This enables users to use farm specific default values concerning the availability of organic manure on the farm, grazing intensity, the chemical composition of organic manures and crop yields. This link is incorporated in the software of PerceelsVerdeler.

Instead it was suggested to organize a further exchange on the concept of Düngeplanung and the PerceelsVerdeler or Dutch fertilizer recommendations. This could result in a DST that has a higher practical impact and that could stimulate farmers to optimize the distribution of fertilizers over fields. This could be realised by adoption of strong functions of Düngeplanung in Dutch systems and vice versa and could result in mutual gains for the stakeholders involved (science, drinking water company, National and regional governments).

5.7 THE NETHERLANDS – NOORD BRABANT

The FAIRWAY case study site at Noord Brabant is managed to reduce pesticide leaching to groundwater in the groundwater protection areas in the Noord Brabant province. An important tool to reduce leaching is the Environmental Yardstick for pesticides. This tool shows farmers and advisors the environmental impact of all permitted pesticides on specific receptors, including ground water. Farmers can take this information into account when choosing pesticides, and can compare the environmental impact between crops, farms and region. The Danish tool Plant Protection Online also holds information on this topic, which is why the tool was tested in the North Brabant case study.

5.7.1 Workplan

The workplan for the application of Plant Protection Online in the FAIRWAY case study site at Noord Brabant is summarized in Table 34.

Table 34. Workplan for the FAIRWAY case study site at Noord Brabant, The Netherlands.

Action	Action details	Target deadline	Involved partners
Overview of selected DSTs and data requirements	Describe expectations/expected outcome by DST. Use evaluation scheme 1 (See Appendix).	October 2018	CLM
Secure access and pre-test selected DSTs	Contact the owners of the DSTs and obtain access to DSTs. Pre-test the DST and ask for support if necessary.	November 2018	CLM
Testing of selected DSTs	Enter simulated situations. Discuss the results with owner	January 2019	CLM, SEGES
Describe and evaluate results	Evaluate results and compare with the Dutch pesticides and tools.	February 2019	CLM
Evaluate impact on practical management and implementation in a Dutch context	Discuss results with experts and practioners.	February 2019	CLM
Evaluate impact on practical management	Discuss results in workshop with partners	12 March 2019	CLM
Summarize successes and difficulties		April 2019	CLM

5.7.2 Assessment, testing and implementation of selected DSTs.

In the Netherlands, farmers are only allowed to use pesticides approved by the Dutch Board for the Authorization of Plant Protection Products and Biocides (CTGB). Based on information provided by

the pesticide producers and models, the CTGB determines the risk of leaching to groundwater (amongst other environmental effects specified in the European Uniform Principles).

In the following section, the pesticide advice for relevant crops was tested with the Danish tool Plant Protection Online. The results were discussed with field experts and compared to the Dutch Environmental Yardstick and the advice given in the case study site at North Brabant.

Plant Protection Online

a. Assessment

Plant Protection Online is a website with a number of tools, divided into weeds, pests and diseases. Some of the tools are available for all three, but most are only available for weeds. The most interesting tools for the North Brabant case were the following:

1. Problem solvers

The problem solvers are tools to determine possible pesticide mixtures, calculating their costs and pesticide (environmental) load. Pesticide mixtures are determined based on the crop species and weed, pest or disease species, taking into account the level of infection. The problem solver for weeds in the tool is by far the most extensive, with a good number of crops and weed species to choose from. To obtain results, the user must fill in the expected yield and growth stage of the crop, as well as the specific weed species and their growth stage and density (Figure 30). From this, the tool automatically calculates the 'need', or damage threshold.

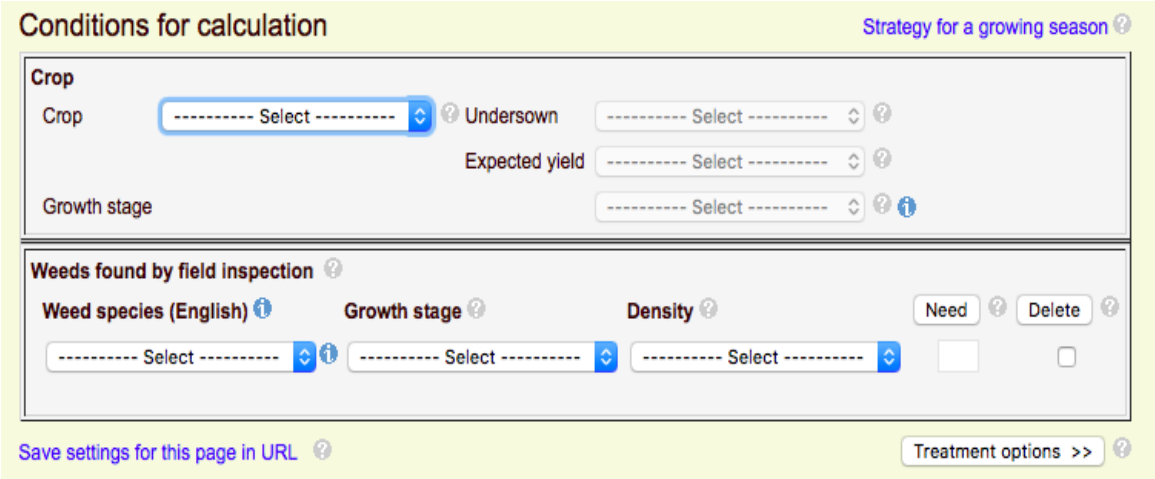


Figure 30. Conditions to fill in the weeds problem solver in Plant Protection Online.

By filling in the conditions, the user obtains a field report (Figure 31). This report shows the possible mixes of pesticides and their dosage, to achieve the desired weed suppression, or 'need'.

An interesting feature is the PL, or pesticide load. This value indicates the impact the pesticide with the specified dosage has on the environment. Also the costs per ha are interesting when choosing a specific mixture.

No.	Trade names	Dosage (unit/ha) Actual	Dosage (unit/ha) Normal	Cost DKK/ha	TFI	PL
1	Safari	10 g	10 g	74.0	0.11	0.055
	Goltix SC 700	0.65 l	1 l	185.3	0.22	0.299
	Betanal Power	0.11 l	0.6 l	20.9	0.05	0.019
	Renol	0.3 l		15.0		
	Totals			*295.2*	*0.38*	*0.373*
	Safari may be used with max 30 g/ha. Goltix SC 700 may be used with max 3,0 l/ha per year.					
2	Ethosan SC	0.019 l	0.07 l	4.5	0.02	0.014
	Herbasan	0.41 l	1.5 l	28.7	0.09	0.042
	Safari	10 g	10 g	74.0	0.11	0.055
	Goltix SC 700	0.65 l	1 l	185.3	0.22	0.299
	Renol	0.3 l		15.0		
	Totals			*307.4*	*0.44*	*0.410*
	Ethofumesat may be used only every 3rd year with max 71 g/ha (0,142 l/ha). Safari may be used with max 30 g/ha. Goltix SC 700 may be used with max 3,0 l/ha per year.					

Figure 31. Field report example of Plant Protection Online.

The problem solvers for pests and diseases provide a limited number of grain crops and a very limited amount of pests/diseases.

2. Identification keys

The identification keys consist of lists of weeds, pests and diseases which can be found in a specific crop. They provide schematic drawings of the cotyledons and the first true leaves, as well as pictures of early and more developed growth stages (Figure 32). When selecting a specific weed, the tool shows additional information, depending on the relevance of the species.

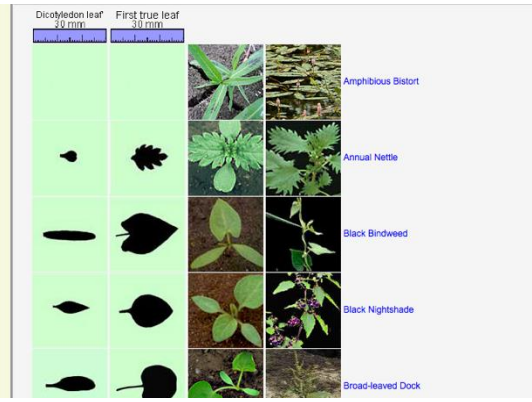


Figure 32. Identification key weeds in Plant Protection Online.

Also for this tool, the information on weeds is extensive, but very limited for pests and diseases.

3. User's mixture

The tool user's mixture is used to compare the efficacy of selected herbicides on weed species. It shows the efficacy on the whole list of weed species, both as a mixture and as individual pesticide components. It also shows the recommended target efficacy for 1, 10, 40 or 150 weed plants per m^2.

b. Testing

To test Plant Protection Online, two perspectives were considered. Firstly, reduction of pesticide leaching to the groundwater (groundwater perspective) which is the goal of the North Brabant Case. Secondly, practical use for growers and advisors in the field (grower perspective) which is necessary to ensure widespread use.

1. Problem solvers

To test the use of problem solvers for the reduction of leaching to the groundwater, several scenarios were tested with different crops and levels of crop and weed emergence. What is interesting is that potatoes, one of the most important crops grown in the Netherlands, are not part of the tools. Other popular crops like sugar beet, maize and wheat are available. The field reports produced by the problem solvers were compared to advice issued in the North Brabant case study. The Plant Protection Online results were almost always lower than maximum dose. This was expected for the lower density (2-10 plants per m^2), but not for the higher densities (41-150 plants per m^2). It did however depend on the weed species, as for some weeds (near) maximum dosage is given, independent of density.

The integration of the damage thresholds and lower dosages are very interesting for the groundwater perspective. It may be a useful tool for an advisor, especially when in doubt if treatment is necessary and also whether a lower dosage is sufficient (lower dosage means less leaching to groundwater).

Plant Protection Online was also tested by advisors who work with the farmers in the North Brabant case study. They all agreed that the tool was not useful for farmers, as it takes too much time and assumes skills in identifying species and levels of weeds. In Denmark, the tool is also mostly used by advisors. They did like the information and advice on lower dosages, specifically for projects like the North Brabant case study. There are similar tools available in the Netherlands (e.g. the Delphy mobile app) that help farmers to identify weeds and determine necessary pesticide applications. These tools, however, do not currently give damage thresholds or reduced dosages.

The problem solver for diseases was not met with enthusiasm, as lower dosages are risky in terms of resistance development. It made the advisors unsure about the reliability of the data. A more detailed explanation of the input underlying the models could be useful in convincing the advisors.

Table 35. Positive (advantages) and negative (disadvantages) features of the problem solvers for weeds, pests and diseases of the Plant Protection Online system.

Advantages	**Disadvantages**
Extended list of crops (weeds)	Limited number of crops (pests and diseases)
Damage threshold	Many steps/decisions
Advice for lower dosage (weeds and pests)	Advice for lower dosage (fungicides)
Combination of weed and pest treatment	Need for recognition of weed/pest/disease

2. Identification keys

The identification key is useful to a certain degree. It is very detailed for weeds, but not accessible in the field for farmer training purposes. With current developments of mobile apps that recognize plant species, the identification key may lose its usefulness in the near future.

Also, the key is very limited in terms of diseases and pests.

Table 36. Positive (advantages) and negative (disadvantages) features of the identification key of the Plant Protection Online system.

Advantages	**Disadvantages**
Extensive database (weeds)	Limited database (pests and diseases)
Additional information on species	Not handy in the field

3. User's mixture

The user's mixture tool is very useful when there is doubt over whether a certain mixture will be enough, or whether all components (active ingredients) are necessary. It could also be useful for advisors when preparing mixtures. Most advice was not testable as a number of pesticides allowed in the Netherlands are not allowed in Denmark. This is especially true for maize, where none of the advised products were available.

For sugar beet, there were more products available, although, no complete advice could be tested. Instead of Betanal + Goltix + Gardo Gold, we tested the first two, with and without Safari. The advised mixture of 0.5 l/ha of Betanal and 0.5 kg/ha of Goltix is not sufficient against most weeds at 2-3 leaves, independent of density and weed growth stage (Figure 33).

In this case, Safari is almost never a useful addition, as it only adds a few percentage points to the efficacy.

Component
1 : Betanal, 0.5 l / ha
2 : Goltix SC 700, 0.5 l / ha
3 : Safari, 0.5 g / ha
+ Renol , 0.3 l / ha

Weed growth stage: 2-3 leaves

Weed species	Calculated efficacy (%)				Rec. efficacy target (%)				
	Mixture	Component 1	2	3	plants/m² 1	10	40	150	...
Annual Meadow-grass	**37**		37		80	82	83	84	85
Annual Nettle	**70**	4	54	3	91	93	94	95	96
Black Bindweed	**52**	18	13	1	93	95	96	97	98
Black Nightshade	**74**		71	2	93	95	96	97	98
Bugloss	**37**	26	1		89	91	92	93	94
Charlock	**92**	47	78	12	91	93	94	95	96
Cleavers	**31**	4	7	2	91	93	94	95	96
Common Chickweed	**76**	19	54	0	89	91	92	93	94
Common Chickweed ALS-res	**76**	19	54	0	95	95	95	96	97
Common Chickweed SU-res	**76**	19	54	0	95	95	95	96	97
Common Field-speedwell	**80**	27	54	1	89	91	92	93	94
Common Fumitory	**56**	23	16		91	93	94	95	96
Common Mouse-ear	**19**	19			89	91	92	93	94
Common Orache	**83**	51	45		91	93	94	95	96

Figure 33. User's mixture results, comparing 0.5 l/ha Betanal, 0.5 kg/ha Goltix and 0.5 g/ha Safari.

Table 37. Positive (advantages) and negative (disadvantages) features of the Users Mixture of the Plant Protection Online system.

Advantages	Disadvantages
Damage threshold	(no disadvantages found)
Mixtures and individual pesticides compared	

c. Implementation

Plant Protection Online, in its current form, would be difficult to implement in the Netherlands. The tool was not developed for Dutch crops and pesticides. It assumes that farmers know the specific weeds and their densities and growth stages, but does not give a tool to fill out this information while in the field. The tools could however be useful for advisors, especially when determining damage thresholds and reduced dosages.

An important disadvantage is that tools for pests and diseases do not account for a sufficient number of crops and pests/diseases. Also, the dosages advised for diseases are very low, while in the Netherlands there is a concern that low dosages may speed up fungal resistance development. The low dosages were advised by researchers of the University and based on experimental

results. If the experiments were short-term, this may explain the advice for low dosages, as resistance takes time to develop.

To be implemented on a large scale, the information provided by the tool should be incorporated into existing tools. Dutch farmers often rely on mobile apps, accessing the information when needed, preferably in the field. Incorporating the interesting features of Plant Protection Online into existing apps would be preferable to creating a new tool.

5.8 PORTUGAL – BAIXO MONDEGO

The quality of water bodies in Portugal is not ideal. Some analysis in 2015 concluded that groundwater abstractions in Portugal are responsible for supplying 33% of the total volume of drinking water consumed, and many of the groundwater polluted water points found coincide with these public supply points. In 2016, about 25% of the groundwater in Portugal was classified as having a mediocre state. Concerning compliance with the environmental quality standards for pollutants defined in the context of water policy, 12% of the groundwater in Portugal has a mediocre state, with pollution from diffuse sources (agriculture) responsible for 11% of the cases. Nitrates and ammoniacal N from agriculture are one of the main causes of water pollution in Portugal, caused by excess nutrients added to the soils, especially since manure and wastewater sludge are increasingly being added to the soil as fertilizers. In 2017, 43 aquifer systems were analysed. 47% of them had monitoring points where the presence of ammoniacal N was detected. 84% of these had problems with nitrate pollution, exceeding the maximum allowable nitrate levels (50 mg / L). In fact, pesticides and fertilizers from agriculture drain to groundwater and rivers. This is a problem because, although 99% of the water that comes to the houses is controlled and has good quality (after treatment), efficiency problems remain. The percentage of unbilled water (illegal use, losses by breaks, as well as offers to entities or citizens without registration) is 30% of the total extracted, and this water is not treated for consumption purposes.

Between 2009 and 2016, the Baixo Mondego hydrographic region was the only one in Portugal in which the percentage of water bodies with mediocre state increased from 20% to 23%. Baixo Mondego has a high percentage of agricultural land and therefore is an interesting area to study. There are two important areas to study within Baixo Mondego (Figure 34): a nitrate vulnerable zone where there is no downstream water extraction and an upstream water extraction site. In this context, our aim was to study the application of organic fertilizer in agriculture, the presence of nitrates and ammoniacal N in soil, and their losses to groundwater in Baixo Mondego. In Portugal there is a poor monitoring of pesticides in the water, and could be also an important issue to be tested with a DST. Although, farmers are quite controlled at this level, for example they need a certificate to buy and apply pesticides and this not happens with fertilizers. Furthermore, as studying two DSTs would be a very time consuming task, we decided to focus on nitrates.

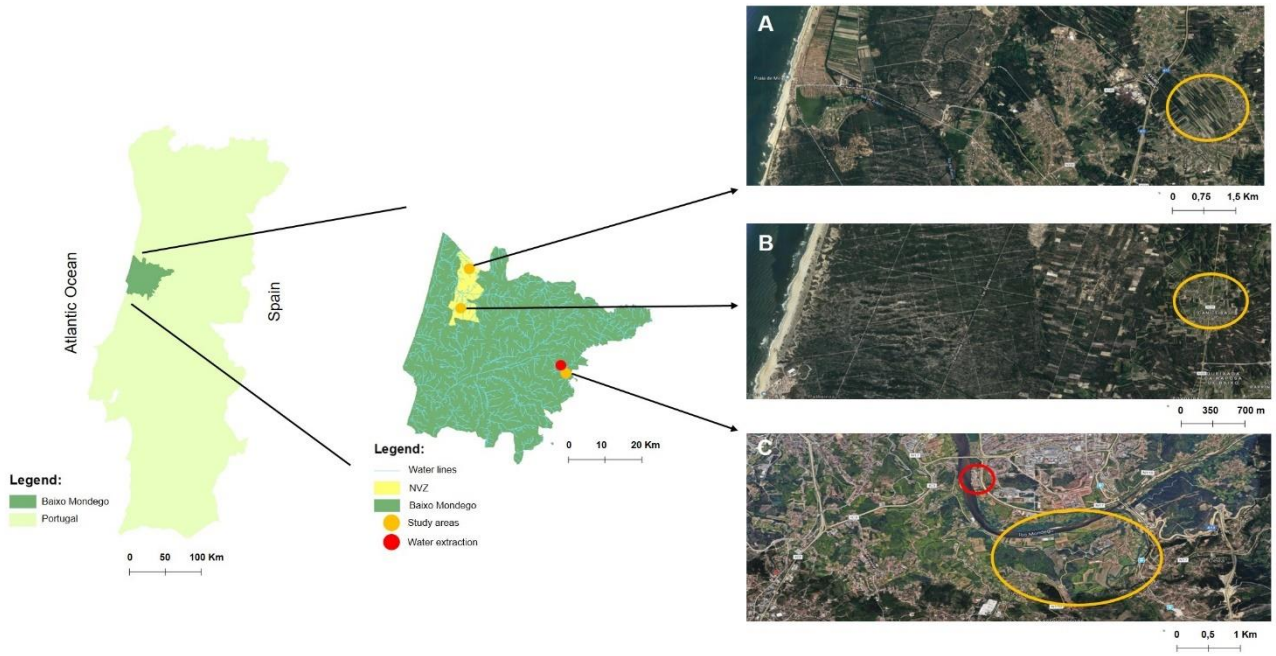


Figure 34. Farm locations for the DST testing: (A and B) nitrate vulnerable zone; (C) upstream of water extraction site.

