Inventory of applied mitigation measures and BMPs in pilot case study areas and assessment of the potential for the uptake of new ideas

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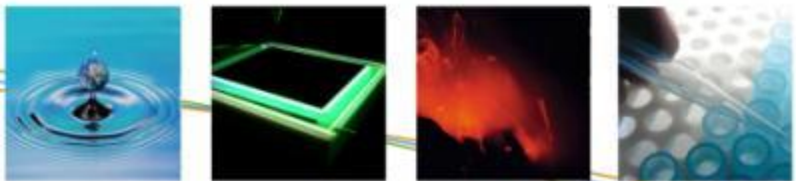

CHANGE RECORD

Version	Date	Description
1.0	31/05/2018	Draft version
2.0	30/09/2018	Final version
3.0	10/05/2019	Revised after midterm review: for each action lab a section with conclusions is added, the summary is rewritten to give key messages, the list of BMPs is aligned with the revision of D4.1

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List of abbreviations & acronyms

BMPs	Best Management Practices
PPPs	Plant Protection Products
PoMs	Programmes of measures
IPM	Integrated Pest Management

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1 Introduction

Agriculture is the largest source of pesticides and nitrate pollution in fresh European waters. The ultimate goal of the WATERPROTECT project is to contribute to the effective implementation of best management practices and mitigation measures to protect drinking water supplies. The focus in WATERPROTECT is on pollution of drinking water related to agricultural sector at a local level. Package WP4 in the WATERPROTECT project deals with best management practices and mitigation measures and the second task within this WP is an inventory of applied BMPs in pilot case study areas and assessment of the potential for the uptake of new ideas.

Objective of the Task 4.2 was to gather information regarding existing mitigation measures and BMPs within case study sites as well as to assess the willingness of farmers to implement additional, innovative measures, depending on costs and benefits. Realization of the task was planned through a series of interviews and questionnaires with farmers operating within case study areas.

An extensive literature review on existing best management practices, based on previous research projects, was done in the first task of the work package. This concluded with a list of 56 best management practices, for which synthetic descriptions were prepared and reported as the deliverable 4.1. This list was used to prepare questionnaires on applied BMPs in action lab areas. It occurred that additional BMPs were identified during the process of questionnaire distribution and the final list of BMPs reviewed in the project increased from 56 to 80 (Annex 1).

The seven case studies cover different climatic conditions, different types of farming systems, different legal frameworks, larger and smaller water collection areas. For that reason, lists of BMPs included in questionnaires varied between case studies and were developed by action lab leaders to reflect conditions characteristic to catchments being analyzed. For instance, the Belgium Action Lab had its focus on pesticides, therefore for that case study only BMPs aimed at reduction of pesticides' concentrations were selected. Contrary to that, action labs in Romania and Poland chose those BMPs that aimed at nutrient reduction (nitrogen and phosphorus).

This report presents results of questionnaires in each of the analyzed catchments.

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2 Belgium - the Bollaertbeek catchment

2.1 Brief introduction to the action lab

The Belgium Action Lab is situated in the west of the country, in the province of West-Flanders. The study area includes small villages of Voormezele and Wijtschate and parts of Kemmel and the city of Ypres. The study area has a surface of 22,6 km² of which 81% is used for agriculture (1907 ha). The Bollaertbeek catchment has a mixed urban and rural land-use. There are 164 farmers having their fields in the study area.

The Bollaertbeek catchment is a part of the surface water capturing area of the drinking water production company 'De Watergroep'. They abstract water at the outlet of the Bollaertbeek catchment to produce drinking water.

Water is also used by farmers to irrigate their parcels, to fill and clean their sprayers and as drinking water for their animals.

The main soil type is sandy loam (68 %), which is prone to capping and runoff and erosion of PPP due to capping (Table 1).

Table 1: Percentage of different soil types in the Bollaertbeek catchment

	Percentage (%)
Clay	10
Loam	14
Sandy Loam	68
Sand	1
Anthropogen	6

9% of the all fields are classified to be very high and high erosion sensitive and 11% are classified as medium erosion sensitive. Specifically, a part of the catchment near to Kemmel is hilly and therefore erosion sensitive. 77% is low and very low erosion sensitive fields. 3% of all fields do not have an erosion classification (e.g. buildings).

In the Belgium Action Lab 81% of the catchment is in agricultural use (*Figure 1*). There are 164 farmers of which 49 responded to the questionnaire. 43.8% of the catchment area was surveyed, which means that half of the agricultural land was successfully researched. Representativeness of the questionnaires is considered to be high (*Figures 2* and *3*).