5.8.1 **Workplan**

The workplan for application of the DST in the FAIRWAY case study site at Baixo Mondego is summarized in Table 38.

Table 38. Workplan for application of MANNER-NPK in the FAIRWAY case study site Baixo Mondego, Portugal.

Action	**Action details**	**Planning**	**Involvement**
Overview of selected DST.	Describe expected outcome by DSTs, using evaluation scheme 1.	October 2018	CERNAS
Access and support for selected DST.	Meet with the owners of the DST, in Cambridge, to obtain access to the DST and ask for support.	October 2018	CERNAS / ADAS
Define the areas to test the DSTs.	Define the areas with interest to test the selected DSTs.	November 2018	CERNAS / MAPs
Pre-test of the DST.	Read the software user guides and make a pre-test to find potential problems.	November 2018	CERNAS
Creating a test database.	Development of a questionnaire with the necessary information to run the model, and ask farmers to fill in.	December 2018 /January 2019	CERNAS / Farmers
Run model.	Enter the data and run the model.	January/February 2019	CERNAS
Results.	Describe the results and summarize the successes and difficulties. Discuss it with the experts involved in the test.	March 2019	CERNAS / MAPs
Final evaluation.	Evaluate the possibility of implement this DST or develop and implement a similar DST applied to Mediterranean conditions.	March 2019	CERNAS / MAPs

5.8.2 **Assessment, testing and implementation of selected DSTs.**

MANNER-NPK

a. Assessment

The choice of which DST to test in Baixo Mondego from the selected DST's, considered some important issues. All DST's with the following characteristics were excluded:

- do not have an English language version;
- focus on surface water;
- focus on pesticides;
- consider different climatic conditions from Portugal.

Portugal has a different climate (Mediterranean), characteristics in soil, temperature, precipitation etc. which limits the selection of DST. The *PLANET nutrient management* software was a good option as it is in line with our goals. However, it is a complex software for its end users, who are farmer's advisors. Therefore, software integrated in PLANET was chosen to be tested, which is simpler and designed for farmers use. PLANET and MANNER-NPK were developed in the UK by ADAS and North Wyke Research, but are maintained and supported by ADAS. MANNER-NPK is a practical software tool that provides farmers with a quick estimate of crop available N (N), phosphate (P_2O_5) and potash (K_2O) supply from organic manure applications. MANNER-NPK has drawn together the latest research information on factors affecting organic manure N availability to crops and N losses to the environment, via nitrate leaching, ammonia volatilisation and denitrification. Using this tool, it is possible to test the likely impact of changes to organic manure management practices, comparing two different situations and identifying which characteristics of the application lead to differences in the result. These results help farmers to improve the management of organic fertilizer applications, in order to reduce the amount of N and nitrate lost to the environment and to monetize the value of manure nutrients. The results can be used in crop nutrient management plans and when calculating the remaining balance of manufactured fertiliser to apply.

b. Testing

<u>MANNER-NPK operation</u>

The MANNER-NPK model is divided into three stages (Figure 35): farm details, specifically the address of the farm (A); field details, such as crop type, soil texture and whether or not the study area is located in a nitrate vulnerable zone (B); application details, such as the manure type, the application date and rate, the application method, the method of soil incorporation, the delay to soil incorporation, information about precipitation and wind, and the soil moisture (C).

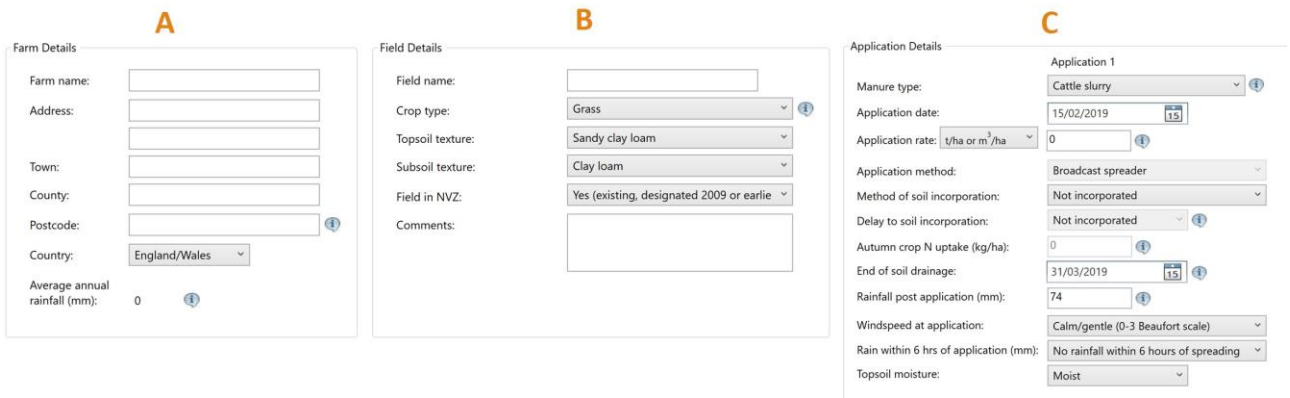


Figure 35. Different stages of the MANNER-NPK data inputs.

After entering all the required information, the software creates a final report (Figure 36) with the estimated amount of each nutrient contained in the manure such as N, ammonium, uric acid, phosphate (P_2O_5), potash (K_2O), etc. These quantities may change if the user enters their own manure analysis data rather than using default values. The total amount of N and other nutrients introduced into the soil are estimated according to the amount of manure applied. Regarding the N, the tool gives the amount that is mineralized, the amount lost by nitrate leaching, ammonia volatilization and denitrified, the crop available and the N use efficiency. Finally, it gives a breakdown of the potential financial value of all the organic manure applications, and for individual applications and nutrients.

Manure analysis

Application	DM (%)	Total N	NH_4-N	Uric acid-N	Nitrate-N	Total P_2O_5	Total K_2O	Total SO_3	Total MgO
		kg/t or kg/m^3							
App 1	35	19.0	5.6	3.7	0.2	14.0	9.5	4.0	2.6
App 2	60	30.0	6.2	4.1	0.2	25.0	18.0	8.0	4.4

MANNER-*NPK* Results

			Nitrogen losses (kg/ha)			Crop available N (kg/ha)		
Application	Total N (kg/ha)	Mineralised N (kg/ha)	Nitrate-N	Ammonia-N	Denitrified-N	Current crop	Following crop year 2	N use efficiency (%)
App 1	228	26	60	56	4	21	3	9
App 2	360	54	71	62	5	42	7	12
Total	***588***	***81***	***131***	***117***	***9***	***63***	***10***	***11***

Application	Total P_2O_5 (kg/ha)	Available P_2O_5 (kg/ha)	Total K_2O (kg/ha)	Available K_2O (kg/ha)	Total SO_3 (kg/ha)	Total MgO (kg/ha)
App 1	168	101	114	103	48	31
App 2	300	180	216	194	96	53
Total	***468***	***281***	***330***	***297***	***144***	***84***

Figure 36. Example of a MANNER-NPK report.

Testing difficulties

Throughout the testing some difficulties arise:

(1) The MANNER-NPK software is in English language, so farmers in Portugal cannot use it. Questionnaires had to be made in Portuguese in order to get the information from each farm to run the model, so it was not possible get farmers feedback on the use of the software;

(2) The post code to introduce in software refers to UK regions and their annual average precipitation. A region with the same annual average precipitation as in Baixo Mondego had to be found and its post code used. The seasonal rainfall pattern also differs, and this affects the amount of rainfall considered in the month of manure application. However, since it is possible to enter the amount of precipitation after manure application and between the application of the manure and the end of soil drainage, it is possible to reduce the error;

(3) In Portugal, not all farmers are required to make a fertilization plan. This is only mandatory in special situations, such as in NVZ or in the case of certification of agricultural products. Thus, not all farmers develop a fertilization plan and, when they do so, they do not use the table included in the code of good agricultural practices. This leads farmers to often not know exactly the day and time of the manure application. This is what happens in Baixo Mondego. In NVZ most farmers know the day of application of fertilizer, but outside this zone, farmers often just know the time of the month. In these cases, an estimate of the day and hour was made. When the software asks to the user to enter the precipitation and wind speed after manure application, an error could be introduced. In Baixo Mondego case there was no significant precipitation in the days before and after the application, which reduced the possible error;

(4) It was not possible to adapt the financial analysis made by the software to Portugal. The £ value tab calculated by software shows a breakdown of the potential financial value of all the organic manure applications and for individual applications and nutrients in £, in England. In Portugal the currency is the € and the potential financial values could be different. Then, the financial analysis could not be real to Portugal.

Characteristics of the analysed farms

In Baixo Mondego 11 farms were analysed (5 in the nitrate vulnerable zone and 6 upstream of the water extraction) and 20 manure applications were analysed. Figure 37 - Figure 40 show the characteristics of the analysed farms.

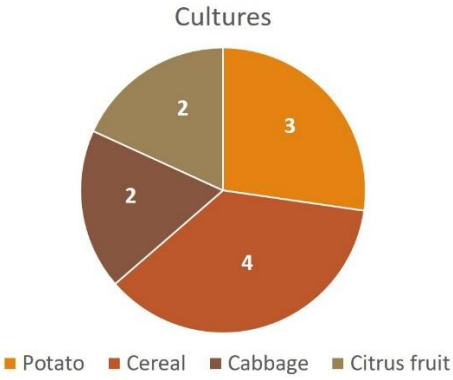


Figure 37. Number of types of culture analysed.

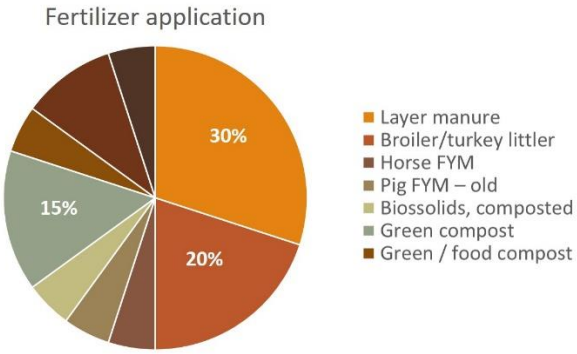


Figure 38. Percentage of application of different types of fertilizers in the cultures analysed.

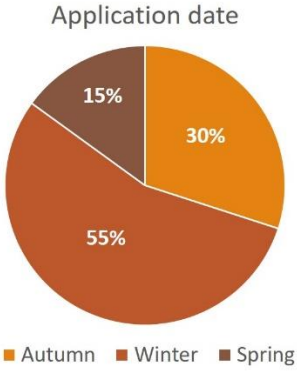


Figure 39. Season of manure application.

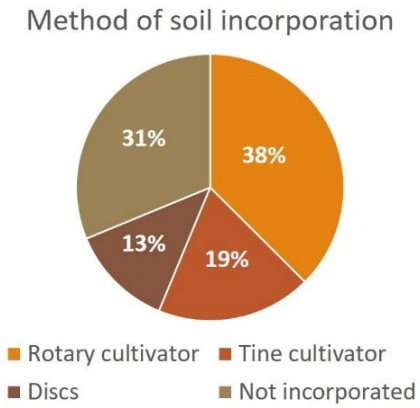


Figure 40. Types of method of soil incorporation after application of manure.

In crops, analysed in Baixo Mondego, only one manure application technique is used for all: broadcast spreader. Regarding soil incorporation of organic manures, it decreases ammonia emissions. This reduction depends on the method of soil incorporation, with the greatest reduction from incorporation methods with the greatest degree of mixing with the soil in the order: plough > rotary > disc > tine. Furthermore, in Baixo Mondego the delay to soil incorporation is mainly between 10-15 days after manure application. According to the software, the longer time delay to soil incorporation is associated with greater loss of ammonia, with 10-15 days considered a medium to long time. After manure application, rainfall only occurred in one case, although with very low amounts. According to the software, rainfall events soon after manure application have been shown to reduce ammonia emissions, as a result of manure being washed into the soil. Therefore, the lack of rainfall in the Baixo Mondego case contributed to increased ammonia emission. However, the wind was always very weak, which reduces the emission of ammonia by volatilization, according. Regarding the soil moisture content, we assumed that the soil was relatively dry at all the farms.

Results

In nitrate vulnerable zones in Portugal, the amount of organic fertilizers to be applied cannot exceed 170 kg/ha/year of N. The same rules should be followed for the remaining zones, but this is not mandatory as in nitrate vulnerable zones. Software estimates of the percentage of the farms analysed in Baixo Mondegothat obey the rule is shown in Figure 41 - Figure 42.

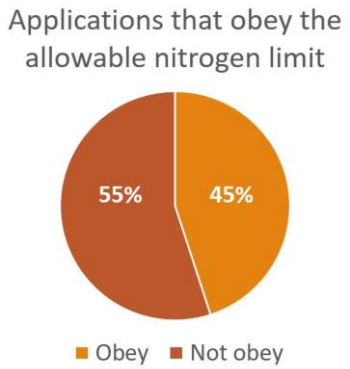


Figure 41. Total number of farms (%) that obey the allowable N limit application.

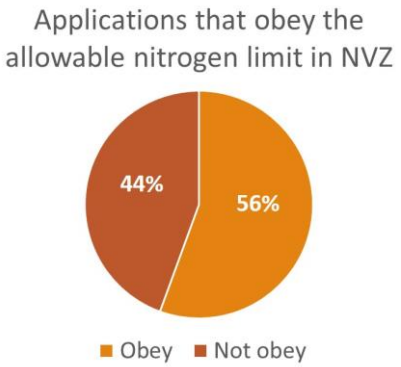


Figure 42. Farms in NVZ (%) that obey the allowable N limit application.

Regarding the percentage of N loss from each type of manure (Table 39), layer manure and broiler/turkey litter have the greatest losses. Green and food compost have the lowest losses.

Table 39. Percentage of N loss from manures applied to soil in the MANNER-NPK DST.

Type of manure	N losses
Layer manure	30%-53%
Broiler/turkey litter	21%-38%
Cattle FYM fresh	14%
Duck FYM old	12%
Pig FYM old	9%
Horse FYM	6%
Green / food compost	4%
Biosolids composted	3%
Green compost	0%-3%

Table 40 shows that highest N losses are due to ammonia emission, followed by nitrate leaching and denitrification.

Table 40. Percentage of N loss by type of loss in MANNER-NPK.

Loss route	N losses
Ammonia volatilization	40%-100%
Nitrate leaching	15%-60%
Ammonia denitrified	0%-10%

Difference in N efficiency per crop is shown in Table 41. Highest N efficiency is shown for cabbage and cereal crops.

Table 41. Percentage of N use efficiency per crop of organic manure.

Type of crop	N efficiency
Other (cabbage)	21%-28%
Cereals	12%-27%
Potato	7%-11%
Maize	10%
Other (citrus fruit)	7%-8%

The largest N use efficiency is shown for layer manure and with the broiler/turkey litter applications compared to other manure applications (Table 42).

Table 42. N efficiency (%) for types of manures

Type of manure	N efficiency
Layer manure	9%-33%
Broiler/turkey littler	12%-30%
Biosolids composted	14%
Cattle FYM – fresh	10%
Pig FYM – old	8%
Horse FYM	7%
Duck FYM (old)	7%
Green / food compost	5%
Green compost	3%-5%

It is interesting to make a detailed analysis of results on a case-by-case basis, in order to obtain recommendations for an individual case. Small details (Table 39 - Table 42) can make the difference and, in practice, farmers are not aware of some of these facts. The main problems found with the results are the low efficiency of manures, the failures to obey the rules of nitrogen values present in the soil, and the improper management of manure application by farmers, since they do not know the dates or timing of applications. Apparently, about half of them do not obey the requirements for the amount of N applied to the soil with the manure. It is important to realize that there are factors to influence this, such as the type of manure applied, the date of application, the method of incorporation, etc. and they are usually not considered. This type of software and analysis are really important; if farmers make small changes they can reduce the losses of nitrogen. Small changes in the proper management of organic manure application can be a way to improve the quality of groundwater.

Table 43 presents some advantages and disadvantages of using MANNER-NPK.

Table 43. Advantages and disadvantages of MANNER-NPK seen in a Portuguese context.

Advantages	Disadvantages
Freeware.	Software only works on UK microsoft operating system.
Suitable as an advisory tool for advisors and farmers at farm level.	Currently the tool is used in UK and new data would need to be added for use in PT (language, climate, types of culture, etc.)
Very intuitive tool that is easy to understand and use.	The introduction of soil moisture should consider influential variables besides precipitation, such as evapotranspiration, irrigation, water table depth, etc.
The input data are easy to obtain: basic information about the crop, fertilizer application and weather conditions.	The result of the financial analysis should be adapting to the currency in Portugal (€).
Supply of information that is of interest to farmers to a correct fertilizer application management: N use efficiency, N losses, crop available N, etc.	The results may not be 100% real, just helping as an orientation.

c. Implementation

The implementation of MANNER-NPK in Portugal would be difficult, since the software has some characteristics associated with UK conditions. Most of them are possible to overcome, but others can lead to inaccurate results. The needs in terms of functionality, use and access to MANNER-NPK were identified: (1) MANNER-NPK only works on windows operative system, and specifically on a UK windows computer, since it assume the UK postal code and it only accepts the postal code this way; (2) The software does not discriminate a great number of crop types; in Portugal a wide variety of vegetables are cultivated, such as cabbage, lettuce, tomato, onion, that have different characteristics. It would be interesting to study these cultivation systems more specifically (3) The soil moisture should consider several variables that are not taken into account in the software, such as evapotranspiration, irrigation, water table depth, etc. This is an issue to improve, since the user has to estimate the soil moisture.

The obstacles for implementation of MANNER-NPK in Portugal are also identified: (1) The fact that the software is in English is the first barrier to farmer's use (2) The nitrate vulnerable zones in UK do not have exactly the same regulations as in Portugal, although most of them are similar. This may influence the message that appears in the report when rules of nitrate vulnerable zones are not followed; (3) The climatic conditions in the UK considered in the software are not the same as in Portugal (Mediterranean climate). Although it is possible with this software to make an estimate of rainfall, the results could be misleading. (4) Farmers do not know some characteristics of manure application, such as the day and timing of application. This leads to the introduction of incorrect information in the software, which could lead to wrong results. Farmers should be encouraged to properly manage manure applications, in order to reduce groundwater N and nitrate pollution and to have a higher N use efficiency in the crop.

In conclusion, MANNER-NPK would be a useful software tool for farmers to design their own fertilization plans without help, as the software is easy to access and use. There are guides and help available, and the people responsible for the DST were very helpful giving support and clarifying any doubts. This made the test easier. Although there is already an excel file in Portugal that calculates the nitrogen required to the crop, it calculates the amount of nitrogen to be applied to a particular crop, taking into account laboratory analyses of nitrogen supplied by soil, irrigation water and residues from previous crops. MANNER-NPK is more complete: it provides farmers with a quick estimate of crop applied and available N, as well as of P2O5 and K2O, considering several characteristics of the crop, soil, climatic conditions and fertilizer application, without the need for analysis laboratory tests. It also provides an estimate of N losses and N use efficiency. This can be a realistic estimate, if adapted to the characteristics of the study site. So, to implement the DST in Portugal it would need some adaptations. Ideally, software is developed in Portuguese language, considers the meteorological conditions in Portugal and a wide variety of vegetables. Once implemented in Portugal, it would be necessary to organize workshops to teach farmers how to use the software and explain the benefits they can derive from it. There may be older farmers who are not set with the use of computers, but all the other farmers would like to have an easy-to-use tool that allows them to have a lot of information in a simple way.