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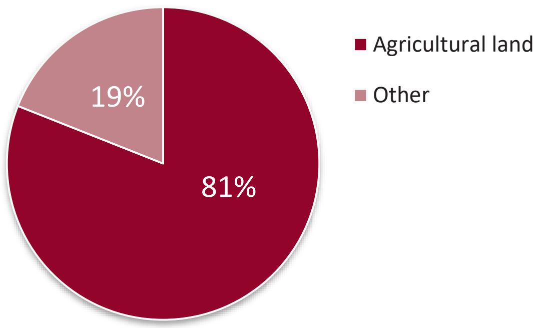

Figure 1: Percentage of agricultural land use in the Bollaertbeek catchment

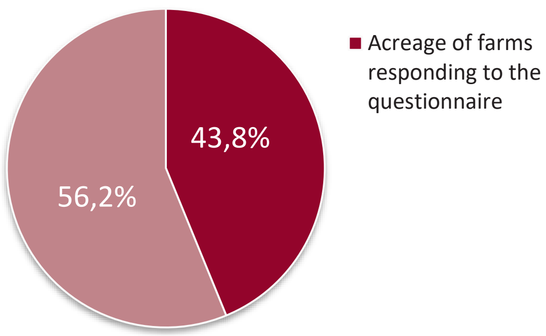

Figure 2: Percentage of farms area in the Bollaertbeek catchment responding to the questionnaire

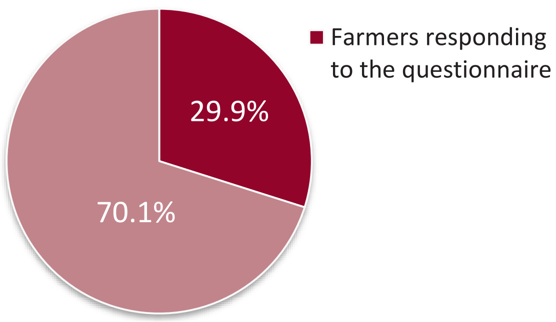

Figure 3: Percentage of farmers in the Bollaertbeek catchment responding to the questionnaire

As the Belgium Action Lab has its focus on pesticides, farmers were divided into two groups. The first group represented farmers, who spray themselves and have a big influence on water quality related to pesticides. The second group is represented by farmers, who do not spray themselves, the spraying on their fields is done by a contracting sprayer. This group has a little influence on water quality and was not included in the research.

2.2 Water quality problems within the action lab

There are several water quality problems in the Bollaertbeek catchment, such as Plant Protection Products (PPPs), phosphorous (algae problem), low oxygen content, suspended matter, phosphoric acid, medicines, household water.

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In this project, focus is on Plant Protection Products only. Water was analyzed for 41 active ingredients. Mostly herbicides were found. From the top 10 of active ingredients identified in the catchment (namely S-Metolachloor, Linuron, Chloridazon, Dimethinamid, Terbutylazine, Metobromuron, Bentazone, Metribuzin, MCPA and Metazachloor), only 2 products are approved for non-professional use.

In the Bollaertbeek catchment, there are few problems with nutrients in the surface water. The CVBB (Coördinatiecentrum Voorlichting en Begeleiding duurzame bemesting; Coordination centre Information and Guidance on sustainable fertilization) already works on nutrients in this region, giving farmers an advice on fertilization, providing individual fertilizer plans for farmers based on soil analysis and promoting BMPs to reduce nutrient losses. For that reason in this project questions on BMPs focused on nutrients were not included in the Belgian questionnaire.

2.3 Methodology

Surveys were conducted in two stages. The first step was a call to farmers with a small questionnaire in order to learn whether the farmer sprays himself or not:

- 34 farmers of the 164 farmers in the action lab could not be reached. This is 20,7 % of all farmers in the catchment, in total 228 ha of the catchment area, which is 11,9 %.
- 46 farmers do not spray themselves and have little influence on water quality. This group represents 28% of the farmers in the catchment, in total 469 ha or 24,6% of the catchment area.
- 86 farmers spray themselves and have big influence on water quality. This group is the largest group and is 52,4% of the action lab area, in total 1210 ha or 63,5% of the catchment area.

In the second step questionnaire was applied face to face, directly to farmers in the target area:

- 49 farmers of the 86 farmers who spray themselves. 56% of the farmers, who have a lot of influence on water quality have been reached. Their results are presented below.
- In total 835 ha of the catchment area. This represents 44% of the total acreage of the catchment or 69 % of the area sprayed by the farmer.

The key for selecting the survey respondents was a question “do they spray themselves or are the sprayings on their fields done by a contract sprayer?” Farmers, who do not spray themselves, have only little influence on water quality related to pesticides, e.g. point pollution of pesticides of water courses, which are the most important sources of pollution, are excluded. Therefore, the Belgium Action Lab is focused on farmers who spray themselves on their farm.

All farmers (164) have been called (but 34 of them could not be reached), 49 large questionnaires (F2F-meeting with farmers) were applied.

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Representativeness of the questionnaires is quite high. 21% of the farmers could not be reached, but 28% do not spray themselves, so have only a minor influence on the pollution of surface water (*Figure 4*). 52,3 % of the farmers in the area, representing 63,5 % of the total catchment area acreage, have a big influence on the pollution of surface water in the catchment (*Figure 5*). Of this group with big influence, 56% of the farmers has been reached (*Figure 6*), representing 69% of the acreage that been sprayed by the farmer (*Figure 7*), or 44% of the total catchment area (*Figure 2*). In the questioned farms, different types of farms, young farmers, old farmers, large farms, small farms were included.

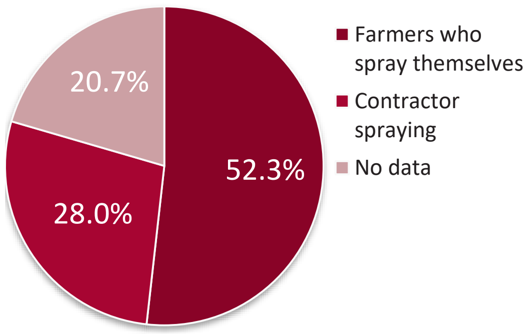

Figure 4: Percentage of farmers in the Bollaertbeek catchment who spray themselves in comparison with contractor spraying

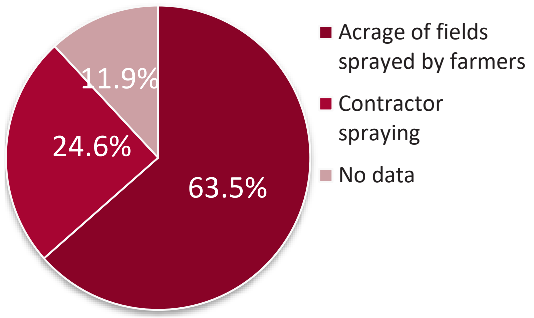

Figure 5: Percentage of farms area in the Bollaertbeek catchment sprayed by farmers in comparison with contractor spraying

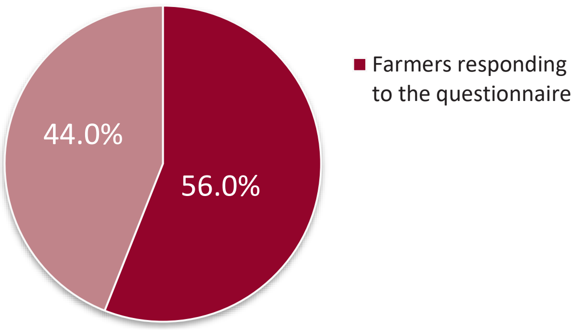

Figure 6: Percentage of farmers in the Bollaertbeek catchment who spray themselves responding to the questionnaire

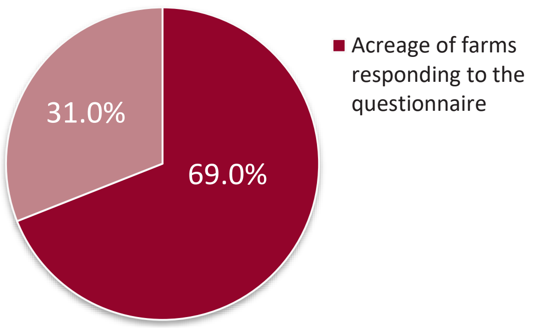

Figure 7: Percentage of farms area in the Bollaertbeek catchment sprayed by the farmer responding to the questionnaire

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2.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

BMPs were selected for improvement of the water quality in case of pollution with Plant Protection Products.

BMP numbers 9, 20, 23, 25, 28 and 38 are obligatory by law (see Annex 1 for BMP key):

- Crop rotation (BMP 9) is obligatory, as it is obligatory that farmers have to cultivate at least three different crops on their farms.
- All farmers who spray themselves need to have a spraying license (BMP 20).
- Only approved PPPs are allowed in Belgium, as all purchased products need to be registered (BMP 23). Suppliers of PPPs give an advice about the correct conditions of use.
- Sprayers need to be inspected every 3 years by a certified institution (BMP 25).
- PPPs must be stored in lockable rooms/containers in Belgium (BMP 28).
- Using drift reducing nozzles (BMP 38) is obligatory since 2017. There is a transition phase until 2020. Not every farmer implemented this BMP yet, but say they will do so this year.

BMP numbers 29 and 35 are obligatory for certification in Belgium. In Belgium, when you cultivate crops for sale, you are obligate to have the "Vegaplan" certificate. One of the obligate conditions is that you dispose obsolete PPPs by an authorized waste collection company (BMP 29) and that you clean and safely manage empty containers/packages, seals and caps (BMP 35), so all farmers implement these BMPs.