5.9 SLOVENIA – DRAVSKO POLJE

The Annual Nutrient Cycling Assessment (ANCA) Tool was developed in The Netherlands (https://www.wur.nl/en/article/Annual-Nutrient-Cycling-Assessment.htm). The ANCA (Dutch: KringloopWijzer) is a farm specific tool for assessment of soil surplus of N, P and C within dairy farms (cycling from feeds, to herd, to storage, to soil, to crops and back to herd) and emissions by losses from this imperfect cycle. The N surplus based on the soil balance can be used as indicator for both losses to surface water and groundwater. Currently ANCA is a widely used tool to provide farm-specific environmental performance figures. Since all output is produced using traceable and reliable input data, ANCA may also be used for licensing, or evidencing environmental performance. The model outcomes help dairy farmers to demonstrate to the authorities and dairy industry that they have produced their milk in accordance with sustainability standards. Since 2018 almost all Dutch dairy farmers (16,000) are obligated to use this tool (web version) which is freely available for registered farmers. If they comply with the standard values in the tool they are rewarded with 1 EUR per 100 kg of milk.

In Slovenia the only tool that helps farmers improve their nutrient management is the Načrtovanje gnojenja Tool for developing individual fertilizer plans. The tool is similar to those in use in other EU countries. The tool is intended to assist agricultural advisers and farmers to optimize fertilizer use in all agricultural sectors, most notably in horticulture and field crop agriculture. With its help, we can quickly calculate the recommended quantities for phosphorus, potassium and nitrogen fertilizers, both with organic as well as with easily soluble mineral fertilizers, as well as the need for land lime. We can make annual or multi-year fertilization plans, while at the same time we can plan the correct crop rotation and take into account the amount of organic fertilizers on the farm. However, the tool has limitations in that it is based on standard fertilizer guidance (Smernice za strokovno gnojenje), which is a collection of the main fertilizer application instructions based on literature, experience, plant development observations, and chemical analyses of soil and plant parts and not on long-term field trials in Slovenia. The guidelines are in line with the regulations and requirements for the quality of crops and the preservation of a clean environment, and aim to set a broader framework that is not based solely on political decisions or fashion trends, but on rational expert findings. One of the limitations is that the results of soil analysis and fertiliser plans are not stored centrally and spatially represented but a rather stored individually on farms in a print version.

Hence, DSTs for better assessment of nutrient cycles at farm level and soil quality and fertility are needed in Slovenia.

Figure 43. ANCA tool (KringloopWijzer) module structure.

5.9.1 Workplan

The workplan for application of ANCA in the FAIRWAY case study site at Dravsko Polje is summarized in Table 44.

Table 44. Workplan for the FAIRWAY case study site at Dravsko Polje, Slovenia.

Action	Action details	Planning	Involvement
ANCA tool evaluated	It will evaluated on fictional data to see if the Slovenian system can supply all data that is needed.	November 2018	KGZ Maribor
Further analysis and testing on actual farm	Data from real farms will be used for ANCA testing to see what are strength and downfall of the tool.	December 2018 – March 2018	KGZ Maribor
Tool presented to the board of local MAP (Partnership for drinking water)	At 3rd meeting. 3-5 farmers from that board will be asked to join comparative testing.	December 2018	KGZ Maribor
Results of testing presented to MAP	Results, experiences of testing and suggestions for improvement will be presented at 3rd meeting of MAP to all stakeholder groups.	March 2019	KGZ Maribor
Results of testing for developers	Results will be compiled and presented to ANCA tool developers.	April 2019	KGZ Maribor UL
Final evaluation	Concluding remarks about possibilities for use in Slovenia	April 2019	KGZ Maribor UL

5.9.2 **Assessment, testing and implementation of selected DSTs.**

ANCA

a. Assessment

Similar tools are not in use in Slovenia. The testing included 5 farmers from water protection areas in the Dravsko polje area (Figure 44).

The objectives of testing the ANCA tool were to help farmers to:

- meet demands of society,
- overview their farm and to focus on weak spots and improvements in nutrient management.

By testing and later adapting the tool, we would like to encourage farmers in the Dravsko polje area to more closely monitor their farming practices and thus the effect of their management practices on the ground water. In the case that the tool turns out to be appropriate, we will propose that a modified version of this or similar tools should be used at national level (all water protection areas with N concentration problems).

Use of this tool has multiple effects on stakeholders: (1) Environmental agency: New management practices of farming impact on the water protection area and water quality improvements; (2) Farm advisors: Advisors can easily convince farmers to implement new technology in practice; (3) Farmers: Overview of their farm management and focus on weak spots, as well as for demonstration of sustainability standards to the authorities and to the general public.

Figure 44. Farm locations of the ANCA tool testing sites.


Figure 45. Visit to farm and observation of their practices.

b. Testing

We included in the testing 5 dairy farms of different sizes (Table 45).

Table 45. Farm information.

Farm	Milk production (kg/year)	Animals (No.)			Agricultural land (ha)		
		Cows	Heifer	Other	Grassland	Corn	other
FARM 1	100,000	16	6	10	12.1	6.8	1.6
FARM 2	365,763	35	33		16.05	12.5	5
FARM 3	294,282	30	24		10.37	12.7	7.5
FARM 4	472,774	51	27		12.5	14	11
FARM 5	300,000	45	34	9	30	16	17

Findings:

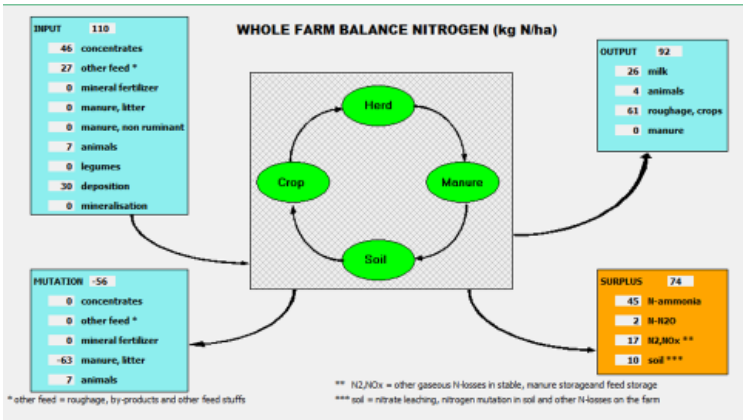
- Slurry is surface-applied, which results in high ammonia emissions (In the Netherlands it is not allowed to broadcast slurry).
- Poor N used efficiency of slurry applied to the crop – From the draft results an obvious measure (increase N use efficiency), that would include practice of increasing the number of slurry applications with decreased volume quantities rates, could be proposed.
- Due to the low milk production per cow on the farms, the emission of greenhouse gases was relatively high – need to increase milk production per cow, to increase the efficiency of production in general.

An example of the results from ANCA is presented in Figure 46. Advantages and disadvantages regarding ANCA are summarized in Table 46.

Additional production	Organic manure	Synthetic fertiliser	Soil and crop	Other	Characteristics	Key figures	BEX and

Efficiencies		Nitrogen			Phosphate	
		This farm	BIN		This farm	BIN
Farm use efficiency (%)	V	43	29	V	100	76
Herd use efficiency (%)		22	22	V	35	30
Manure use efficiency (%)	X	34	83		100	100
Soil use efficiency (%)	V	129	65	V	160	90
Crop use efficiency (%)	X	66	86	X	64	88

Nutrient losses		Per hectare			Per ton milk	
Nutrient surplus whole farm balance		This farm	BIN		This farm	BIN
- nitrogen (kg)	V	41	188	V	8,5	18,2
- phosphate (kg)	V	-27	8	V	-5,7	0,8
Nutrient surplus soil balance						
- nitrogen (kg)	V	-34	133	V	-7,2	12,8
- phosphate (kg)	V	-27	8	V	-5,7	0,8
Gasous nitrogen losses						
- N-ammonia: stable and manure storage (kg N)	X	17	14	X	3,5	1,4
- N-ammonia: excretion during grazing (kg N)	V	0	1	V	0,0	0,1
- N-ammonia: manure application (kg N)	X	31	25	X	6,5	2,5
- N-ammonia: crop residues (kg N) *Clarification*	V	0,1	0,8	V	0,03	0,08
- N-N2O: stable and manure storage (kg N)	X	0,5	0,4	X	0,11	0,04
- N-N2O: soil (kg N)	V	1,1	4,8	V	0,22	0,47
- N-other: stable and manure storage (kg N)	X	23,1	4,7	X	4,84	0,47
- N-other: ensiling (kg N)	V	2,5	3,4	X	0,53	0,34



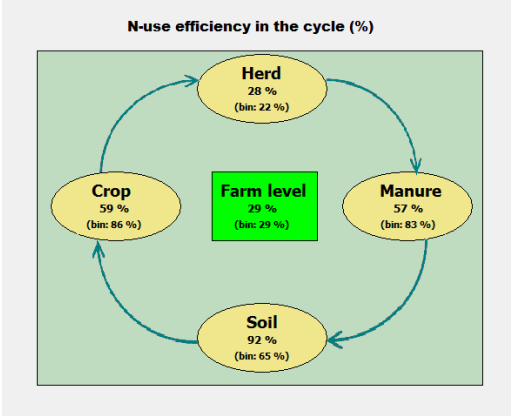


Figure 46. Results of the ANCA tool for farm 5.

Table 46. Advantages and disadvantages of ANCA seen in a Slovenian context.

Advantages	Disadvantages
Farmer	
• Farmers would benefit from analysis of feed and manure. It would help them to better manage nutrients and to be environmentally and economically efficient.	• Majority of the data are not available and had to be estimated. • Few farms have home produced feed/fodder (silage), slurry, manure analyses (farmers understand feed analyses as a cost and not as a contribution to the business). • Few farms weighed harvested yields of grass or crops. • Farmers expressed worries that the introduction of ANCA in Slovenia would be taken as an additional administrative obstacle (unless financial incentives were in place as € / l of milk). • Less time to do the job they are primarily trained for (agriculture production).

Government (*Reader should be aware that ANCA is not an instrument used in by the government in the Netherlands. There is a lot of discussion about the quality of the data and control. The milk companies (Friesland Campina) force farmers to use ANCA)	
• Better quantification and localization of the problems in production management • Reliable spatially represented data stored centrally gives better overview of sustainability of the agriculture • Enables possibility to report on efficient use of money from EU CAP founds in regard to Nitrate directive, WFD • *With specific of Slovenian agriculture where farmers are not very loyal to milk companies we see this system to operate with optimal trust only as state/governmental system.	• Obvious spatial difference between farms (NL-larger, more oriented in one branch; SI-smaller heterogeneous branch structure). • In Slovenia are farms heterogeneous (milk and meat production on the same farm – 69% of farms). • As farmers often claim that they already know where the problem is on their farms there is a doubt why are this type of tool is needed. • Problems and constrains with resources (time, money, personal) for supporting this type of tool.
Program	
• The programme is nicely structured and divided in to separate pages covering different modules (crop, manure, soil, and herd). • The results are with use of BIN* value (average value to reach) and traffic light colour system easy to understand (*Dutch Farm Accountancy Data Network (Dutch: Bedrijven-Informatienet, BIN)	• There is no possibility of modification: we have two grass cuts before maize is planted • BIN values and standards are set for NL farms • Problem is in relationship between corn silage against grass silage which is in Netherlands 1:2, and in Slovenia is 2:1 • Help (warnings) is in Dutch . • The programme would benefit from incorporating farm land parcel units and spatial representation. • Programme is for less friendly for less educated farmers less – so we cannot imagine that farmers will use it by themselves (we have previous experience with the program FADN) – the farmers would need assistance from the agricultural extension service.

Each of the farmers was visited by the agricultural extension service and interviewed on all required data. Where data was not available (slurry, feed analysis) standard values from literature were used for calculation. For the quantities of the fodder they measured all storage capacities on the farm.

Results of testing DST were part of workshop on 14th March 2019, prepared by extension service (KGZ Maribor) to commemorate world water day (22nd March 2019) (talk with farmers, change experience). The practical experiences with the tool were presented at special seminar on 4th March 2019, to representatives of the Ministry responsible for agriculture, Agency for agricultural markets and rural development and Chamber of agriculture. The MSc Students of agriculture also attended this seminar. Results, experiences of testing and suggestions for improvement were presented at

the 3rd meeting of MAP - Water Partnership for Drinking Water on 28th March 2019, to all stakeholder groups (farmers, farm business, water companies, municipalities, ministry).

Figure 47. Workshop with farmers from the case study area on World Water Day.

Figure 48. MAP - Water Partnership for Drinking Water meeting in Dravsko Polje.

Figure 49. Seminar on possible use of DST of nutrient management in Slovenian agriculture for the Ministry responsible for agriculture, Agency for agricultural markets and rural development and Chamber of agriculture and students.

c. Implementation

It is unlikely to expect exact implementation of the tested tool (ANCA) due to the previously mentioned differences in the agricultural systems. In the draft of the new Slovenian proposal of PRP for 2021-2017 they included in cross-compliance text also implementation of Farm Sustainability Tools for Nutrients (FaST) promoted by EC for the next CAP. What will be the practical execution of this proposal is difficult to say. The EU Commission stated that they will prepare generic tools that will include minimal requirements and will be available to all member states. The Commission also support all already implemented tools if they fulfil all the requirements set by the EU Commission.

Barriers/obstacles:

- There are many different data bases in Slovenia which are unrelated to each other. Energy and time should be invested in synchronisation of existing databases and also establishment of new ones (soil quality data bases). The problem is also that there are existing databases supported from different IT companies. It might be better to start from the beginning, however this would require time.
- From the scientific point of view we propose to use a type of the DST similar to ANCA, which are more complex and cover several aspects (fertilizer use, advising, production, emission, analysing ….). Tools should also be able to address heterogeneity in farming practices and soil types. They should be designed as spatial tools.
- Beside ANCA we also recommend considering Danish DST tools (Dyrkningsvejledninger, Plant Protection Online) which were present to us by Danish partners, as they have governmental scientific and execution support
- However the complex structures of the tools means more money for implementation and more administrative barriers. It also requires a lot of measured data and experimental farms.
- Another problem is how to address different topography and climate at the same farm.
- The question is also how one tool – even the simplest one - can address heterogeneity of topography, geology and climate in one country. Slovenia has Alpine, Pannonia and Mediterranean climate; Karstic, Alluvial, Flysch and Magmatic geology, Mountain and flatland topography.
- There is a problem with the age and education of the farmers (average age 57 – 4% less than 35, 70% of farmers doesn't have any agricultural education). An average farmer has only primary school education, so it is almost impossible to expect farmers to work with computers in the short term. However this could be overcome with the Dutch model were extension service agricultural advisors are using it with data provided by farmers.
- Farmers and some governmental employees were quite surprised about ANCA and its possibilities - that led to scepticism regarding transferability. Scepticism was related to capabilities of the model to represent heterogeneous soils, cost of soil, manure and feed analysis, capability of government to properly collect and define the average values, additional bureaucracy as well as doubt that farmers are ready for new nutrient management and technological jump. In contrast, some of the governmental employees and agricultural extension service were supportive and acknowledged the need for implementation of this type tool in practice.

As Slovenia doesn't have tools of this kind (ANCA tool), anything similar would be an improvement to help monitor sustainability of nutrient cycling management and GHG emission reduction on our farms. It would also greatly improve reporting on efficient use of money in the Rural Development Programme, especially reaching requirements of agri-environmental-climate conditions (measures) indicators.

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7. APPENDIX

7.1 EVALUATION SCHEME 0

In Task 5.2, firstly the MAP leaders of each involved FAIRWAY case study site were asked to make the final selection of the DSTs, they would like to test and/or demonstrate. In milestone M5.1 each case study site had already indicated which DSTs they intend to test and/or demonstrate as part of task 5.2, however a final selection was needed. For this purpose, evaluation scheme 0 was developed. Evaluation scheme 0 was based on the short list of 36 DSTs, which in Task 5.1 were found to be DSTs of national importance to the participating countries and relevant to the project aims. By using the available information on the DST produced in Task 5.1 the MAP leaders should for each DST identify barriers and whether a similar DST to handle the task already exist. Additionally, the MAP leaders were asked to write comments om main use, indicated whether the DST was voluntary to use or a part of the legislation. Finally, the MAP leaders should make their final selection of the DST they would like to test and/or demonstrate as part of Task 5.2.

The evaluations schemes for each involved FAIRWAY case study site can be found below.