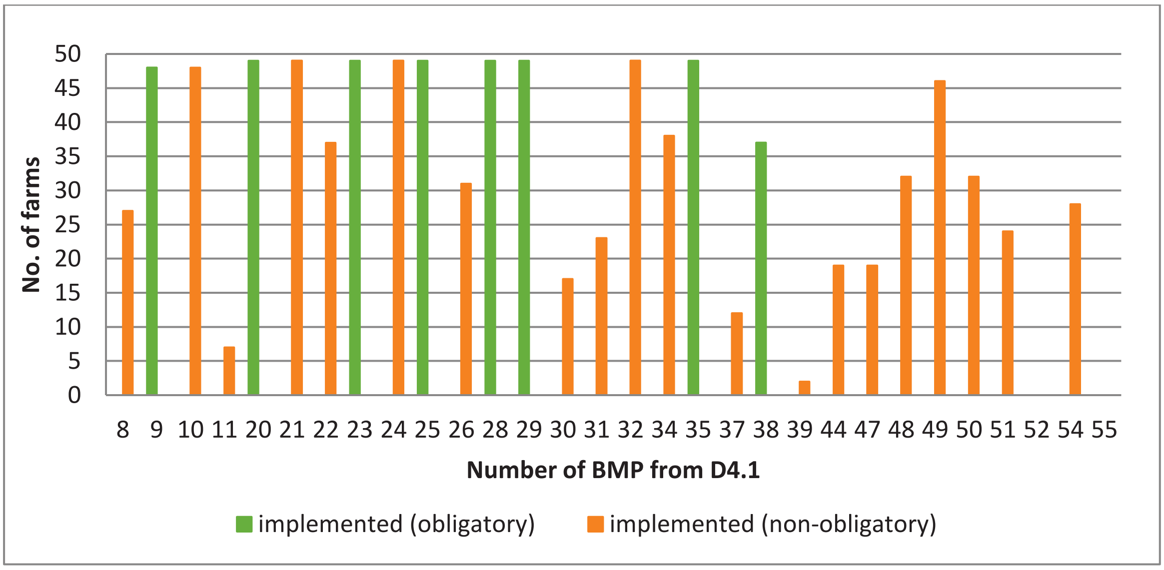

Figure 8: Belgium: Summary of survey results illustrating the number of farms currently using selected best management practice. See Annex 1 for BMP key.

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Some other BMPs are already fully implemented by all farmers surveyed, although they are not obligatory. Results of the survey are presented in *Figure 8*. The percentage of farms where BMPs are implemented is presented in *Figure 10*.

- BMP 10: Plant cover in autumn and winter. This BMP is implemented by all farmers, but not all farmers do implement them on a maximal base. For some farmers it is depended on the type of cultivation before or after the winter period if a plant cover is possible or not.
- BMP 21: Always plan and organize your spray activities. All farmers do plan before they start spraying, so the same groups of PPPs are sprayed in one time.
- BMP 24: Do store sprayers safely. All farmers said that they store their sprayers inside, so no point source pollution by rain can occur.
- BMP 32: Prevent overflow and foam escape during filling. Farmers indicate that they either add anti-foaming product to the spray liquid, or they always stay with the sprayer during filling. Most farmers also do indicate that they don't spill, overflow or produce foaming because the product is too expensive.

With respect to the BMP 22 – regarding weather and field conditions during spraying, most farmers indicate that they spray mostly for the best effective PPPs use, but not exactly to minimize the risk of drift of PPPs. Mostly relative humidity and/or temperature is a weather condition that is not considered a lot.

BMP 39: Use sprayer types allowing spray-drift reduction is a BMP that involves a large investment and is therefore not yet strongly applied.

BMPs 52 and 55 (Double sowing and establishment of retention structures) are measures more necessary in high erosion sensitive areas, so in our catchment not that urgent/necessary to be implemented.

BMPs on nutrients were not included in the questionnaire, as there are not many problems on nutrients in the catchment. However, in Flanders, the northern part of Belgium, following BMPs are generally implemented and/or obligatory:

- BMP 1: Nutrient balance on farm and/or field level
- BMP 2: Fertilizer program
- BMP 3: Liming
- BMP 4: Incorporating organic manures immediately after application on cultivated land (obligatory)
- BMP 5: Injection, trailing shoe or band spreader used for slurry
- BMP 6: Avoiding the application of chemical fertilizers and manure during high-risk periods (has still some potential to be used)
- BMP 62: Spreading slurry in early growing season to maximize crop uptake
- BMP 64: Soil analysis for pH, nutrients or organic matter (obligatory)

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2.5 Potential for uptake of new mitigation measures

BMPs 9, 20, 23, 25, 28, 29, 35 and 38 are obligatory by law or certification. Since they are already implemented, the potential to be implemented is rather low. Other BMPs are already implemented by all farmers (BMP 10, 21, 24, 32). Therefore, the potential to be implemented is rather low too. These are mostly easy and feasible measures, which do not require big investments or big adaptations in the farming system.

Other BMPs are not yet fully implemented, but have a big potential to be implemented. However, some BMPs ask some more effort to be implemented. For example BMP 30: Choose a safe filling and cleaning place for the spraying equipment: Many farmers are willing to have a look if they can change their cleaning and filling place to an unpaved surface on the farmyard. Some of them wanted to have information on the installation of a filling and cleaning place with collection of remnant water on the farm, but this is already a bigger investment. Therefore, not all farmers are willing to install a filling and cleaning place on the farm. However, **these farmers often have interest in a public cleaning place for cleaning their sprayers**. This is not an investment that is possible to be implemented in one year.

BMP 39: Use sprayer types allowing spray-drift reduction. This is a BMP with a larger investment cost price, so not many farmers are willing to implement this BMP yet.

BMP 49: Improved soil management to increase the water holding capacity of the soil includes a wide range of possible measures, such as preparation of a rough seedbed, avoiding surface soil or subsoil compaction. All farmers do implement this BMP on one way or another or do want to implement the BMP.

BMP 50, inter-ridge bunding is already implemented by 32 farmers and have a potential use by additional 45 farmers. This is an upcoming BMP and more and more planting machines are equipped with the necessary equipment. On high erosion sensitive areas it is an obligatory BMP, but not on other fields. However, more and more farmers who don't have high erosion sensitive fields also implement or have the potential to implement this BMP.

BMP 52: Double sowing, is not implemented by any farmer. For the moment, no farmer is ready to implement this BMP because of the perception that this derogates yields. Therefore the potential is zero.

BMP 55: Establish retention structures, is also not implemented by any farmer. There is a small potential to implement this BMP, but most area (77%) are low or very low erosion sensitive fields so this BMP is only useful on a few fields.

BMP 11: Grass buffer zones: This BMP is also less implemented and has a smaller potential to be implemented, because this BMP causes economical/financial losses due to the loss of possible area to be cultivated. Some farmers don't meet the conditions (don't drive or turn on the grass buffer zones, zone may not be located near to other grass fields,…) to receive financial funding.

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A summary of respondent's attitudes to the potential implementation of the BMPs and current BMP usage are presented in *Figure 9*. The percentage of farms willing to implement each best management practice and current BMP implementation are presented in *Figure 10*.

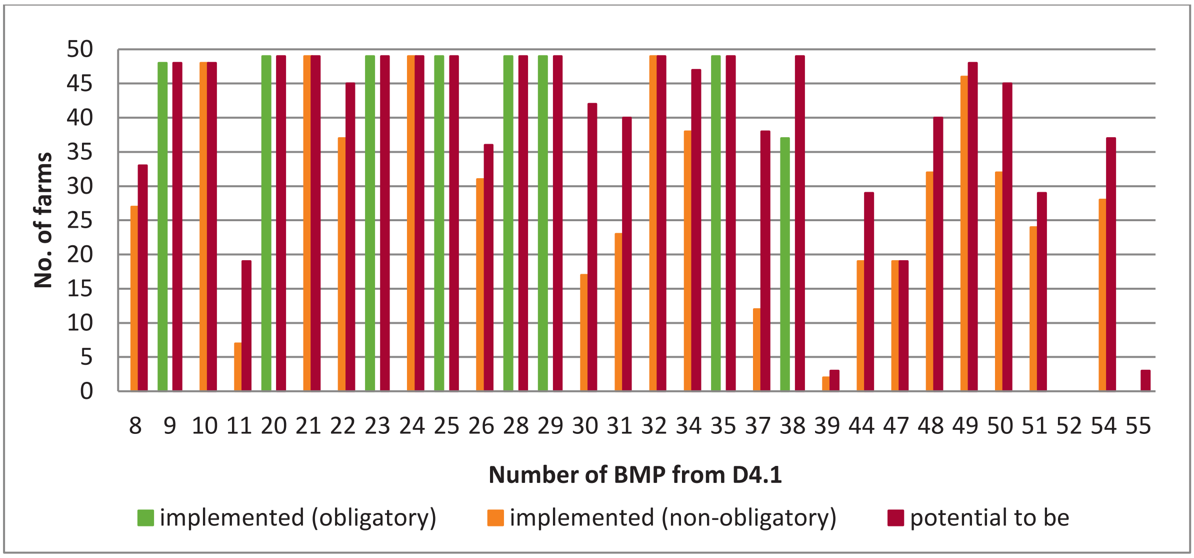

Figure 9: Belgium: Summary of survey results illustrating the number of farms currently using selected best management practices and their potential for implementation. See Annex 1 for BMP key.