7.1.1 Denmark - Aalborg

			Barriers												
No.		**DST name**	Language	Data requirements*	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	⋮	**A similar DST to handle the task is already in use in your country** **Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6							x			Yes	Denmark have Mark Online developed since 1987. The program is continuously corrected according to the existing legislation.		
2	DE	ISIP							x			Yes	The method in Denmark are called N-MIN-Metoden. Based on actual content of nitrate in the soil. The method is used most in field trails and in environmental projects to estimate the leaching. Used by the farmers in 1990`s. Commercialized by SEGES		
3	DK	Mark Online				x						Currently in use	Fertilization is based on livestock units, manure standards, utilization rate of manure and nitrogen standards for the crops. All Danish farmers must send in a fertilizer accounts and a registered and completed spraying accunt every year to Ministry of Environment and Food of Denmark. The Agricultural Agency. The program is continuously corrected according to the existing legislation. Mark Online is commercialized by SEGES	Legislative for farmers	
4	DK	Dyrkningsvejledninger										Currently in use	Dyrkningsvejledninger (Growing guides) is commercialized by SEGES	Voluntary for farmers	
5	DK	Plant Protection Online				(x)						Currently in use	The program is developed to lover the use of pesticides, use of low dose and not the dose on the package. In several years high focus on treatment index (Behandlingshyppighed – named BI). Plant Protection Online is commercialized by SEGES	Legislative for farmers	
6	DK	CTzoom/CTtools							x			Currently in use	Public databases used by the municipality from governmental registers. Commercialized by Conterra	Voluntary	
7	DK	BEST Kemi							x			Currently in use	Commercialized by GEUS in Denmark	Voluntary	

8	DK	TargetEconN							x			Currently in test comparing the model results and data inputs to 2 other Danish models (SMART, Norsminde), also catchment models.	TargetEconN is currently tested and compared to the two other models in Denmark, and the results will provide information for the Ministry of Environmenta and Food for cost-effective implementation of the WFD. The model has also been discussed with the water Utility Company in Aalborg.		x
9	FR	PHYTOPIXAL	x	(x)	x	x	x	x	(x)			No	Denmark has no program that can handle soil erosion and leaching of nitrate and pesticides at the same time. There are programs at Aarhus University that can handle soil erosion, but Denmark is not a special hilly area.		
10	FR	SIRIS	(x) UK version		x	x	x	x	x	x		No	Denmark has the DST Plant Protection Online and a database where that is possible to search active substances, but the program can´t calculate leaching at catchment level. The Danish Environmental Protection Agency approve pesticides and Aarhus and GEUS test pestisides in fiels trials in the program “Varslingssystem for udvaskning af pesticider til grundvand (VAP)” - Warning system for groundwater pesticide leaching Could be interesting to test together with Environmental Yardstick for Pesticides		X
11	IE	Teagasc NMP online							x			Yes – Mark Online contains many similar elements	Denmark has the program Mark Online to execute spraying plans, fertilizer plans and fertilizer accounts for the farmers.		
12	IE	FarmHedge							x			Yes	DMI – Denmark's meteorological institute has the main part of commercial advice to farmers in relation to the weather and few farmers have their own weather stations		
13	NL	ANCA	x						x			Yes - Mark Online contains many similar elements	Denmark has the program Mark Online to execute spraying plans, fertilizer plans and fertilizer accounts for the farmers. The programs are connected with livestock data at farm level. The program can calculate simple and comprehensive nutrient balances. There are other programs that can calculate emission at farm level. OML-Multi information (Operational Meteorological Air Quality Models) calculate emission to the air.		
14	NL	Adviesbasis CBGV	x						x			Yes - Mark Onlinecontains many similar elements	Denmark has the program Mark Online to execute spraying plans, fertilizer plans and fertilizer accounts for the farmers. The program can connect to N-less. A program that can calculate leaching of nitrate.		
15	NL	Beregeningswijzer	x						x			Yes	Denmark has the program Water Accounting Online (Vandregnskab Online) to irrigation. Commercialized by SEGES		
16	NL	BedrijfsWaterWijzer (BWW)	x						X			No	This are separate programs in Denmark. In general, the are programs for diary production, pig- and plant production. The programs can communicate with each other in some ways.		
17	NL	Bodemconditiescore	x						X			Yes	The soil types are mapped in the past, but the university are doing new maps in different technological ways. The target is to understand the soil type in 1-1,5 meter in the rooting depth.		
18	NL	NDICEA	x						X			Yes	The soil types are mapped in the past, but the university are doing new maps in different technological ways. The soil types are not decided nationwide with new technology, but various projects work in this are.		
19	NL	Environmental Yardstick			x	x	x	x	X*	(x) Only test of 3 active substance		Yes and No	Plant Protection Online has some of the same elements but not so visible. *The name of the pesticide and the content of active substance may vary from country to country The Danish Environmental Protection Agency approve pesticides and Aarhus and GEUS test pestisides in fiels trials in the program		x

													“Varslingssystem for udvaskning af pesticider til grundvand (VAP)” - Warning system for groundwater pesticide leaching. So the farmers always use approved pesticides.		
20	NL	STONE	x						X			Yes	A combination of the program Mark Online and the program N-less has focus on that task. Maybe TargetEconN in the future (Operational Meteorological Air Quality Models) calculate emission to the air.		x
21	NO	Catchment-lake modelling network							X			No	Maybe TargetEconN in the future		
22	NO	Skifteplan							X			Yes	Mark Online in combination with N-less can cover this task and maybe TargetEconN in the future.		
23	NO	Agro-meteorological service										Yes	DMI – Denmark's meteorological institute has the main part of commercial advice to farmers in relation to the weather, but some farmers have their own weather stations		
24	SI	Načrtovanje gnojenja	X						x			Yes	Mark Online and Dyrkningsvejledninger (Growing guides) cover this.		
25	SI	Smernice za strokovno gnojenje	X						x			Yes	The websites and are the communication channels for professional information to farmers and agricultural advisors.		
26	SI	OECD/EUROSTAT N balance	X						x			Yes	All Danish farmers must send in a fertilizer accounts and a registered and completed spraying accunt every year to Ministry of Environment and Food of Denmark. The Agricultural Agency. Indirectly the fertilizer account takes care of the nutrient balance.		
27	SI	GROWA-SI	X						x			?	Groundwatermodels?		
28	SI	State network of groundwater monitoring points	X						x			Yes	The Danish Environmental Protection Agency has this task in Denmark		
29	SI	FITO-INFO	X						x			Yes	The websites www.Landbrugsinfo and www.Landmand.dk are the communication channels for professional information to farmers and agricultural advisors. Mark Online/ Dyrkningsvejledninger (Growing guides)		
30	UK	PLANET							x			Yes	Mark Online in combination with N-less can cover this task and maybe TargetEconN in the future. Denmark are 100 percent nitrate sensitive areas, so a program to pin point these areas don´t make sense.		
31	UK	FARMSCOPER							x			Yes	A combination of Mark Online in combination with N-less can cover this task together with wetlands, constructed wetlands and new mitigation measures like intelligent bufferzones, constructed wetland with woodchips ect. (PDF fil). At the moment the targeted regulation has focus on this task.		
32	UK	Check it out							x			Yes	In Denmark, the farmers legislative need a certificate to be allowed to spray in the fields with pesticides.		
33	UK	Sentinel Online							x			Yes	In Denmark the program are named and		

34	UK	Procheck							x			Yes	Plant Protection Online has in a way this function.		
35	UK	SCIMAP							x			No	TargetEconN has maybe the potential?		
36	UK	WaterAware							x			No	Denmark has already the program Mark Online to fertilizer plans and fertilizer accounts		

7.1.2 **United Kingdom - Anglian Region**

			Barriers											
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	…	**A similar DST to handle the task is already in use in your country** **Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	X			X	X		X			Yes	The England Case Study is based on pesticides		
2	DE	ISIP	X				X		X				The England Case Study is based on pesticides		
3	DK	Mark Online	X			X			X			(Yes) Systems exist for nutrients, less so for pesticides			
4	DK	Dyrkningsvejledninger	X			X	X					No, there is no single source of Good Ag Practice for different crops although there are some chargeable newsletters.			
5	DK	Plant Protection Online						X				Yes, Various sources exist			
6	DK	CTzoom/CTtools	X	X									Our case study is based on pesticides		
7	DK	BEST Kemi	X	X								(Yes), the Environment Agency records quality of groundwater for nitrates and pesticide	Our case study is based on surface water, this is a groundwater DST		
8	DK	TargetEconN		X		X			X	X			This is currently a nitrate model, our case study focuses on pesticides		
9	FR	PHYTOPIXAL					X		X	X		Some information available and usable in Scimap	Interesting model as it links topography and land use – seems rather specific with local calibration needed		
10	FR	SIRIS	X	X	X		X					No			
11	IE	Teagasc NMP online				X						Appears similar to PLANET	Our Case Study is based on pesticides	V	
12	IE	FarmHedge		X		X						Similar Weather apps are available in the UK		V	

13	NL	ANCA	X	X		X	X					PLANET would pick up some features such as rising soil nutrients and provide correspondingly lower recommendations.	Very few dairy farmers in our Case Study area.	Nutrient management is a requirement in NVZ in Case study	
14	NL	Adviesbasis CBGV	X			X	X					AHDB fertiliser manual	Our case study is focussed on pesticides	Nutrient management a requirement in NVZ in case staudy	
15	NL	Beregeningswijzer	X						X			Several chargeable point based (in-field monitors) and field based model systems are available that optimise irrigation use for crop quality with associated aim to avoid runoff/leaching.		V	
16	NL	BedrijfsWaterWijzer (BWW)	X	X		X			X	X		No	Our case study is focussed on pesticides	V	
17	NL	Bodemconditiescore	X									A version of Visual Soil Assessment is available in the UK.	We have used VSA type training for a soils event in the control area of our Case study	V	
18	NL	NDICEA										No	Our case study is focussed on pesticides		
19	NL	Environmental Yardstick	X			X						Some on pesticide label, some in Environmental Information Sheets on Voluntary Initiative website	Interesting to see label, aurthorisation and biological / ecological information in one place	V	X
20	NL	STONE	X	X	X				X				Our case study is focussed on pesticides		
21	NO	Catchment-lake modelling network	?				X		X				Our case study is focussed on pesticides		
22	NO	Skifteplan	X			X	X					PLANET covers many of the functions	Our case study is focussed on pesticides		
23	NO	Agro-meteorological service	X	X			X					Several farming oriented weather apps are available			
24	SI	Načrtovanje gnojenja	X			X	X					Similar to AHDB Fertiliser Manual and PLANET	Our Case Study is focussed on pesticides		
25	SI	Smernice za strokovno gnojenje	X			X	X					Similar to AHDB Fertilsier Manual and PLANET	Our Case Study is focussed on pesticides		
26	SI	OECD/EUROSTAT N balance							X			All farmers in NVZ must follow nutrient management rules	Our Case Study is focussed on pesticides		
27	SI	GROWA-SI	X	X	X	X	X		X				Specialist software for policy use in Slovenia		

28	SI	State network of groundwater monitoring points	X				X					Environment Agency and Water Companies maintain monitoring networks and data is available			
29	SI	FITO-INFO	X			X	X					Data available through AHDB and Pesticide Green Book	Country specific		
30	UK	PLANET											Commonly used by agronomists (usually built into bespoke agronomy software, but can be standalone) in our Case Study area.		
31	UK	FARMSCOPER											Available in Case Study Area but we are not aware of any farmers or advisers using the tool		
32	UK	Check it out											Available in our Case Study and may be used by advisers and catchment advisers as a basis for providing advice.		
33	UK	Sentinel Online											Some agronomists report using this information.		
34	UK	Procheck											Can be used by agronomists		
35	UK	SCIMAP											Catchment scale modelling		
36	UK	WaterAware											Freely available in Case Study area but unsure how widely it is used.		

7.1.3 **France - La Voulzie**

			Barriers											
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	…	**A similar DST to handle the task is already in use in your country Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	X			X	X		X				“Eau de Paris” focus on pesticides		
2	DE	ISIP	X				X		X				“Eau de Paris” focus on pesticides		
3	DK	Mark Online	X				X	X (commercial)	X						
4	DK	Dyrkningsvejledninger	X			X			X						
5	DK	Plant Protection Online		X				X (commercial)		X					
6	DK	CTzoom/CTtools	X	X		X	X	X	x	x			“Eau de Paris” focus on pesticides		
7	DK	BEST Kemi	X	X	X	X	X	Not available to public	X	X			Designed for Denmark		
8	DK	TargetEconN	X	X	X	X	X	X Not available to public	X	x			“Eau de Paris” focus on pesticides		
9	FR	PHYTOPIXAL		X	x				x	x			This DT is too much in the academic field / research to be deployed now	Voluntary	
10	FR	SIRIS											**Commentary One:** In France, there is a database providing the total volume of pesticides SOLD per commune since 2007 (BNV-d). It is possible to make multi-community requests and for specific catchment basin sizes. This database provides export format specifically compatible for SIRIS. Pesticide application volumes are therefore not a limitation in France. Link to the BNV-d : *https://bnvd.ineris.fr/* **Comment two**: Local specificities are taken into account by the sales database at the commune level.	Voluntary	x

11	IE	Teagasc NMP online	X				X						“Eau de Paris” focus on pesticides		
12	IE	FarmHedge	X			X							“Eau de Paris” focus on pesticides		
13	NL	ANCA	X			X	X (available only to registered dairy farmers)						“Eau de Paris” focus on pesticides		
14	NL	Adviesbasis CBGV	X			X							“Eau de Paris” focus on pesticides		
15	NL	Beregeningswijzer	X			X							“Eau de Paris” focus on pesticides		
16	NL	BedrijfsWaterWijzer (BWW)	X			X							“Eau de Paris” focus on pesticides		
17	NL	Bodemconditiescore	X				X						“Eau de Paris” focus on pesticides		
18	NL	NDICEA	X										“Eau de Paris” focus on pesticides		
19	NL	Environmental Yardstick	X				X								
20	NL	STONE	X												
21	NO	Catchment-lake modelling network	X						X (complex model component – needs expertise)	X					
22	NO	Skifteplan	X												
23	NO	Agro-meteorological service	X	X		X	X				X		Seem to be specific to Norwegian farmers		
24	SI	Načrtovanje gnojenja	X												
25	SI	Smernice za strokovno gnojenje	X												
26	SI	OECD/EUROSTAT N balance	X						X						

27	SI	GROWA-SI	X	X	X	X	X		X	(X)	X		“Eau de Paris” focus on pesticides		
28	SI	State network of groundwater monitoring points	X	X	X	X	X				X		Seem to be specific to Slovenian farm types		
29	SI	FITO-INFO	X	X		X	X				X				
30	UK	PLANET	X										“Eau de Paris” focus on pesticides		
31	UK	FARMSCOPER	X			X	X								
32	UK	Check it out	X												
33	UK	Sentinel Online	X												
34	UK	Procheck	X												
35	UK	SCIMAP	X	X					X		X				
36	UK	WaterAware	X	X			X				X				

7.1.4 **Germany - Lower Saxony**

			Barriers											
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is	Software access	…	**A similar DST to handle the task is already in use in your country Yes/No**	**Comments on main use in our case study**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6										Currently in use	Düngeplanung is currently in use in our case study Lower Saxony. It is used to generate fertilization plans based on the agronomic optimum considering legal restrictions. Furthermore, it includes a number of agronomics aspects (esp. plant nutrition).	Both. Some elements are legally binding but Düngeplanung goes beyond these requirements	
2	DE	ISIP										Currently in use	ISIP has been used to estimate N-mineralization during growing season on field scale-	Voluntary	
3	DK	Mark Online	x	(x)		x	(x)			(X) account required		Yes, Düngeplanung contains many similar elements	Generation of fertilizing plans according to Danish system. Examination how data management in Mark Online is organized • General management of agronomic farm data • Fertilization management (calculation of N-quota, P-fertilization, …) • Spraying schemes for farmers)		X
4	DK	Dyrkningsvejledninger	x			x	(x)			(X) account required		Yes, In Lower Saxony frequent newsletters and a comprehensive paper-based manual that contain similar information.	Is very helpful to understand how the agricultural legislation and recommendations in Denmark look like.		
5	DK	Plant Protection Online				X Some product used in Germany are banned in Denmark and the other way around					We focus on nitrate	Yes, different data bases exist (both public and private) which list products available, specify information (including restrictions)			
6	DK	CTzoom/CTtools	x	x					x	(x)	Too complex; Scale does not fir (we mainly work on field scale)	In Lower Saxony, there is a similar approach. Here the federal authority for mining, energy and geology calculates the potential nitrate concentration in the groundwater based on land use, soil and climatic conditions (the so-called “basic emission monitoring”).	It would be interesting to compare the systems of Denmark and Germany. However, the Danish one is tailored to the Danish database and testing would become very complex.		
7	DK	BEST Kemi	x	x						(x)	Scale does not fit We focus on nitrate	Before a plant protection product is approved, a similar modelling procedure is executed.	Testing would be very comprehensive and does not fit the focus of our case study site		
8	DK	TargetEconN	x	x		(x)	x		x	(X)	Too complex; Scale does not fit (we mainly work on field scale)	Yes, LWK and Federal Ministry for Nature Protection (NLWKN) calculate costs for mitigation methods based on field trials.			

9	FR	PHYTOPIXAL	x	x	x		x	(x)	x	(x)	Scale does not fit (we mainly work on field scale)	?	Not sufficient information about input data available.		
10	FR	SIRIS	x	(x)	x	?	?				We focus on nitrate	?	Not sufficient information about input data available.		
11	IE	Teagasc NMP online		?	?			x		?		Yes, Düngeplanung contains many similar elements	Calculate fertilization plans according to the Irish system Finding out how geographically data is integrated		x
12	IE	FarmHedge		x		(x)	x				Tailored to Irish infrastructure	Yes, different weather apps (combined with recommendations), however, mainly provided by private companies.			
13	NL	ANCA	x			x	(x)				In our case study we do not focus on dairy production	Yes, in Germany it is legally binding to calculate comprehensive nutrient balances including losses/emissions of animal keeping. However, specific measures are not included.	Calculate losses of dairy farms with own data set – compare it to system of Lower Saxony. Investigate measures implemented in ANCA		x
14	NL	Adviesbasis CBGV	x					(x)				Yes, In Lower Saxony frequent newsletters and a comprehensive paper-based manual that contain similar information.			
15	NL	Beregeningswijzer	x					(x)				Yes, ISIP contains a module for irrigation management. Furthermore, other (free-access) models exist to calculate soil-water-dynamics.			
16	NL	BedrijfsWaterWijzer (BWW)	x								In our case study we do not focus on dairy production	No			
17	NL	Bodemconditiescore	x												
18	NL	NDICEA		(x) Not clear yet if live weather data can of our case study can be included			X Pest monitoring include in DST is country-specific					Yes, tests to asses soil quality do exist (e. g.).	Investigating how soil quality is assessed in NDICEA (Are there differences with the methods we use?) Findin.g out how the IT interface is designed		x
19	NL	Environmental Yardstick									We focus on nitrate	No			
20	NL	STONE	x	x	x	?	x		x		Scale does not fit; too complex				
21	NO	Catchment-lake modelling network	?	x	x		x		x		Scale does not fit; too complex				
22	NO	Skifteplan	?			x	x	x		x		Yes, Düngeplanung contains many similar elements	The integration of the water balacance in the soil is potentially interesting.		

23	NO	Agro-meteorological service					x					Yes			
24	SI	Načrtovanje gnojenja	x		x	x	(x)			x		Yes, Düngeplanung also covers some additional aspects such as mineralization of harvest residues.			
25	SI	Smernice za strokovno gnojenje	x			x	x					Yes, In Lower Saxony frequent newsletters and a comprehensive paper-based manual that contain similar information.			
26	SI	OECD/EUROSTAT N balance										Yes, in Germany all farmers are obliged to calculate a (standardized) nutrient balance			
27	SI	GROWA-SI	x			X	x		(x)	x		Yes, GROWA has also been calibrated to other regions of Germany			
28	SI	State network of groundwater monitoring points	x				x					Yes, the Ministry for Nature Protection (NLWKN) maintain a dense monitoring network. Furthermore, water companies offer free access to their measurement results.			
29	SI	FITO-INFO	x			x	x					Yes, In Lower Saxony frequent newsletters and a comprehensive paper-based manual that contain similar information.			
30	UK	PLANET		(x)		x	x					Yes, but not combined in one application	The idea to combine information on crop management with production of organic manure in order to identify nitrate sensitive areas, is potentially interesting. However, PLANT is tailored to England and Wales so far.		
31	UK	FARMSCOPER		(x)			x				Scale does not fit (when workind wirh individual farmers, general recommendation on measures are not useful)	Yes, there are comprehensive catalogues describing all (approved) mitigation methods in detail.			
32	UK	Check it out				x	x				We focus on nitrate.				
33	UK	Sentinel Online				x	x			x	We focus on nitrate.				
34	UK	Procheck				x	x	x			We focus on nitrate.				
35	UK	SCIMAP				(x)	(x)				We focus on nitrate.				
36	UK	WaterAware				(x)	(x)				We focus on nitrate.	Generally yes but not specific for mollucicides.			

7.1.5 Northern Ireland - Derg catchment

			Barriers												
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	…	**A similar DST to handle the task is already in use in your country Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	X			X	X	X (non-advisors have to pay)			Our focus is pesticides	Yes		Both	
2	DE	ISIP	X				X				Our focus is pesticides	No		Vol	
3	DK	Mark Online	X				X	X (commercial)		X		Yes	Has a similar function to NMP Online in IE	Vol	
4	DK	Dyrkningsvejledninger	X			X						No	Optimised for Danish approved and tested pesticides.Danish field trials used to optimise results – may not be applicable in IE. A lot of adaptation would be needed.	Vol	
5	DK	Plant Protection Online		X				X (commercial)				No	Real-time weather data may not be available for IE or NI. A lot of adaptation would be needed. The price: E180/ha is very expensive!	Vol	
6	DK	CTzoom/CTtools	X	X		X	X	X			Our focus is pesticides	No		Vol	
7	DK	BEST Kemi	X	X	X	X	X	Not available to public	X	X	Software developed for each municipality – will not be transferrable	No	Designed for Denmark and requires access to GEUS Jupiter database of wells and boreholes. Requires local groundwater chemical monitoring data. A lot of adaptation would be needed.	Both	
8	DK	TargetEconN	X	X	X	X	X	X Not available to public	X		Our focus is pesticides	No			
9	FR	PHYTOPIXAL	X	X	X				Needs GIS expertise	X	Requires site specific calibration – but we will still try it in IE	Yes	Contaminant risk model – similar to SCIMAP but with adaptations already in place for pesticides which justifies trialling it. The model requires a lot of data and testing to adapt to other study areas.		**X**
10	FR	SIRIS	X		X	?						No	French databases on pesticides are use but should be applicable across Europe. We will test this if we have time – however it is not as directly applicable to our case study as some of the other DSTs.		
11	IE	Teagasc NMP online						X			Our focus is pesticides	Not in NI	.		
12	IE	FarmHedge					X				Our focus is pesticides				

13	NL	ANCA	X				X	X (available only to registered dairy farmers)			Our focus is pesticides			
14	NL	Adviesbasis CBGV	X				X				Our focus is pesticides			
15	NL	Beregeningswijzer	X				X	X (not sure how much)			Our focus is pesticides			
16	NL	BedrijfsWaterWijzer (BWW)	X				X				Our focus is pesticides			
17	NL	Bodemconditiescore	X				X				Our focus is pesticides			
18	NL	NDICEA									Our focus is pesticides			
19	NL	Environmental Yardstick					X				Does not consider runoff transfers. Only spray drift.		We were considering use of EY in our case study but the model does not consider runoff transfers of pesticides to waterways (only spray drift - to date) and this is the key transfer pathway in our catchment.	
20	NL	STONE									Our focus is pesticides			
21	NO	Catchment-lake modelling network							X (complex model component – needs expertise)	X	Our focus is pesticides			
22	NO	Skifteplan	?								Our focus is pesticides	Yes		
23	NO	Agro-meteorological service	X	X		X	X					No	The DST is developed specifically for Norwegian farmers; focus on optimum application of nutrients and pesticides. Would require a lot of adaptation for use in IE.	
24	SI	Načrtovanje gnojenja	X								Our focus is pesticides			
25	SI	Smernice za strokovno gnojenje	X								Our focus is pesticides			
26	SI	OECD/EUROSTAT N balance							X very high skill level required		Our focus is pesticides			
27	SI	GROWA-SI	X	X	X	X	X		X	X (only for Slovenian Env Agency)	Our focus is pesticides			
28	SI	State network of groundwater monitoring points	X	X	X	X	X						Specific to Slovenian farm types and farming practices. Would need major re-development for use in IE.	

29	SI	FITO-INFO	X	X		X	X						Specific to Slovenian farm types and farming practices. Would need major re-development for use in IE.		
30	UK	PLANET									Our focus is pesticides	Yes	NMP online is similar.		
31	UK	FARMSCOPER				X	X						Farmscoper was developed for English and Welsh farms and farming practices. The nutrient attenuation models on which the model is based may not be applicable to other soil types and climatic zones. Mitigation measures may need adapted to suit Irish farming practices. Our use of Farmscoper will focus on pesticides.		**X**
32	UK	Check it out							Simple training tool				Tool to improve farmer practice when using pesticides. E-learning tool. Could be useful if integrated in another app but on its own not a priority at present.		
33	UK	Sentinel Online							Simple online tool			No	Developed for the UK only but should also apply (with caveats) within IE. Quick access to the information needed for decision making in pesticide use for farmers.		
34	UK	Procheck		?	?	?	?						Seems a general look-up on pesticide availabilities and properties for the UK. Could be useful if integrated in another app but on its own not a priority at present.		
35	UK	SCIMAP		X					Need experience in GIS			SCIMAP is already used for surface contaminant (sediment/phosphorus) risk modelling	A high resolution digital elevation model is required (minimum 2m) for accurate field-scale modelling of risk. The model is well-supported and widely used. Adaptations for pesticides will be needed. Models surface water movement so more applicable to P than N in Irish landscape. Further information of surface transport of pesticides required.		**X**
36	UK	WaterAware		X			X				Developed by commercial company		WaterAware requires the EA WIMBY maps – the equivalent are not available in IE/NI. Real-time weather data are also required. A lot of adaptation would be needed.		

7.1.6 The Netherlands - Overijssel

			Barriers											
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	...	**A similar DST to handle the task is already in use in your country Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6													X
2	DE	ISIP					X				X	Yes	ISIP supports fertilization in winter wheat. This is not so relevant for the case of Overijssel		
3	DK	Mark Online	X								X		Seems very broad.		
4	DK	Dyrkningsvejledninger	X				X								
5	DK	Plant Protection Online									X	Yes	Issue not most relevant in case Overijsel		
6	DK	CTzoom/CTtools	X				X					yes	After tuning to the Dutch circumstances, added value to tools currently used in NL would probably be low.		
7	DK	BEST Kemi		X			X					Yes	Issue not most relevant in case Overijsel. Focus in Overijssel is on farm management.		
8	DKx	TargetEconN				X						No	Catchment scale is indirectly relevant in Overijssel. Interesting concept. But seems impossible to adopt on the short term.		
9	FR	PHYTOPIXAL					X					yes	Interesting stuff for model developers working on transport of contaminants on catchment scale. Not main focus in Overijssel.		
10	FR	SIRIS					X					Yes	Issue not most relevant in case Overijsel. In focus in other Dutch case		
11	IE	Teagasc NMP online				X						yes	Interesting tool. But we already test Dungeplannung. This tool seemingly does not address application limits that are set by regulation and has great similarities with Dungeplannung and PerceelsVerdeler. Therefore, added value could be limited.		
12	IE	FarmHedge					X					No	Run off not major problem in the Netherlands		

13	NL	ANCA										Yes	Already applied in Overijssel		
14	NL	Adviesbasis CBGV										Yes	Already applied in Overijssel		
15	NL	Beregeningswijzer										Yes	Already applied in Overijssel		
16	NL	BedrijfsWaterWijzer (BWW)										Yes	Already applied in Overijssel		
17	NL	Bodemconditiescore										Yes	Already applied in Overijssel		
18	NL	NDICEA										Yes	Already applied in Overijssel		
19	NL	Environmental Yardstick										Yes	Already applied in Overijssel		
20	NL	STONE										Yes	Not relevant because this Stone functions predominantly as a policy evaluation tool. Too much focus on catchment scale		
21	NO	Catchment-lake modelling network					X					Yes	Too much focus on catchment scale, whereas case Overijssel act in the domain of farm management		
22	NO	Skifteplan	X				X					Yes	Too much focus on catchment scale, whereas case Overijssel act in the domain of farm management		
23	NO	Agro-meteorological service	X				X					Yes	Seems not applicable in the Netherlands		
24	SI	Načrtovanje gnojenja					X					Yes	Interesting tool. But we already test Dungeplannung. This tool seemingly does not address application limits that are set by regulation and has great similarities with Dungeplannung and PerceelsVerdeler. Therefore, added value could be limited.		
25	SI	Smernice za strokovno gnojenje					X					Yes	Interesting tool. But we already test Dungeplannung. Not sure about the direct applicability under different circumstances.		
26	SI	OECD/EUROSTAT N balance									X	Yes	Already covered by other tools that perform well.		
27	SI	GROWA-SI					X				X	yes	Only indirectly relevant for Overijssel. High emphasis on catchment and water flow modelling.		
28	SI	State network of groundwater monitoring points										yes	Too much focus on catchment scale, whereas case Overijssel act in the domain of farm management		
29	SI	FITO-INFO													

30	UK	PLANET					X					yes	See Manner NPK		
31	UK	FARMSCOPER										No	Very interesting tool. But beyond the scope of case Overijsel. Interested in exchange on this approach for national explorations.		
32	UK	Check it out										No	Interesting. This is so open, that we already learned from this system without recording it as an official exchange. It shows how to pose good questions!		(X)
33	UK	Sentinel Online										No	Attractive interface. So inspires, but beyond the scope of case Overijssel.		
34	UK	Procheck										No	Not most relevant (no N, P) for case Overijssel		
35	UK	SCIMAP							X				Questionable if this is really relevant and handy on farm scale, which is the domein of case Overijssel.		
36	UK	WaterAware										?	Attractive interface. So inspires, but beyond the scope of case Overijssel.		

7.1.7 The Netherlands - Noord Brabant

			Barriers												
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	…	**A similar DST to handle the task is already in use in your country** **Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6									We focus on pesticides				
2	DE	ISIP									We focus on pesticides				
3	DK	Mark Online				x						Yes	In the Netherlands there are several private farm information management system that part of the farmers uses esp. those that are required to do so by their buyers. We were impressed by the comprehensiveness of Mark Online and high share of farmers using this program, but we don't see how we could introduce such a system as long as there is no legal obligation for farmers to keep and share digital information on their spraying schemes with the authorities.	Voluntary	
4	DK	Dyrkningsvejledninger	X				X					Yes, Noord-Brabant frequent newsletters, emails with crop recommendations and comprehensive manuals that contain similar information.			
5	DK	Plant Protection Online					X In Denmark the range of herbicides that are allowed is much smaller than in the Netherlands					No, not in this form: there are tables on the effectivity of herbicides on different weed species, but no dosage recommendation based on growth stage and density	We are interested in recommendations on lower dosing of herbicides based on growth stage and weed density. However, we struggle with the recommendations since they are based on the small range of herbicides allowed in Denmark. For example, terbutylazin is not included which is a herbicide effective against Crane's-bill , Common stork's-bill, but very prone to leaching. So apart from PPO, we are now trying to make a comparison with Pesticide Load Indicator and the Environmental Yardstick for pesticides.	Voluntary	x
6	DK	CTzoom/CTtools									We focus on pesticides				
7	DK	BEST Kemi									Drinking water companies in NL are probably using the similar modelling procedure. Not our scope: we focus on farm advice				

8	DK	TargetEconN									We focus on pesticides				
9	FR	PHYTOPIXAL	x	x	x		x	(x)	x	(x)	Too complex for farmer's use. Scale does not fit (we work on field scale)	?	Not sufficient information about input data available.		
10	FR	SIRIS									Not updated since 2012?		Might be interesting to compare input data (pesticides properties) and outcomes with the Environmental Yardstick for Pesticides? Just as a theoretical exercise, we will not test SIRIS in our casestudy area.		
11	IE	Teagasc NMP online									We focus on pesticides				
12	IE	FarmHedge					x				Only one advice on pesticides (wind speed to avoid spray drift)	For spray drift, several wheather forecast systems exist		Voluntary	
13	NL	ANCA									We focus on pesticides				
14	NL	Adviesbasis CBGV									We focus on pesticides				
15	NL	Beregeningswijzer									We focus on pesticides				
16	NL	BedrijfsWaterWijzer (BWW)									We focus on pesticides				
17	NL	Bodemconditiescore										We work with a likewise method: Delphy Bodemschat			
18	NL	NDICEA									We focus on pesticides				
19	NL	Environmental Yardstick										Currently in use			
20	NL	STONE									We focus on pesticides				
21	NO	Catchment-lake modelling network									We focus on pesticides. Scale does not fit; too complex				
22	NO	Skifteplan									We focus on pesticides				
23	NO	Agro-meteorological service					X					Yes, several systems exist in the Neterlands			
24	SI	Načrtovanje gnojenja									We focus on pesticides				

25	SI	Smernice za strokovno gnojenje								We focus on pesticides				
26	SI	OECD/EUROSTAT N balance								We focus on pesticides				
27	SI	GROWA-SI								We focus on pesticides				
28	SI	State network of groundwater monitoring points									Yes, the waterboards and water companies maintain a dense monitoring network.			
29	SI	FITO-INFO	X			X	x				Yes, in public websites (on registered plant protection products and their use requirements), in private DSTs phenological forecasting models on pest and diseases			
30	UK	PLANET								We focus on pesticides				
31	UK	FARMSCOPER								We focus on pesticides (and scale does not fit, as we tailor advice to individual farmers)				
32	UK	Check it out									Yes, we have a likewise tool to prevent farmyard leaching and also on planning/in field use of pesticides	On farmyard emission we have a nice tool in Dutch developed for arable farming, fruit orchards and flower bulbgrowing: . We have a English translation available in word. A DST to promote IPM in planning plant protection and prevention emissions by pesticide use is	Voluntary. Legislative: Farmers need too show that they have filled out a IPM-plan, but the format is not stipulated.	
33	UK	Sentinel Online				X					Yes, we have public websites on registered plant protection products and their use requirements and on pest, disease and weed indentification.			
34	UK	Procheck				X			x		Yes, public websites on registered plant protection products and private manuals.			
35	UK	SCIMAP								We focus on pesticides				

36	UK	WaterAware										Methaldehyde is forbidden in NL so environmental impact of mollucicides is not a priority for us.			

7.1.8 **Norway - Vansjø**

			Barriers												
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is	Software access	⋮	**A similar DST to handle the task is already in use in your country** **Yes/No**	**Comments on main use in our case study**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	x			x						Yes	Various farmer information systems are already in use in Norway to generate fertilizer plans based on the agronomic optimum (e.g. Skifteplan, Jordplan).		
2	DE	ISIP	x				x					No	Too much development work required to adapt it to our case study site.		
3	DK	Mark Online	x			x						Yes	Various farmer information systems are already in use in Norway to generate fertilizer plans based on the agronomic optimum (e.g. Skifteplan, Jordplan).		
4	DK	Dyrkningsvejledninger					x			x		Yes	Similar products in use in Norway include: The fertilizer handbook () (an annual handbook) (manuals for organic farming)		
5	DK	Plant Protection Online						x				No?	To my knowledge, no field-scale DST focusing on pesticides is in common use in Norway. We do however have VIPS (), a web-based tool which provides warning of pest attacks based on weather forecast and reports of incidents and modelling. In our case study site we are not focusing on pesticides.		
6	DK	CTzoom/CTtools					x			x		Yes	A simple tool to calculate root zone N concentration and any associated need for extra fertilization within the growing season, given weather, is		
7	DK	BEST Kemi		x	x		x					No	There is very little groundwater in Norway, so this DST is not relevant in our catchment.		
8	DK	TargetEconN		x							Large time investment to develop and transfer to our catchment, where P is the main problem.	No?	Nothing similar available to my knowledge		
9	FR	PHYTOPIXAL	x	x	x				x			No?	Looks like a nice tool, although with some big barriers to transferability (would require much support from the development team). In our case study site we are not focusing on pesticides, so it is not relevant to us.		
10	FR	SIRIS	x									?	In our case study site we are not focusing on pesticides, so it is not relevant to us in this project. Looks interesting though.		
11	IE	Teagasc NMP online				x				x		Yes			
12	IE	FarmHedge					x				Adapting the app to a new country becomes onerous because of the commercial side/farmer networking	Yes	Agrometeorology Norway (lmt.nibio.no) and VIPS contain some similar features, and some others not included in FarmHedge. VIPS is available as both a web version and an app.		
13	NL	ANCA				x	x					Yes	Some elements of this tool are present in e.g. Skifteplan		
14	NL	Adviesbasis CBGV	x				x					Yes	Similar farm advice in Norway from e.g. Skifteplan/Jordplan and the fertilizer handbook ()		

15	NL	Beregeningswijzer	x	x			x	x				Yes	Similar irrigation advice provided in Norway through VIPS ()		
16	NL	BedrijfsWaterWijzer (BWW)	x		x		x					No	There is little dairy farming in our case study		
17	NL	Bodemconditiescore	x									Yes	Around 55% of Norway's agricultural soils have been mapped by NIBIO and the results are publically available from GeoNorge. The dataset includes many different soil properties aside from broad soil type.		
18	NL	NDICEA					x				Model adaptaion/calibration/validation required for regions with substantial snowfall/soil frost. Data for this may not be available from our catchment.	Yes	A tool produced by NIBIO () contains similar elements to NDICEA.		
19	NL	Environmental Yardstick					x?					No	In our case study site we are not focusing on pesticides, so it is not relevant to us in this project. Looks interesting though.		
20	NL	STONE		x	x		x		x	x		No	In our case study site several tools with similar outputs are in use – the NIVA catchment-lake modelling network (focus on N and P), as well as NIBIO's Agricat (which focuses on P). These are catchment-based though, rather than regional/national, as STONE is.		
21	NO	Catchment-lake modelling network										Yes	This is used in our study site for strategic/longer-term decision support, in particular for e.g. catchment managers and policy advice.	Voluntary	
22	NO	Skifteplan										Yes	Widely-used nutrient management tool in Norway, used to generate annual fertilization plans.	Voluntary, although all farmers must produce a fertilization plan, and tools such as Skifteplan are often the best way of doing this	
23	NO	Agro-meteorological service										Yes	Used by farmers to advise farming activities based on the weather forecast	Voluntary	
24	SI	Načrtovanje gnojenja	x							x		Yes	Similar tools used in our catchment: skifteplan, jordplan		
25	SI	Smernice za strokovno gnojenje	x			x	x					Yes	Similar products in use in Norway include: The fertilizer handbook () (an annual handbook) (manuals for organic farming)		
26	SI	OECD/EUROSTAT N balance										Yes			
27	SI	GROWA-SI	x				x			x		Yes	The Teotil export coefficient model would be the Norwegian equivalent, although it has more limited functionality. Few surface waters in Norway are thought to be vulnerable to N-related inputs, and those that are are primarily coastal. Tools which estimate fluxes to the coast are therefore of most use (like Teotil).		
28	SI	State network of groundwater monitoring points										Yes			
29	SI	FITO-INFO	x			x	x					Yes	Similar information is available in the form of manuals and web-material. There is also VIPS (), a web-based tool which provides warning of pest attacks based on weather forecast and reports of incidents and modelling. In our case study site we are not focusing on pesticides.		
30	UK	PLANET				x	x					Yes	DSTs similar to the nutrient management part of PLANET exist in Norway. The link to NVZ regulations is not relevant in much of Norway, as most Norwegian agricultural land is not within an NVZ.		

31	UK	FARMSCOPER					x					No	A useful-looking tool, but too much work required to adapt it for Norwegian conditions. Elements of the tool are present in various DSTs in use in the catchment (e.g. Agricat and INCA models)		
32	UK	Check it out										No	Could be useful. Though in our case study we are not focusing on pesticides.		
33	UK	Sentinel Online				x	x					Yes	This pulls together functionality from various Norwegian DSTs into one place		
34	UK	Procheck				x	x	x				Yes	contains much of this information, including the ability to download relevant information		
35	UK	SCIMAP					x					Yes	Norwegian soil erodibility maps bring together similar data streams		
36	UK	WaterAware					x					No	Similar tools exist in Norway, but do not go so far as to highlight risk of leaching of pesticides. This could be a useful extension to existing tools. However, in our case study we are not focusing on pesticides.		