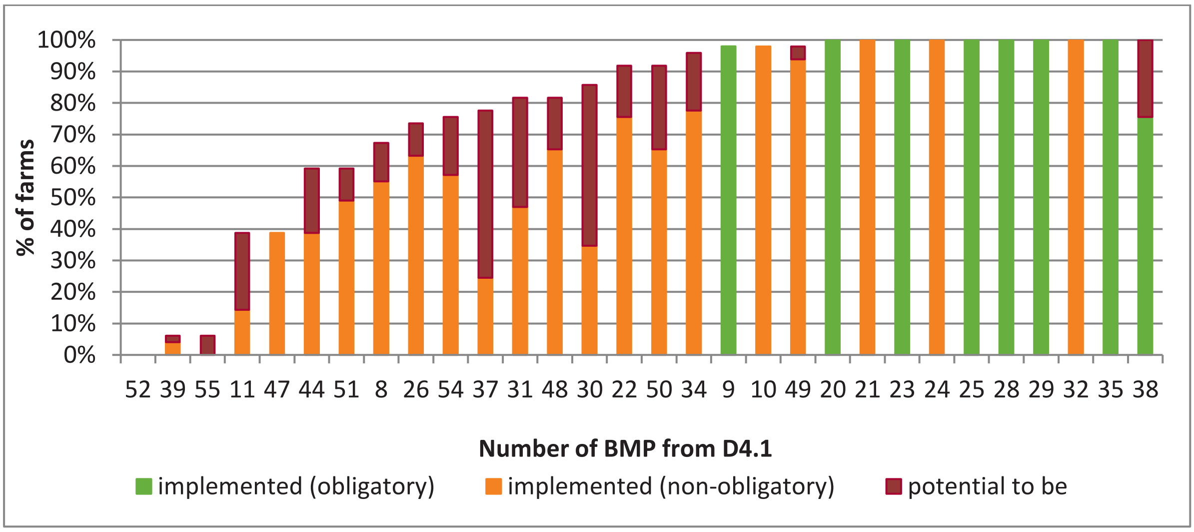

Figure 10: Belgium: Summary of survey results illustrating the percentage of farms currently using selected best management practice and their potential for implementation. See Annex 1 for BMP key.

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2.6 Conclusions

In the Belgian Bollaertbeek action lab, we questioned the implementation of pesticide pollution mitigation measures and tried to assess the willingness of farmers to implement additional, innovative measures to mitigate pesticide pollution. Therefore, 49 farmers were interviewed. We found that measures, which are obligatory by law in Belgium, such as the spraying license for spraying operators, sprayer inspection, management of empty containers/packages …, are implemented.

We also see high implementation rates or high willingness to implement easy and cheap measures such as safe storage of the sprayer, filling and cleaning on unpaved surface. These measures are rather behavioral changes that can be implemented if the farmer is aware of the problem and do not require big investments or adaptations in the farming system. **Rising of the awareness is a key to improve implementation of these measures.**

However, some measures require higher investments, entail a loss of income for the farmer or are not easily feasible in practice and require bigger adaptations in the farming practice. Some examples of these measures are a fully equipped filling and cleaning area at the farmyard, grass buffer strips, new spray technologies. We clearly see that these measures are less or not implemented and the willingness to implement these measures is low. Financial incentives could improve the implementation of these type of measures.

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3 Ireland – the Ballycanew and the Castledockerell catchments

3.1 Brief introduction to the action lab

The Irish case study consists of two agricultural catchments situated in the south east of the country in County Wexford. While situated in relative proximity, both catchments are distinct in terms of their hydrogeological setting and dominant agricultural production systems.

The Ballycanew Catchment (area 12km^2) is characteristic of mostly poorly drained soils overlaying volcanic rhyolite bedrock. Within the catchment, 97% of the land is used for agriculture, mostly for grass-based production (77%), with the remainder used for arable crops. The main grass-based farm enterprises are beef and dairy production with spring barley being the main tillage crop.

In contrast, the Castledockerell Catchment (11 km^2) is characteristic of mostly free draining soils overlaying fissured slate bedrock. Of the total land area, 93% is used for agriculture, most of which is used for cereal crop production (54%), with the remainder used for grass-based production. Spring barley is the main tillage enterprise while beef and sheep production are the main grass-based enterprises.

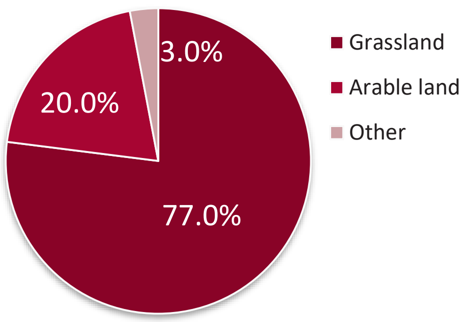

Figure 11: Percentage of agricultural land use in the Ballycanew Catchment

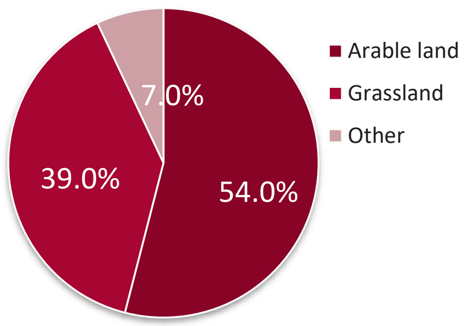

Figure 12: Percentage of agricultural land use in the Castledockerell Catchment

In the Irish Action Lab there are 40 farms in each catchment, a total of 80 farmers of which 35 responded to the questionnaire. Almost half of farmers have been reached. They represent 3110 ha of agricultural land which is larger than overall area of the Ballycanew Catchment and the Castledockerell Catchment. In this case farm boundaries go beyond boundaries of the catchments.