7.1.9 **Portugal - Baixo Mondego**

			Barriers												
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	We are not interested in study these properties	**A similar DST to handle the task is already in use in your country** **Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	X									No	The Regional Direction for Agriculture in Portugal has established a guide of good agricultural practices, with fertilization plan, in vulnerable areas to nitrate pollution.		
2	DE	ISIP	X									No	The Regional Direction for Agriculture in Portugal has established a guide of good agricultural practices, with fertilization plan, in vulnerable areas to nitrate pollution.		
3	DK	Mark Online	X									No	The Regional Direction for Agriculture in Portugal has established a guide of good agricultural practices, with fertilization plan, in vulnerable areas to nitrate pollution.		
4	DK	Dyrkningsvejledninger	X									No	The Regional Direction for Agriculture in Portugal has established a guide of good agricultural practices in vulnerable areas to nitrate pollution.		
5	DK	Plant Protection Online					X					No			
6	DK	CTzoom/CTtools	X									No			
7	DK	BEST Kemi					X					No	In Portugal, the farmers need a certificate to buy and spray pesticides in the fields.		
8	DK	TargetEconN					X					No			
9	FR	PHYTOPIXAL	X									No			
10	FR	SIRIS	X									No			
11	IE	Teagasc NMP online					X					No			
12	IE	FarmHedge					X					No			

13	NL	ANCA						X				No			
14	NL	Adviesbasis CBGV	X									No			
15	NL	Beregeningswijzer	X									No			
16	NL	BedrijfsWaterWijzer (BWW)	X									No			
17	NL	Bodemconditiescore	X									No			
18	NL	NDICEA						X				No			
19	NL	Environmental Yardstick										X	No		
20	NL	STONE						X				No			
21	NO	Catchment-lake modelling network										No			
22	NO	Skifteplan						X				No			
23	NO	Agro-meteorological service						X				No			
24	SI	Načrtovanje gnojenja	X									No			
25	SI	Smernice za strokovno gnojenje	X									No			
26	SI	OECD/EUROSTAT N balance										No			
27	SI	GROWA-SI						X				No			
28	SI	State network of groundwater monitoring points						X				No			
29	SI	FITO-INFO						X				No			

30	UK	PLANET					X					No	We will try to test and apply part of PLANET (Tool manures) in Portugal.		X
31	UK	FARMSCOPER					X					No	We will try to test and apply part of FARMSCOPER (Nitrates) in Portugal.		X
32	UK	Check it out									X	No	In Portugal, the farmers need a certificate to buy and spray pesticides in the fields.		
33	UK	Sentinel Online									X	No			
34	UK	Procheck									X	No			
35	UK	SCIMAP									X	No			
36	UK	WaterAware									X	No	Portuguese Environment Agency has mapped vulnerable areas to nitrate pollution in 2016.		

7.1.10 **Slovenia - Dravsko Polje**

			Barriers											
No.		**DST name**	Language	Data requirements	Lack of support / documentation	Developed based on country specific legislation	Differences between regions (e.g. climate) / farm types	Financial cost	Specialist software or skills required (e.g. if ran in GIS and no one in the case study area is experienced.)	Software access	…	**A DST to handle the task is already in use in your country Yes/No**	**Comments on main use**	**Legislative or Voluntary**	**Mark the DST you select for testing**
1	DE	Düngeplanung 1.6	X			X						Yes	Slovenia has already the program Načrtovanje gnojenja to fertilizer plans. However, German set of mind is close to Slovenian, German case study has similar groundwater quality problems that why we are interested in how it works in Germany.		
2	DE	ISIP	X									No	The method in Slovenia are called N-MIN-Metoda. It is performed in the field and measures actual content of nitrate in the soil.		
3	DK	Mark Online	x					X				No (only smart part)	We have similar tool but with considerably less functions. High cost, county specific tool.		
4	DK	Dyrkningsvejledninger	X				X					Yes	We have standard fertilisation guide, which is not based on field trials		
5	DK	Plant Protection Online	x			x	x	x				No	Plant protection products are under control in Case study.		
6	DK	CTzoom/CTtools	x			x	x	x	x	x		No	County specific tool, would need modification.		
7	DK	BEST Kemi	x	x		x	x	x	x	X		No	Demanding for general users.		
8	DK	TargetEconN	x	x		x	x		x	x		No	Demanding for general users.		
9	FR	PHYTOPIXAL	x		x				x	x		No	Demanding for general users.		
10	FR	SIRIS	x	x			x					No	Problem in language		
11	IE	Teagasc NMP online	x									Yes	Slovenia has already the program Načrtovanje gnojenja to fertilizer plans.		
12	IE	FarmHedge	x			x	x					No	Designed for specific area of interest. We have problem with groundwater.		
13	NL	ANCA	x									No	Very interesting for our case study. In Dravsko polje dairy production generating excess nutrients is a big problem. It seem it could contribute to our case study. It is prepared to be used on individual farms.		√ - 1 First choice
14	NL	Adviesbasis CBGV	X									Yes	We have standard fertilisation guide.		
15	NL	Beregeningswijzer	x				x		x	x		No	It is commercial software.		
16	NL	BedrijfsWaterWijzer (BWW)	x							x		Yes	Very interesting as it addresses nutrient balance on a dairy farms. This would be interesting tool to be demonstrated or tested in Dravsko polje.		√ - 2 – it could be demonstrated at the same time as it was developed by the same group.
17	NL	Bodemconditiescore	x									No	It is a Visual Soil Assessment tool doesn't include N or P.		
18	NL	NDICEA	X				x					No	It is interesting as it is specified for organic production.		

19	NL	Environmental Yardstick	X									No	Plant protection products are under control in Case study.		
20	NL	STONE	X			x	x					Yes	Slovenia has similar tool GROWA.		
21	NO	Catchment-lake modelling network	X									No	Lake water quality is not a problem in Dravsko polje CS.		
22	NO	Skifteplan	x			x	x					Yes	We have standard fertilisation guide.		
23	NO	Agro-meteorological service	x			x	x					Yes	We have this service Slovenia		
24	SI	Načrtovanje gnojenja											Intended to assist agricultural advisers and farmers to optimize fertilizer use in all agricultural sectors, most notably in horticulture and field crop agriculture. With its help, we can quickly calculate the recommended quantities for phosphorus, potassium and nitrogen fertilizers, both with organic as well as with easily soluble mineral fertilizers, as well as the need for land lime. We can make annual or multi-year fertilization plans, while at the same time we can plan the correct crop rotation and take into account the amount of organic fertilizers on the farm.	L	
25	SI	Smernice za strokovno gnojenje											A collection of the main fertilizer applicationinstructions based on experience, plant development observations, and chemical analyses of soil and plant parts. The guidelines are in line with the regulations and requirements for the quality of crops and the preservation of a clean environment, and aim to set a broader framework that is not based solely on political decisions or fashion trends, but on rational expert findings.	V/L	
26	SI	OECD/EUROSTAT N balance											This handbook sets out the main principles of the methodology across OECD and EU Member countries. The aim is to be able to consistently produce an indicator based on a single methodology and harmonised definitions for all countries. In Slovenia results are prepared by Agricultural Institute for Ministry of environment and spatial planning. This paper based tool serves as basis for reporting to EU about Nitrate directive implementation and as basis for preparation of legislation and measures for drinking water protection.	L	
27	SI	GROWA-SI											The regional water balance model GROWA-SI (Water Quality model) is the official state model for reporting of Nitrate directive implementation on country wide level. It was developed by JULICH Institute form Germany for Slovenian Environmental Agency (SEA). It can calculate groundwater recharge rates for Slovenia. It has the capability to account also N balances.	L	
28	SI	State network of groundwater monitoring points											Policy makers and water managers (Ministry, Environmental Agency) accept their decisions based on the state approved water quality monitoring network. Measured values and their trends over the years serve as one of the base indicators for actions in introducing new measures or of success of in the past introduced measures. Temporal scale of state monitoring one to twice per year. Monthly, daily or weekly monitoring scale (depends on conditions) is performed by drinking water suppliers (water companies).	L	
29	SI	FITO-INFO											Slovene information system for plant protection. Information systems for public use: Plant protection products – Plant protection related legislation; Organisms names, descriptions, pictures; Forecast information's; Important information for plant producers – news; All other information regarded to plant protection...	V	
30	UK	PLANET	X			x	X					Yes	We have similar tool for fertilisation planning.		
31	UK	FARMSCOPER	X			X	x					No	It seems quite site specific.		
32	UK	Check it out	X									No	Plant protection products are under control in Case study.		
33	UK	Sentinel Online	X			x	X					Yes	Plant protection products are under control in Case study.		
34	UK	Procheck	X			x	x		X			No	Plant protection products are under control in Case study.		
35	UK	SCIMAP	X						X			No	GIS based tool. Need additional knowledge.		
36	UK	WaterAware	x				x					No	It needs connection to local Meto data. Would need to be modified.		

NB: The Danish Environmental Protection Agency approve pesticides and Aarhus and GEUS test pestisides in fiels trials in the program “Varslingssystem for udvaskning af pesticider til grundvand (VAP)” - Warning system for groundwater pesticide leaching

7.2 EVALUATION SCHEME 1

After each involved FAIRWAY case study site had made the final selection of the DSTs they would test and/or demonstrate evaluation scheme 1 was filled out. Evaluation scheme 1 was prepared to help the MAP leaders evaluate the selected DST even further (in regard to scale, data requirements, level of experience/training required, stakeholders etc.). To fill out evaluation scheme 1 it was required, that the MAP leader spent time pre-testing the DST and took contact to the owner of the DST for support.

The filled out evaluation schemes can be found below.

7.2.1 Denmark - Aalborg

Environmental Yardstick for Pesticides

FAIRWAY case study site:	**Aalborg, Denmark**
Name of Decision Support Tool (DST) that will be tested:	What will be the 'foreign' DST you want to examine in your case? Name and very short description: Environmental Yardstick for Pesticides
Name, institute and country that will test the DST:	**SEGES**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☒To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☒To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____
At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	Protection of groundwater based on pesticide selection

Brief reason for the choice of the DST	Is it possible for farmers to choose pesticides there has a low risk leaching to groundwater in Denmark with the Environmental Yardstick for Pesticides? Based on the professional advice from SEGES to Danish farmers and advisors.
DST status in your country	Do you already use a similar DST in your case? ☒Yes ☐No If yes, name and a very short description of the DST (including main output, scale and end users): Middeldatabasen (agent database): The database has: Indicators on Health, Environmental behavior and Environmental impact. But it is not so easy to compare the active substances like in the Environmental Yardstick for Pesticides. Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☒ Yes ☐ No What is the target application of the DST you already use in your country? ☒To quantify loads of pesticide to surface water ☒To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other (please specify) **NB**_____ **NB:** The Danish Environmental Protection Agency approve pesticides and Aarhus and GEUS test pestisides in field trials in the program (VAP)" - Warning system for groundwater pesticide leaching. Danish farmes uses only approved pesticides by the Danish state. If illegal pesticides are used, an amount of money will be deducted from the basic payment

What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☐Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☐Water managers:_____ ☐Environmental agency:_____ ☒Farm advisors: Better understanding of the choice of pesticides and risks ☒Farmers: Better understanding of the choice of pesticides and risks
What scale should the DST be used?	☒Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☐Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers ☐Citizens ☐_____ **And how?** ☐Workshops ☒Demonstrations

	☐Field visits ☐_____
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments: liter pr. hectare, gram pr. hectare ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☒Farm data ☐Farm type. ☐Livestock ☐Crops ☐Fertilizer use ☒Pesticide use ☐Soil management ☐Field operations ☐Economic data ☐Field boundaries ☐_____ Comments: The Environmental Yardstick for Pesticides ☒Data of measures ☐List with description attached ☐Costs the measure/measures attached ☒Efficiency of the measure/measures attached Comments:The annual use of the amount of active substances is important What is the most important data in relation to the test? That the test will be on common use of the pesticide at farm level/field level. The annual use of the amount active substances are based on farm level/field level.

Are demonstration data available for testing?	☒Yes ☐ No Comments:_Yes if the farmers are willing to provide data. Data is not public data, but each year the farmers send in a spray journal /spray account to the Danish state. If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☒Yes ☐ No Are pseudo data used in this test? ☒Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: Often the advisors/farmers use mixed active substances. This complicates the choice of pesticides, like pesticide resistance is a challenge. ☒ Data requirements (availability) ☒ Privacy of (farm)data ☐ The complexity of the DST ☐ Language ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☒_Mix of active substances development of resistance is a challenge ☐_____
Additional reflections on the use of this DST	Short:

	In Denmark, the range of approved pesticides is low, so the farmer's choices are low

SIRIS

FAIRWAY case study site:	**Aalborg Denmark**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: SIRIS is a French DST mainly used by the administration to refine surveillance programs of pesticides. In SIRIS "Le-rang" defines the risk. A high "Le-rang"-percentage means a high risk of pesticide leaching. SIRIS does not distinguish between differences in risk between spring and autumn. The leaching potential in SIRIS considers the organic matter in soil.
Name, institute and country that will test the DST:	**SEGES, Denmark**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☒To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____
At what scale will you test the DST	☐ Farm and/or parcel ☒ Catchment
What will be the main output:	Comparison of risk/loss profiles using pesticides in Denmark and France.
Brief reason for the choice of the DST	If the risk profiles for loss of pesticides are the same in France and Denmark, SIRIS can be used by Danish authorities and agricultural advisors

DST status in your country	Do you already use a similar DST in your case? ☒Yes ☐No If yes, name and a very short description of the DST (including main output, scale and end users): In Denmark, farmers are only allowed to use pesticides approved by the Danish Environmental Protection Agency. The chemical agents are tested in the Danish Pesticide Leaching Assessment Programme to provide an early warning of the risk of groundwater contamination when approved pesticides are used in accordance with current regulations. If a pesticide or its degradation products leach to the groundwater the monitoring results generated by the programme provide a basis for reassessment of the substance by the Danish Environmental Protection Agency. The Danish DST Plant Protection online does not visually display the risk effect. In Denmark the risk is controlled by taxes on pesticides, so a high risk means high taxes. The tax is calculated on factors such as health, environmental behaviour and environmental effect: Link to legislation. _____ _____ Is the DST already a part of the legislation in your country? ☒Yes ☐ No Voluntary? ☐Yes x No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☒To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies

examine have for the case study?	☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☒Inspiration for the development of a new DST ☒Other: Is the leaching risk profiles the same in Denmark and France? _____
What potential stakeholder group should use the DST?	☒Water managers ☒Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers:_Common understanding ☒Environmental agency: Common understanding ☒Farm advisors: Common understanding ☒Farmers: Common understanding
What scale should the DST be used?	☒Test on a theoretical level ☒Farm level ☒Catchment level ☒Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☐Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers ☐Citizens ☐_____ **And how?**

	☒Workshops ☐Demonstrations ☐Field visits ☐_____
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____ ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☒Farm data ☐Farm type. ☐Livestock ☐Crops ☐Fertilizer use ☒Pesticide use ☐Soil management ☐Field operations ☐Economic data ☐Field boundaries ☐_____ Comments: Test of pesticides at crop level. ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test?

	_____
Are demonstration data available for testing?	☐Yes ☒ No Comments:_____ If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☒Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☐Yes ☒ No – or yes from France in the project
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: Huge difference between soiltypes _____ ☒ Data requirements (availability) ☒ Privacy of (farm)data ☒ The complexity of the DST ☒ Language ☒ Needed skills ☒ Absence of tutorial ☒ Support from developer ☒A French program at a website, immediately not so easy to understand. ☐_____

Additional reflections on the use of this DST	Short: It is an authority program and not constructed to use at advisory/farm level.

TargetEconN

FAIRWAY case study site:	**Aalborg, denmark**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **TargetEconN (not foreign in this case)**
Name, institute and country that will test the DST:	**Berit Hasler, Aarhus University, Denmark**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☒To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☒To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____
At what scale will you test the DST	☒ Farm and/or parcel ☒ Catchment The model identifies cost-effective measures at field parcel level, but is a catchment model.
What will be the main output:	Cost-effective allocation of measures to reduce nitrogen loads to surface water, as well as cost-effective level of abatement. Total costs to achieve nitrogen load targets, as well as cost-effectiveness ratio.
Brief reason for the choice of the DST	The model provides information on the cost-effective allocation and choice of measures to achieve nitrogen load targets, which is of interest for local decision makers and decision makers in public bodies, like the EPA. The model results might inform these decision makers on cost-effective choices of policy measures.

DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): __The model has not been applied in Aalborg. _____ Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☒To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will examine have for the case study?	☐Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☒Water managers ☒Environmental Agency ☐Farm advisors ☐Farmers

	Comments:__The model has to be run by experts, and the results are of main interest for water managers in the water utilities and environmental agencies, potentially also agricultural agencies. ___
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers:_____Provide information at field scale level on the cost-effective shoice of measures to protect the water. __ ☒Environmental agency:_____Provide information at catchment level and national level on the cost-effective solutions and choices of measures to reduce nitrogen loads to surface water. The model is also useful to test the effect of uncertainty on the assumptions on leaching, retention, cost-levels etc. _____ ☐Farm advisors:_____ ☐Farmers:_____
What scale should the DST be used?	☐Test on a theoretical level ☐Farm level ☒Catchment level ☒Country level
What stakeholders you want to involve in the testing process? And how?	☒Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☐Agricultural advisors ☒Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens ☐_____ **And how?** ☐Workshops ☐Demonstrations ☐Field visits ☒Interviews
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____ ☒Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...)