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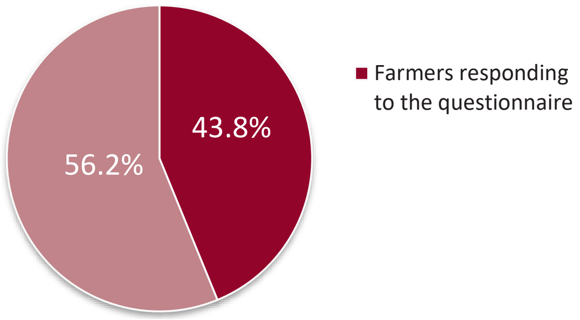

Figure 13: Percentage of farmers in the catchments responding to the questionnaire

3.2 Water quality problems within the action lab

Point and diffuse sources of both agricultural and domestic contamination are present in both catchments. In Ballycanew, grassland mineral fertilizer application typically begin in early spring and continue through the growing season. Organic fertilisers, mainly cattle slurry, are spread throughout the growing season, with most applied in spring and early summer particularly in the period after the first cut of silage in May/June. Typically grassland does not routinely receive pesticide application but some grassland weed control is done using a small range of grassland herbicides. The arable crops (mainly spring barley) receive a herbicide and a fungicide application and often an insecticide. Most of the pesticides are applied in the early to mid growing season (April-May).

In the predominantly arable Castledockerell catchment, typical management of the spring barley production involves ploughing from January to February with sowing from late February to early April and harvesting from August to early September. Compound mineral fertilisers (N,P,K) are typically incorporated into the soil at sowing time with additional nitrogen application during the early growing season. Grassland does not routinely receive pesticide application but some grassland weed control is done using a small range of grassland herbicides. The arable crops (mainly spring barley) receive a herbicide and a fungicide application and often an insecticide. Most of the pesticides are applied in the early to mid growing season (April-May).

While, point and diffuse contamination sources are present in both catchments, due to differing hydrogeological settings, both study catchments are dominated by distinct contaminant pathways. In the poorly drained Ballycanew catchment, impacts on water quality primarily include nitrate (and potentially pesticide) loss to groundwater in the uplands and phosphorus loss to surface water and a perched groundwater table. The free draining arable land of the Castledockerell catchment is vulnerable to nutrient and pesticide leaching to groundwater and surface water via belowground pathways as well as phosphorus loss to surface water *via* quick flow pathways during rain events.

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3.3 Methodology

Surveys were conducted via the existing Teagasc advisory network which operates within the two study catchments. Paper copies of the surveys were circulated and completed by the farmers during discussion group meetings. These meetings are facilitated by trained Teagasc advisors in order to discuss technical issues and share information.

Each survey included 32 best management practices (BMPs) (see Annex 1) for mitigating losses of pesticides and/or fertilisers. Each respondent was asked firstly to indicate whether or not they currently use the BMP (yes/no), and secondly, whether or not they want to use this BMP in the future (yes/no).

A total of 35 surveys were completed and returned. These 35 respondents represented a total farmed land area of 3110 ha. This farmed area for survey respondents is larger than the overall area of the catchment (2307 ha). This is due to the fact that farm boundaries do not necessarily follow catchment boundaries, and hence the surveys may refer to some land outside of the catchments. Nonetheless, all farmers are operating to some extent within or near the study catchment so the results are representative.

3.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

All of the BMPs included in the survey (n=32) were currently implemented on at least one farm (*Figure 14*). Note, as several non-responses were observed in a small number of respondent surveys. The “no data” of the survey means that the farmer did not respond to that particular question of the survey. The reason for this is very likely due to the question not being applicable for them. The percentage implementation based on the total number of respondents for each BMP is illustrated in *Figure 16*.

Note, several of the BMPs included in the survey are obligatory under various legislative acts. In Ireland, the main regulations (among several others) that control the marketing and use of pesticides include the Sustainable Use of Pesticides Regulations (SI 155/2009) and the Plant Protection Products Regulations (SI 159/2012). With respect to pesticide usage, pesticides sprayers must be properly calibrated (BMP 26), appropriate buffer zones must be observed (BMP 11), pesticides must not be applied in certain defined sensitive areas (BMP 44) and they must be stored and transported safely (BMP 24 and BMP27). Note several other BMPs are encouraged under best practice guidelines provided by relevant authorities.