	Comments:__land use at parcel level_ ☒Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_soil type, retention, irrigation, drainage if possible but not necessary._ ☒Farm data ☐Farm type. ☒Livestock ☒Crops ☒Fertilizer use ☐Pesticide use ☐Soil management ☐Field operations ☒Economic data ☒Field boundaries ☐_____ Comments:_ Livestock enters the model as manure inputs_ ☒Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? _The data are included in the model so no need to additional data inputs _
Are demonstration data available for testing?	☒Yes ☐ No Comments:_Yes, data are included in the model for Limfjorden, - spatial data on hydrogeology, farm data on crops and fertilizer inputs, as well as on 12 measures on clay and sandy soils. _ If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____

	☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: ___The model is not tested in other countries because it requires very specific data, and the model is set up in Danish. Furthermore experiences and skills are necessary to run this optimization model. _ ☒ Data requirements (availability) ☐ Privacy of (farm)data ☒ The complexity of the DST ☒ Language ☒ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short:

7.2.2 **United Kingdom - Anglian Region**

Environmental Yardstick of Pesticides

FAIRWAY case study site:	**Anglian Water Case Study area**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: Environmental Yardstick for Pesticides

Name, institute and country that will test the DST:	**University of Lincoln, England**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other. Please specify: To understand whether the Environmental Yardstick for Pesticides is a useful additional measure for farmers and agronomists to be able to access in England. Does it have the potential to improve awareness of relative environmental impact between otherwise similar active ingredients?
At what scale will you test the DST	☐ Farm and/or parcel ☒ Catchment – by means of survey of agronomists
What will be the main output:	A survey or farmers and agronomists. A short report describing the survey, the survey results and any potential concluding remarks on the potential advantages and disadvantages of a tool like Environmental Yardstick for Pesticides to add technical and environmental value to existing agronomic decision support tools already available and commonly used in England.
Brief reason for the choice of the DST	Environmental Yardstick for Pesticides is being used in a climatically and crop choice similar area. Our case study is about pesticides in water. Initial conversations with agronomists and regional Water Supply Company agricultural advisers indicated a potential interest that was worth pursuing. Expert opinion is that environmental information of the kind help in Environmental Yardstick for Pesticides is not held in a single place for industry use in the England.
DST status in your country	Do you already use a similar DST in your case? ☒Yes ☐No If yes, name and a very short description of the DST (including main output, scale and end users): <u>Environmental Information Sheets on the Voluntary Initiative Website.</u> We do not use these directly in our case study but they should be notes as being available. On the Voluntary Initiative website () a not-exhaustive list of

	active ingredients is listed. For each of these an 'Environmental Information Sheet' (EIS) supplies product-specific environmental impact information. They highlight any situations where risk management is essential to ensure environmental protection. EISs reinforce, and supplement, the information presented on a product's label. The product label amongst other things provides user safety information. From the information and tools available to agronomists in the UK it is not easy to make comparisons between products. Additionally the changing impact of different soil organic matter and degree of spray drift is not available. We do not believe that there is a 'one stop shop' where all the information is easily accessible. The risk information on the EIS assumes operator compliance with both the product's recommended conditions of use and the statutory Codes of Practice. Background. A key element of the Voluntary Initiative (VI) is the provision of environmental information on crop protection products. Members of the Crop Protection Association (CPA) have committed to do this by producing Environmental Information Sheets (EIS) for all marketed professional products supplied by CPA member companies. By referencing a product's label and its EIS to the local conditions at the application site product use decisions can be planned and made with a better understanding of the practical implications. EISs do not offer guidance on whether one product is more environmentally acceptable than another. Not all products may currently have an EIS. Failure to locate an EIS may be due to either that the EIS has not yet been produced or that the product is supplied by a company that is not a member of the Crop Protection Association. The Environmental Yardstick looks user friendly with a lot of information located in one place. --- Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐ Yes ☒ No CLM's Environmental Yardstick is not available in England. English farmers are only allowed to use pesticides for use in England, following the label, being appropriately trained and using tested equipment and this should minimise non target contamination. Legal use is assessed during Cross Compliance inspections as part of the Basic Payment Scheme. What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater

	☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other (please specify): To raise awareness of risk to environment from correct use, including Wildlife (mammals and birds), bees, non-target insects and other arthropods, aquatic life, soil and groundwater (earthworms and soil micro-organisms) and non-target plants. For use by farmers and agronomists.
What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☒Inspiration for the development of a new DST ☐Other____ _____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☐Water managers:_____ ☐Environmental agency:_____ ☒Farm advisors:_Better knowledge on the issues that may be associated with differrent pesticides. ☒Farmers:___Increased understanding of the impact that pesticide use may have.
What scale should the DST be used?	☒Test on a theoretical level ☐Farm level ☐Catchment level

	☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers ☐Citizens ☐_____ **And how?** ☐Workshops ☒Demonstrations ☐Field visits ☒_Face to face discussions and a survey
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_None required since this is a survey. ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☐Farm data ☐Farm type. ☐Livestock ☐Crops ☐Fertilizer use ☐Pesticide use ☐Soil management ☐Field operations

	☐Economic data ☐Field boundaries ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☒Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? The questions we be asking are around whether an Environmental Yardstick for Pesticides type product adds anything to existing DST tools used in the industry and how it might be taken up. Also considering potential disadvantages of using the tool. Concerns include the fact that active ingredient choice and like-for-like products are already limited. It may cause confusion between products that are efficient at the task required (eg manage a particular weed) and the Environmental Yardstick for Pesticides product with lowest score (but that might not remove that target weed).
Are demonstration data available for testing?	☒Yes ☐ No Comments:___We can use the information supplied by CLM on their website and in presentation materials to share the concept with farmers and agronomists. It is not necessary to create personalized information for use in the UK, since this is an opinion based survey being conducted at a time when few active ingredients are being applied. If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☐ No Are pseudo data used in this test? ☒Yes ☐ No

What level of expertise and training is required to use the DST?	Not necessary for this survey. Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: ____ Most a straightforward for our survey. However the following points would be relevant to implement. ☒ Data requirements (availability) ☒ Privacy of (farm)data ☐ The complexity of the DST ☒ Language ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☒_Only takes into account rate, organic matter and drift at the moment. Other points like use of low drift nozzles or wetters/stickers may not be included. May not deal with tank mixes. Gives a single answer and so may not allow due consideration of resistance action. ☐_____
Additional reflections on the use of this DST	Short: Due to the nature of the CS ……. Currently agronomists use bespoke tools. We envisage that a new 'second' tool might be unattractive but we wonder if there is the potential to feed the Environmental Yardstick for Pesticides type data into existing DST tools. We already have feedback that if food buyers were keen on this product (similar systems have been tried by 2 retailers in the past) then the list may be mis-used to just exclude allowing use of the highest scoring materials.

7.2.3 **France - La Voulzie**

SIRIS

FAIRWAY case study site:	**La Voulzie**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **SIRIS (not "Foreign")**

Name, institute and country that will test the DST:	**Nicolas SURDYK – BRGM - France**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other. Please specify: ____Detect / identify which substances / products may contribute most to the contamination of groundwater._____
At what scale will you test the DST	☐ Farm and/or parcel ☒ Catchment
What will be the main output:	Prioritization of the potential contribution of the products / substances currently applied (in fact sold) at catchment level.
Brief reason for the choice of the DST	Interoperable database in France. "Eau de Paris" knowing this DST No language barrier
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐Yes ☒ No

	What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will examine have for the case study?	☐Improved understanding/inspiration of how water protection issues are tackled in other case studies ☐Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☒Other: To anticipate future contaminations / problems in order to anticipate them.
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☐Farmers Comments:__ Our partners is a Water company and they will use the tool. The principle is, of course, that the results influence, somehow, the behavior of farmers.
What benefits do you think the DST	☐Water managers: :_____

could have for the stakeholder groups using the respective DST?	☐Environmental agency:_____ ☒Farm advisors: In our case the drinking water company is a Farm advisors. In our case study , the transfer time of the contaminant is long. Knowing the phytosanitary products having the greatest impact from the moment of application could help to anticipate the action of the plant. This DST is simple enough to use (in France in any case) to make quick tests that will obtain results by integrating input data over shorter or longer periods. ☐Farmers:_ As above, the knowledge acquired by the partner will benefit farmers.
What scale should the DST be used?	☐Test on a theoretical level ☐Farm level ☒Catchment level ☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☐Agricultural advisors ☐Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens ☐_____ **And how?** ☐Workshops ☐Demonstrations ☐Field visits ☒_I will make a presentation on the result and the tool to our partner. I already send them some first results_____
DATA requirements	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)**

What data is needed to run the DST (comprehensive list)	Comments:_____ ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☐Farm data ☐Farm type. ☐Livestock ☐Crops ☒Fertilizer use ☐Pesticide use ☐Soil management ☐Field operations ☐Economic data ☐Field boundaries ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? _____

Are demonstration data available for testing?	☒Yes ☐ No Comments: If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☒Farm data: Pesticide used date are generally available at large scale_____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☐Yes ☒ No
Comments, issues and uncertainties requiring further consideration	☐ Differences between regions / farm types for which the DST is developed. Please specify: _ Local specificities are taken into account by the phytosanitary products sales database at the commune level._ ☒ Data requirements (availability) : In France, there is a database providing the total volume of pesticides SOLD per commune since 2007. This database provides export format specifically compatible for SIRIS. These data are so not available elsewhere. ☐ Privacy of (farm)data ☐ The complexity of the DST ☒ Language : ☐ Needed skills ☐ Absence of tutorial : ☒ Support from developer ☐_____
Additional reflections on the use of this DST	Short: The software is not really up to date and sometimes it is sometimes difficult to run it with the recent (Macro vba)

	For phytosanitary products, the calculation of the treatment frequency index (TFI) is mandatory but there is no imposed tool. Our partner at "Eau de Paris" simply uses Excel.

7.2.4 **Germany - Lower Saxony**

Mark Online, NDICEA, NMP and ANCA

FAIRWAY case study site:	**Lower Saxony**
Name of Decision Support Tool (DST) **that will be tested:**	*What will be the 'foreign' DST you want to examine in your case? Name and very short description:* DST to be tested will work with fertilizer plans. In addition to our own DST Düngeplanung in Lower Saxony, the selected tools contain some additional modules such as soil tillage, nutrient mineralization modules, calculation of losses, integration of geographical information, … • Mark Online (DK) • NDICEA (NL) • NMP (not yet confirmed by model owner if we can get access to it) • (ANCA (NL)) – This mainly works with dairy farmers. Since our case study focusses on arable farming, testing it with our own data sets is somewhat restricted.
Name, institute and country that will test the DST:	Landwirtschaftskammer Niedersachsen (LWK) – case study leaders of case study 5
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____

At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	- Fertilizer plans to be directly used by farmers - Nutrient balances at parcel/farm level - Inspiration how other countries handle nutrient surpluses (both from a technical point of view and in country-specific legislation)
Brief reason for the choice of the DST	All of the DST chosen focus on groundwater, nitrate and (most-importantly) work on field or farm scale.
DST status in your country	Do you already use a similar DST in your case? ☒Yes ☐No If yes, name and a very short description of the DST (including main output, scale and end users): Düngeplanung by LWK Main output are fertilizer plans (field level) and nutrient balances (farm level) to be used by farmers. For detailed information please consult the respective DST information sheet- Is the DST already a part of the legislation in your country? ☐Yes ☐ No ☒ Partially (however, it contains some feature which go beyond the legal requirements) Voluntary? ☐Yes ☐ No ☒ Partially What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____

What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☐Water managers:_____ ☐Environmental agency:_____ ☒Farm advisors: • to get an idea who nutrient management is tackled in other countries • inspiration how own DST could be improved ☒Farmers: • to get an idea how well their own nutrient management corresponds to concepts of neighbor countries • identify some measures to improve own nutrient management
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☐Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers (?) ☐Citizens

	☐_____ **And how?** ☐Workshops ☐Demonstrations ☐Field visits There will be a pre-testing by us (case study leaders) with real farm data. If it appears to be feasible we will visit a farmer to directly involve him in a more profound testing.
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____ ☒Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☒ Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments: in NDICEA weather data is downloaded from online database ☒Farm data ☒Farm type ☒Livestock ☒Crops ☒Fertilizer use ☐Pesticide use ☒Soil management ☒Field operations ☐Economic data ☐Field boundaries ☐_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached

	What is the most important data in relation to the test? • Land use (crop rotation), site conditions (esp. soil data), field management (especially fertilization practice)
Are demonstration data available for testing?	☒Yes ☐ No Comments:_____ If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☒Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☒Yes ☐ No I have already started to correspond to some of the contact person. However, this is in progress since more questions will arise during the process of testing
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: • climate (temperature/precipitation) can influence outcome substantially (esp. in DST which work with estimated leaching rates like NDICEA) • location of respective farm (e.g. in the Danish DST MarkOnline restrictions concerning agricultural management exist for designated areas – we have to evaluate to which extent they correspond to German protected areas) • … ☒ Data requirements (availability) • Soil tillage ☐ Privacy of (farm)data ☒ The complexity of the DST

	• While testing we have to also understand the Danish legislation. This makes the process very compley ☒ Language ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short:

7.2.5 Ireland - Derg Catchment

FARMSCOPER

FAIRWAY case study site:	**Derg Catchment, Northern Ireland/Ireland**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **FARMSCOPER**
Name, institute and country that will test the DST:	**AFBI, NI**
Target application of the DST you will test:	☒To quantify loads of pesticides to surface water ☒To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☒To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☒To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____

At what scale will you test the DST	☒ Farm and/or parcel ☒ Catchment
What will be the main output:	Spreadsheet and graphical output per farm giving loadings of: nitrate, phosphorus, sediment, ammonia, methane, nitrous oxide, pesticides, FIOs, soil carbon, soil carbon, energy use) and apportionment among sources. Water and associated contaminants – separated into surface, preferential flow and groundwater recharge are estimated monthly for different land use classes.
Brief reason for the choice of the DST	Farmscoper has been widely used in the UK and individual farm and catchment scales. The main use is for nutrient balancing on farms and estimation of the effects of farming practices on water and air. Allows comparison of impact and costs/benefits of Business as Usual compared to various combinations of mitigation measures.
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☐ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____

What added value can the DST you will examine have for the case study?	☐Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☒Water managers ☒Environmental Agency ☒Farm advisors ☒Farmers Comments: The model can be applied at farm scale to identify fields in which mitigation measures would be best applied (farmers/Farm advisors). At larger scales water companies can use the maps to identify highest risk sub-catchments in which incentive schemes to reduce pesticide use and improve practices can be applied.
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers: A grouped model for all the farms in the catchment (or sub-catchments) could estimate likely pesticide loading and treatment needs for water abstracted from the river for drinking water supplies. ☒Environmental agency: similar to water managers. Could help identify specific sub-catchments for targeted mitigation measures. ☒Farm advisors: The DST could be used on an individual farm basis by farm advisors with their clients (and benefit from the other outputs from the model – economic, nutrient etc) ☒Farmers: Individual farmers could also use the DST to get an overview of their farm operations (pesticides but perhaps more importantly nutrient, water quality, economics etc). ***We will not be able to test the model directly with farmers in the catchment as this engagement might interfere with ongoing work in another project.***
What scale should the DST be used?	☒Test on a theoretical level ☒Farm level ☒Catchment level ☐Country level

What stakeholders you want to involve in the testing process? And how?	☒Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☒Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens ☐_____ **And how?** ☒Workshops ☒Demonstrations ☐Field visits ☐_____
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments: loadings of nutrients and pesticides ☒Spatial data / topography: Spatial data are needed to calculate the following • % Fields near water courses • % area of organic soils • Field boundary type (walls, fence, hedge) • Farm size • Field operations – for each crop the machinery used and the number of times used are input. For harvested crops grain drying etc. is included. Applications of pesticides included. Comments: ☐Hydrogeology: • Soil type, • Climate (Select from: <600mm, 600-700m, 700-900 mm, 900-1200mm, 1200-1500mm, >1500mm Comments: Soil types and rainfall – are the UK classes applicable in NI/RoI geoclimatic zone? ☒Farm data

	☒Farm type. ☒Livestock – types and ages ☒Crops ☒Fertilizer use ☒Pesticide use ☒Soil management ☒Field operations- machinery used and usage ☒Economic data ☒Field boundaries ☒ Dirty water management (with slurry, separate, none) ☐_____ • Comments: For pesticides: Plant protection Products are reported as % of "typical". We need further information as to what "typical" is and if it will apply in Derg Catchment. For nutrients we need to check if estimates of nutrients in livestock manure are based on RB209, which is also used in NI. • https://ahdb.org.uk/documents/RB209/RB209_Section3_WEB_2017-12-06.pdf ☒Data of measures ☒List with description attached ☒Costs the measure/measures attached ☒Efficiency of the measure/measures attached Comments: Mitigation measures are specific to England and Wales – need check whether applicable to NI/IE What is the most important data in relation to the test? Accurate farm level data are essential to validate.
Are demonstration data available for testing?	☒Yes ☐ No Comments: We have adequate elevation data to test the model. If no, what data is not available / cannot be used in your case? ☐Spatial data: _____

	☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☒Yes ☒ No Are pseudo data used in this test? Not yet certain if needed. ☐Yes ☐ No
What level of expertise and training is required to use the DST?	The model is delivered as a set of excel spreadsheets. A person with experience in Excel and some knowledge of farm nutrient budgets should be able to use it at single farm level. Assessing the model accuracy and running sensitivity analyses would need expertise in hydrology and nutrient/contaminant mobilisation and transport. Adjusting the model to better suit the climate and soil hydrology of the west of Ireland would need developer involvement. Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. ☒ Data requirements (availability) ☒ Privacy of (farm)data ☐ The complexity of the DST ☐ Language ☒ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short: The nutrient component of the model is also very useful – and perhaps better captured than the pesticide component, which is only represented as a % of normal practice. If the trial seems positive then a case would have to be made to get further funding to optimize the model for Northern Ireland/Ireland.

Phytopixal

FAIRWAY case study site:	**Derg Catchment, Northern Ireland/Ireland**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **Phytopixal**
Name, institute and country that will test the DST:	**AFBI, NI**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☒To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____
At what scale will you test the DST	☒ Farm and/or parcel ☒ Catchment
What will be the main output:	The approach uses data of soil type, slope, and distance from streams, landuse and farm practices to develop an estimate of contaminant risk at a resolution of 30m X 30m in catchments. The catchments we work in are generally surface water dominated with impermeable clay soils over hard bedrock, where most contaminant loads are delivered in rainfall-runoff events. Areas at highest risk can be prioritized for mitigation measures. The model may need some adaptation for available data within the Derg catchment. Further review of the method is required to determine if mobilization and transfer processes associated with the pesticides (MCPA, glyphosate) have been adequately incorporated within the DST
Brief reason for the choice of the DST	Phytopixel is applicable across a range of scales (field to catchment) at which we operate. The map based component will be familiar to water managers and policy makers and the GIS skills required for its future implementation are likely to exist with the main water utility companies in the catchments (NIWater and Irish Water)
DST status in your country	Do you already use a similar DST in your case?

	☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☐ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☒Other. Demonstrate to Water Utilities the limitation of current data and the need to invest in higher resolution dataset if the maximum benefits of DSTs are to be realized.
What potential stakeholder group should use the DST?	☒Water managers ☒Environmental Agency ☐Farm advisors

	☐Farmers Comments: The model can be applied at farm scale to identify fields in which mitigation measures would be best applied by farmers/Farm advisors. And so the outputs of the DST can be used by these groups. However, the application of the DST requires some level of GIS skills which are more likely to be available in the Water Utilities or Environment agencies. It can also be used at larger scales by water companies to identify highest risk sub-catchments in which incentive schemes to reduce pesticide use and improve practices can be applied.
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers:_ At larger scales water companies can use the maps to identify highest risk sub-catchments in which incentive schemes to reduce pesticide use and improve practices can be applied. ☒Environmental agency: Environmental agencies can use the maps to identify highest risk sub-catchments in which additional compliance checks and investment may be needed to ensure farm practices minimize risk to water quality. ☒Farm advisors: For advising farmers on placement for measures for farm incentive schemes the model can be used to identify fields in which mitigation measures would be best applied (farmers/Farm advisors). ☒Farmers: For the farmer the identification of high contamination risk can assist the farmer with many management decisions, such as when and where to avoid spraying pesticides (***We will not be able to test the model directly with farmers in the catchment as this engagement might interfere with ongoing work in another project)***
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☒Catchment level ☒River Basin level
What stakeholders you want to involve in the testing process? And how?	☒Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☒Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens

	☐_____ **And how?** ☒Workshops ☒Demonstrations ☐Field visits ☐_____
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments: The output units of the model will be a risk index (a scale factor). ☒Spatial data / topography: • digital elevation model • satellite imagery of land use • well-defined water courses ☒Hydrogeology: • soils maps ☒Farm data ☐Farm type. ☐Livestock ☒Crops ☐Fertilizer use ☒Pesticide use ☐Soil management ☒Field operations (number of applications) ☐Economic data ☐Field boundaries ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached

	☐Efficiency of the measure/measures attached Comments: The model will help target where mitigation measures might be useful – but will not specify what measures should be selected. That is for the user to do. What is the most important data in relation to the test? Up to date satellite imagery
Are demonstration data available for testing?	☒Yes ☐ No Comments: We have adequate elevation data and soils data to test the model. A separate project called Source To Tap in the catchment is collecting spatial information on pesticide use in the catchment and water quality monitoring is undertaken across the catchment. Satellite imagery is available but is not up to date If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☒ No Are pseudo data used in this test? ☐Yes ☒ No
What level of expertise and training is required to use the DST?	User would need to be familiar with GIS and spatial data processing. Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: Sub-surface flow cannot be modelled using this approach. In the lower catchment where gravel deposits exist groundwater flow may be an important contributor to pesticide flux. The uncertainties associated with this will need to be considered. ☒ Data requirements (availability) ☒ Privacy of (farm)data

	☐ The complexity of the DST ☐ Language ☒ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short: The DST in its current form does not seem to adequately account for transport of pesticides to waterbodies. We will examine options to replace the 'distance to waterbodies' parameter with a more spatially explicitly metric such as the topographic wetness index

SCIMAP

FAIRWAY case study site:	**Derg Catchment, Northern Ireland/Ireland**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **SCIMAP**
Name, institute and country that will test the DST:	**AFBI, NI**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☒To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____
At what scale will you test the DST	☒ Farm and/or parcel ☒ Catchment

What will be the main output:	The approach uses high resolution digital elevation models to model overland flow across the landscape during rainfall events. The catchments we work in are generally surface water dominated with impermeable clay soils over hard bedrock, where most contaminant loads are delivered in rainfall-runoff events. Maps are generated identifying areas at highest risk of contaminant (may be nutrients/pesticides/sediment) mobilisation in overland flow (catchments are hydrologically flashy and dominated by surface runoff during rainfall events). Areas at highest risk will be prioritized for mitigation measures. The model may need some adaptation to consider transfer processes associated with the pesticides used in the catchment (MCPA, glyphosate). This will be considered in coming months.
Brief reason for the choice of the DST	SCIMAP is applicable across a range of scales (farm to catchment) at which we operate. The map based component will be familiar to water managers and policy makers.
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☐ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____

What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☒Water managers ☒Environmental Agency ☒Farm advisors ☒Farmers Comments: The model can be applied at farm scale to identify fields in which mitigation measures would be best applied (farmers/Farm advisors). At larger scales water companies can use the maps to identify highest risk sub-catchments in which incentive schemes to reduce pesticide use and improve practices can be applied.
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers:_ At larger scales water companies can use the maps to identify highest risk sub-catchments in which incentive schemes to reduce pesticide use and improve practices can be applied. ☒Environmental agency: Environmental agencies can use the maps to identify highest risk sub-catchments in which additional compliance checks may be needed to ensure farm practices minimize risk to water quality. ☒Farm advisors: For advising farmers on placement for measures for farm incentive schemes the model can be used to identify fields in which mitigation measures would be best applied (farmers/Farm advisors). ☒Farmers: For the farmer the identification of high risk areas for runoff can assist the farmer with many management decisions, such as where to avoid spraying pesticides, where to avoid spreading slurry or fertilisers, and where is most likely to lose sediment if ploughed and cultivated as a crop. ***We will not be able to test the model directly with farmers in the catchment as this engagement might interfere with ongoing work in another project.***
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☒Catchment level

	☐Country level
What stakeholders you want to involve in the testing process? And how?	☒Water managers ☒Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☒Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens ☐_____ **And how?** ☒Workshops ☒Demonstrations ☐Field visits ☐_____
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments: The output units of the model will be a risk index (a scale factor). ☒Spatial data / topography: • digital elevation model (LiDAR preferable); • farm and field polygons; • land use (ideally field by field classifications of farming use); • well-defined water courses Comments: A SCIMAP field-scale runoff risk model requires a minimum of 2m digital terrain model resolution to predict accurately in the Irish landscape. This is very expensive for large catchment areas, although ongoing work in NI may provide this in the next year. 5m will be used in the interim. ☐Hydrogeology: • Soil type, • Precipitation. Comments: The model is for surface water flow only (though can provide indications of likely zones of soil saturation). Groundwater is not considered. ☒Farm data ☒Farm type.

	☒Livestock ☒Crops ☐Fertilizer use ☒Pesticide use ☒Soil management ☒Field operations ☐Economic data ☒Field boundaries ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments: The model will help target where mitigation measures might be useful – but will not specify what measures should be selected. That is for the user to do. What is the most important data in relation to the test? Accurate elevation data.
Are demonstration data available for testing?	☒Yes ☐ No Comments: We have adequate elevation data to test the model. A separate project in the catchment is collecting spatial information on pesticide use in the catchment and water quality monitoring is undertaken across the catchment. If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☒ No

	Are pseudo data used in this test? ☐Yes ☒ No
What level of expertise and training is required to use the DST?	User would need to be familiar with GIS and spatial data processing. Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: Sub-surface flow cannot be modelled using this approach. In the lower catchment where gravel deposits exist groundwater flow may be an important contributor to pesticide flux. The uncertainties associated with this will need to be considered. ☒ Data requirements (availability) ☒ Privacy of (farm)data ☐ The complexity of the DST ☐ Language ☒ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short: The SCIMAP approach can be applied to any surface delivered contaminant so is also very useful for sediment and nutrient risk modelling.

7.2.6 **The Netherlands - Overijssel**

Düngeplanung

FAIRWAY case study site:	**Boeren voor Drinkwater Overijssel**
Name of Decision Support Tool (DST) that will be tested:	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **Dungeplanner**
Name, institute and country that will test the DST:	
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater

	☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☒To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other. Please specify: **To implement a system for improved fertilizer distribution of farmland**_____
At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	**A fertilization plan**
Brief reason for the choice of the DST	**In Netherlands we work with 'the PerceelVerdeler' that suggests optimal distribution of fertilizer and organic manure over land. This, however is restricted to grassland and fodder crops (maize). The Dungeplanner also comprises arable crops, which is an added value for arable farmers in the catchment and for diary farmers that change land with arable farmers.**
DST status in your country	Do you already use a similar DST in your case? ☒Yes ☐No If yes, name and a very short description of the DST (including main output, scale and end users): **PerceelVerdeler (see above)**_____ Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐Yes ☐ No: **yes** What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water

	☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other (please specify) **to improve distribution in order to reduce nitrate leaching**
What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☒Initiate improvements or extensions of common used DST's ☒Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Water managers: more landusers in a catchment optimize fertilization. Now only dairy farmers_____ ☐Environmental agency:_____ ☒Farm advisors:_**More business**_____ ☒Farmers:_**Broader improvement of farm management (more farmers involved) will be more effective to solve the nitrate problem**.
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve	☐Water managers

in the testing process? And how?	☐Drinking water company ☒Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☐Farmers ☐Citizens ☒_Researchers_____ **And how?** ☐Workshops ☒Demonstrations ☐Field visits ☒_ **Review it ourselves than test on one or two farms, than demonstrate**
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____fluxes N and P (kg per ha)_____ ☒Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☒Farm data ☒Farm type. ☐Livestock ☒Crops ☒Fertilizer use ☐Pesticide use ☐Soil management ☐Field operations ☐Economic data ☐Field boundaries

	☐_____ Comments:_____ ☒Data of measures ☐List with description attached ☐Costs the measure/measures attached ☒Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? _____
Are demonstration data available for testing?	☒Yes ☐ No Comments:_____ If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☒Yes ☐ No Are pseudo data used in this test? ☒Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☐Yes ☐ No **Probably yes, I did not contact Linda as yet**
Comments, issues and uncertainties requiring further consideration	☐ Differences between regions / farm types for which the DST is developed. Please specify: _____ ☐ Data requirements (availability) ☒ Privacy of (farm)data ☐ The complexity of the DST

	☐ Language ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_Willingness of farmers and Provence of Overijssel to cooperate ☐_____
Additional reflections on the use of this DST	Short:

7.2.7 **The Netherlands - Noord Brabant**

Plant Protection Online

FAIRWAY case study site:	**NL Noord Brabant**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: **Plant Protection Online by SEGES: which gives advice about efficacy of herbicide at different dosage against target weeds in several stadia.** **(On a theoretical level we will also try to compare the Danish Pesticide Load Indicator with the Dutch Environmental Yardstick for Pesticides)**
Name, institute and country that will test the DST:	**CLM in the Netherlands (Jenneke van Vliet, Sara Boeke, Peter Leendertse and Marije Hoogendoorn)**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☐To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other. Please specify: _____

At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	Hopefully an advice to farmers on how to lower the dose of herbicides
Brief reason for the choice of the DST	We do not have such an advice instrument for farmers, only general recommendations on dosing (between a range of f.e. 0,5-1 liter depending on low or high infestation).
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No, but we do apply a method in hindsight If yes, name and a very short description of the DST (including main output, scale and end users): _What is being done to lower dosages of herbicides is the recommendation to spray a low dose (25-50%) in on tiny weeds and then only come back with a second dose if necessary. We call this 'Low Dose System' (LaagDoseringSysteem). A tool called MHLD (Minimum Herbicide Lethal Dose) or Plant Phytosynthesis Measuring Instrument can be used to see whether the first dose has been sufficient – before you can see this by naked eye – so helps for a quick 2nd knock off if necessary. This helps farmers take the 'risk' of having to come back / having to ask the contractor to come back. Since herbicides are cheap as compared to labour costs, it is not always easy to persuade farmers to work with LowDose System. MLHD measuring instruments are costly (1900 euro). Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☒To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management)

	☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will examine have for the case study?	☐Improved understanding/inspiration of how water protection issues are tackled in other case studies ☐Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☒Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☐Water managers:_____ ☐Environmental agency:_____ ☐Farm advisors:_____ ☒Farmers: Potentially saving on herbicide costs
What scale should the DST be used?	☒Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☐Drinking water company ☐Environmental advisors - Municipality

	☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers only if advisors think it is useful to the farmers (so after initial testing by the agricultural farmers themselves) ☐Citizens ☐_____ **And how?** ☐Workshops ☐Demonstrations ☐Field visits ☒_Asking a few independent agricultural advisors to have a look at the tool and its recommendtions__
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____ ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☒Farm data ☐Farm type. ☐Livestock ☐Crops ☐Fertilizer use ☒Pesticide use ☐Soil management

	☐Field operations ☐Economic data ☐Field boundaries ☒ Data on weed densities and types ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? _____
Are demonstration data available for testing?	☐Yes ☐ No Comments:_____ If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☒Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Is support available? ☒Yes ☐ No

Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: Difference between Denmark and the Netherlands in pesticide products allowed on the market _____ ☐ Data requirements (availability) ☐ Privacy of (farm)data ☐ The complexity of the DST ☒ Language, only available in Danish and English (not Dutch) ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short:

7.2.8 **Portugal - Baixo Mondego**

MANNER-NPK

FAIRWAY case study site:	Baixo Mondego and Baixo Vouga (Portugal)
Name of Decision Support Tool (DST) that will be tested:	MANNER-NPK – A practical software tool that provides farmers and advisers with a quick estimate of crop available nitrogen. It is incorporated in PLANET - Nutrient management decision support tool for use by farmers and advisers for field level nutrient planning and for assessing and demonstrating compliance with the Nitrate Vulnerable Zone rules.
Name, institute and country that will test the DST:	Inês Amorim Leitão CERNAS Portugal
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater ☐To quantify loads of nitrate ending up in surface water ☒To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate

	☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☒To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other. Please specify: Crop available nitrogen supply from applications of organic manure.
At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	The fate of organic manure N following land application; N losses via ammonia volatilization, denitrification and nitrate leaching; The total N applied and an estimate of crop available N in the current cropping year and in the year following manure application;
Brief reason for the choice of the DST	The main pollutants associated with drinking water problems in Portugal are nitrogen and nitrates. This is an easy to apply software that gives us information about nitrogen and nitrates.
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☐ No Voluntary? ☐Yes ☐ No What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate

	☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☐Other (please specify) _____
What added value can the DST you will examine have for the case study?	☐Improved understanding/inspiration of how water protection issues are tackled in other case studies ☐Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☒Inspiration for the development of a DST in Portugal ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments:_____
What benefits do you think the DST could have for the stakeholder groups using the respective DST?	☒Farm advisors: It helps them to advise farmers about the planning of the application of organic fertilizer. ☒Farmers: It helps them to plan the application of organic fertilizer in their crops and to avoid losses of N, especially nitrates.
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve	☐Water managers ☐Drinking water company

in the testing process? And how?	☒Environmental advisors - Municipality ☒Agricultural advisors ☒Environmental advisors – National Environmental Agency ☒Farmers ☐Citizens ☐_____ **And how?** ☒Workshops ☒Demonstrations ☒Field visits ☒Choose the best area to test the DST within the study site
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments:_____ ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...) Comments:_____ ☒Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...) Comments:_____ ☒Farm data ☒Farm type. ☐Livestock ☒Crops ☒Fertilizer use ☐Pesticide use ☒Soil management

	☒Field operations ☐Economic data ☐Field boundaries ☐_____ Comments:_____ ☐Data of measures ☐List with description attached ☐Costs the measure/measures attached ☐Efficiency of the measure/measures attached Comments:_____ What is the most important data in relation to the test? _____
Are demonstration data available for testing?	☐Yes ☐ No Comments: We are not sure yet about the fields in which we will apply the DST. If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/theoretical-/common- data be used instead? ☐Yes ☐ No Are pseudo data used in this test? ☐Yes ☐ No
What level of expertise and training is required to use the DST?	Some experience needed to use the software but extensive help and information is available. We already have a demonstration of the DST. Is support available? ☒Yes ☐ No

Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: This DST is based on the rules in the Vulnerable Zones to Nitrates (VZN) in UK. We already have these zones identified in Portugal and we have specific legislation to these areas, but some rules may not be exactly the same. ☐ Data requirements (availability) ☐ Privacy of (farm)data ☐ The complexity of the DST ☐ Language ☐ Needed skills ☐ Absence of tutorial ☐ Support from developer ☐_____
Additional reflections on the use of this DST	Short:

7.2.9 **Dravsko polje, Slovenia**

ANCA

FAIRWAY case study site:	**Slovenia, Dravsko polje**
Name of Decision Support Tool (DST) **that will be tested:**	What will be the 'foreign' DST you want to examine in your case? Name and very short description: ANCA- is tool for assessment of soil surplus of N and P. N surplus on the soil balance can be used as indicator for both losses to surface water and groundwater. The model outcomes help dairy farmers to demonstrate towards authorities and dairy industry that they have produced their milk in accordance with sustainability standards.
Name, institute and country that will test the DST:	**Slovenia, Slovene Chamber of Agriculture and Forestry** **Institute of Agriculture and Forestry Maribor**
Target application of the DST you will test:	☐To quantify loads of pesticides to surface water ☐To quantify loads of pesticides to water groundwater

	☐To quantify loads of nitrate ending up in surface water ☒To quantify loads of nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other. Please specify: To demonstrate that dairy farmers have produced their milk in accordance with sustainability standards.
At what scale will you test the DST	☒ Farm and/or parcel ☐ Catchment
What will be the main output:	The main output will be to show the levels of losses from farm to environment.
Brief reason for the choice of the DST	We would like to help farmers to: - meet demands of society, - overview their farm and to focus on weak spots. By testing and later adapting the tool, we would like to encourage farmers in the Dravsko polje to more closely monitor their farming practices and thus affect the ground water. In the case that the tool turns out to be appropriate, we will propose that its use be expanded at national level (all water protection areas with N concentration problems).
DST status in your country	Do you already use a similar DST in your case? ☐Yes ☒No If yes, name and a very short description of the DST (including main output, scale and end users): _____ _____ Is the DST already a part of the legislation in your country? ☐Yes ☒ No Voluntary? ☐Yes ☒ No

	What is the target application of the DST you already use in your country? ☐To quantify loads of pesticide to surface water ☐To quantify loads of pesticide to water groundwater ☐To quantify loads nitrate ending up in surface water ☐To quantify loads nitrate ending up in groundwater ☐To indicate effective measures that can reduce loads of pesticides/nitrate ☐To indicate effective measures that can reduce loads without effecting/improving yield levels or save costs (e.g. improved fertilization or plant protection management) ☐To quantify/estimate effectiveness of mitigation measures for pesticide/nitrate ☐To quantify/estimate costs-effectiveness of measures ☐To identify high risk areas for pesticide/nutrient sources/transport ☒Other (please specify) We do not use similar tools in Slovenia.
What added value can the DST you will examine have for the case study?	☒Improved understanding/inspiration of how water protection issues are tackled in other case studies ☒Comparison of different approaches (tested versus common used DST) ☐Initiate improvements or extensions of common used DST's ☐Inspiration for the development of a new DST ☐Other_____
What potential stakeholder group should use the DST?	☐Water managers ☐Environmental Agency ☒Farm advisors ☒Farmers Comments: We would like to include in testing farmers from water protection areas.
What benefits do you think the DST could have for the stakeholder groups	☐Water managers:_____

using the respective DST?	☒Environmental agency: New steps of farming on the water protecting area. ☒Farm advisors: New DST, new way of thinking, nutrient flow scheme enables evaluation of innovations // Advisors can easily convince farmers to implement new technology in practice. ☒Farmers: Overview of their farms and to focus on weak spots; for demonstration of sustainability standards towards authorities and to the general public.
What scale should the DST be used?	☐Test on a theoretical level ☒Farm level ☐Catchment level ☐Country level
What stakeholders you want to involve in the testing process? And how?	☐Water managers ☐Drinking water company ☐Environmental advisors - Municipality ☒Agricultural advisors ☐Environmental advisors – National Environmental Agency ☒Farmers ☐Citizens ☒Geological Survey **And how?** ☐Workshops ☒Demonstrations ☒Field visits ☒Testing of DST will be part of advising (talk whit a farmers, change experience, we planning also to show the tool to the students of agriculture)
DATA requirements **What data is needed to run the DST (comprehensive list)**	**Please indicate the respective unit (e.g. precipitation: monthly mm, Mineral fertilizer: kg/ha field-specific)** Comments: <u>Tool needs different type of Farm data with various units, but no spatial or hydrogeology data.</u> ☐Spatial data / topography: (landuse, parcels, catchment, water courses, abstraction wells, ...)

Comments:_____

☐Hydrogeology: (soil type, precipitation, groundwater recharge, drainage, abstractions, irrigation, ...)

Comments:_____

☒Farm data

- ☒Farm type.
- ☒Livestock (livestock units)
- ☒Crops (kg/ha)
- ☒Fertilizer use (kg/ha)
- ☐Pesticide use
- ☒Soil management
- ☒Field operations
- ☐Economic data
- ☐Field boundaries
- ☒Farm feeds
- ☒Contents of grass silage, maize silage
- ☒Farm organic/artificial manure
- ☒Type of housing

Comments: All written data on the farm level are available in pilot area

☐Data of measures

- ☐List with description attached
- ☐Costs the measure/measures attached
- ☐Efficiency of the measure/measures attached

Comments:_____

What is the most important data in relation to the test?

Date about dairy production on the farm.

Are demonstration data available for testing?	☒Yes ☐ No Comments: All written data on the farm level are available in pilot area If no, what data is not available / cannot be used in your case? ☐Spatial data: _____ ☐Hydrogeology: _____ ☐Farm data: _____ ☐Measures: _____ Can pseudo-/**theoretical-/**common- data be used instead? ☒Yes ☐ No Are pseudo data used in this test? ☐Yes ☒ No
What level of expertise and training is required to use the DST?	Is support available? ☒Yes ☐ No
Comments, issues and uncertainties requiring further consideration	☒ Differences between regions / farm types for which the DST is developed. Please specify: difference between farms (NL- bigger, more oriented in one branch; SI-smaller heterogeneousness branch structures) ☐ Data requirements (availability) ☐ Privacy of (farm)data ☐ The complexity of the DST ☒ Language: only in English and Dutch (problem for certain framers) ☐ Needed skills ☐ Absence of tutorial ☒ Support from developer: to adapt tool to Slovenian situation on farms ☐_____
Additional reflections on the use of this DST	Short: If the testing of DST ANCA will be successful we will suggest the use of it also in other part of Slovenia.