With respect to protecting aquatic systems, the Nitrates Directive (91/676/EC) was a specific Council Directive concerning the protection of both surface and groundwater against nitrate pollution from agricultural sources. The directive required member states to identify vulnerable zones and in turn apply action programmes and mandatory rules to them. In Ireland, this was

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implemented via a national territory approach using an action plan for the whole country recently reviewed and implemented under the European Communities Good Agricultural Practice for the Protection of Waters Regulations (Department of the Environment, Community and Local Government, 2017) (SI 605/2017). The legislation obliges farmers to practice several BMPs including avoiding spreading fertilizers during high risk periods (BMP 6), adequate manure storage (BMP 61) and several other nutrient management practices.

One hundred percent of farms already avoid spraying (i.e. applying pesticides) at sensitive times (BMP 22 – See Annex 1 for BMP key) or to sensitive areas (BMP 44). Furthermore, 97% of respondents, utilise liming to optimise soil pH (BMP 3), perform soil analysis (BMP 64), safely store and transport pesticides (BMP 24 and BMP 27), seek professional support when choosing pesticides (BMP 57) and safely dispose of pesticide liquid residues (BMP 37). An avoidance of fertiliser spreading during high risk periods (BMP 6) were practiced in 94% of farms and a fertiliser programme (BMP 2) in 91%.

In contrast, less than 10% of farms assessed employed phased livestock feeding (BMP 17), phytase supplementation (BMP 18), the estimation of the nutrient content of organic manure (BMP 63) and the use of trailing show, injection or band slurry spreaders (BMP 5).

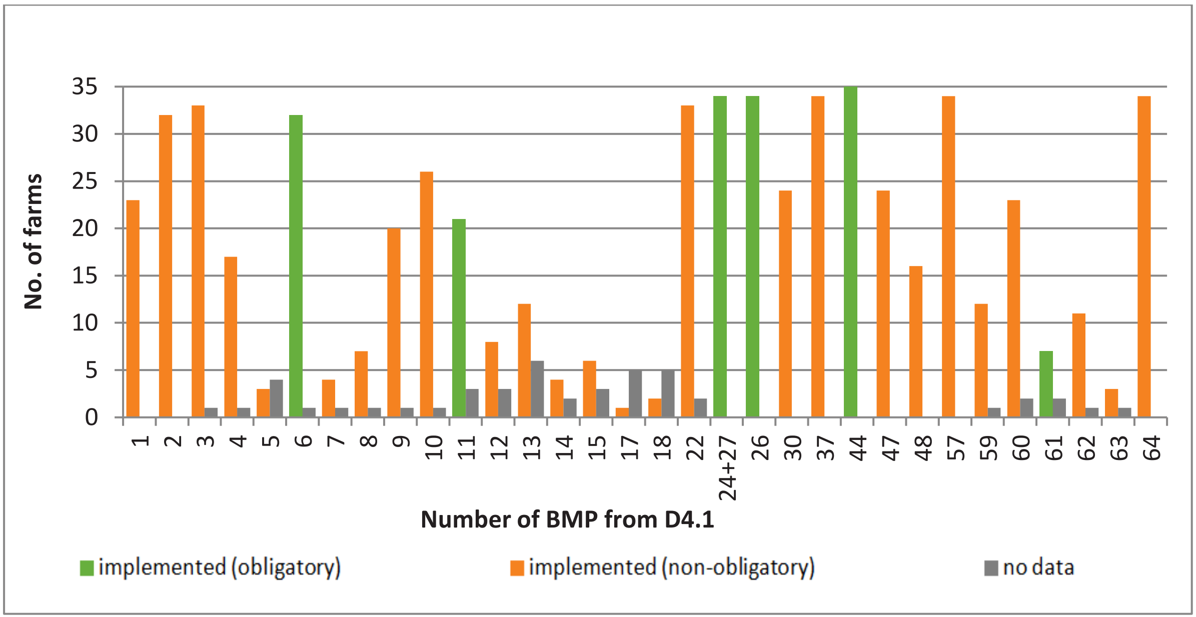

Figure 14: Ireland: Summary of survey results illustrating the number of farms currently using selected best management practice. See Annex 1 for BMP key.

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3.5 Potential for uptake of new mitigation measures

A summary of respondent's attitudes to the potential implementation of the BMPs is presented in Figure 15. As discussed in Section 4.3, due to several non-responses, these values are presented as percentage (i.e. percentage willing to implement) in Figure 16.

To elucidate the potential for future BMP implementation, Figure 16 illustrates, for each BMP, the percentage of respondents that currently use it and the percentage of respondents that deem it implementable. Where current usage is low, and there is a large difference between current usage and potential for further usage, it could be assumed that these BMPs are perhaps seen as more favourable options by the respondents which, in turn, may make them easier to implement. In contrast, where the initial usage and potential are both low the implementation would be potentially more challenging as it is not deemed favourable by the respondents. Note, this does not mean that it is not an effective or potentially implementable BMP. Its implementation may be aided through engagement and knowledge transfer with farmers. Note, where the BMPs are already currently used on a large proportion of respondent farms, the willingness can only be low. However, the potential for further implementation is somewhat irrelevant as the BMPs are already implemented.

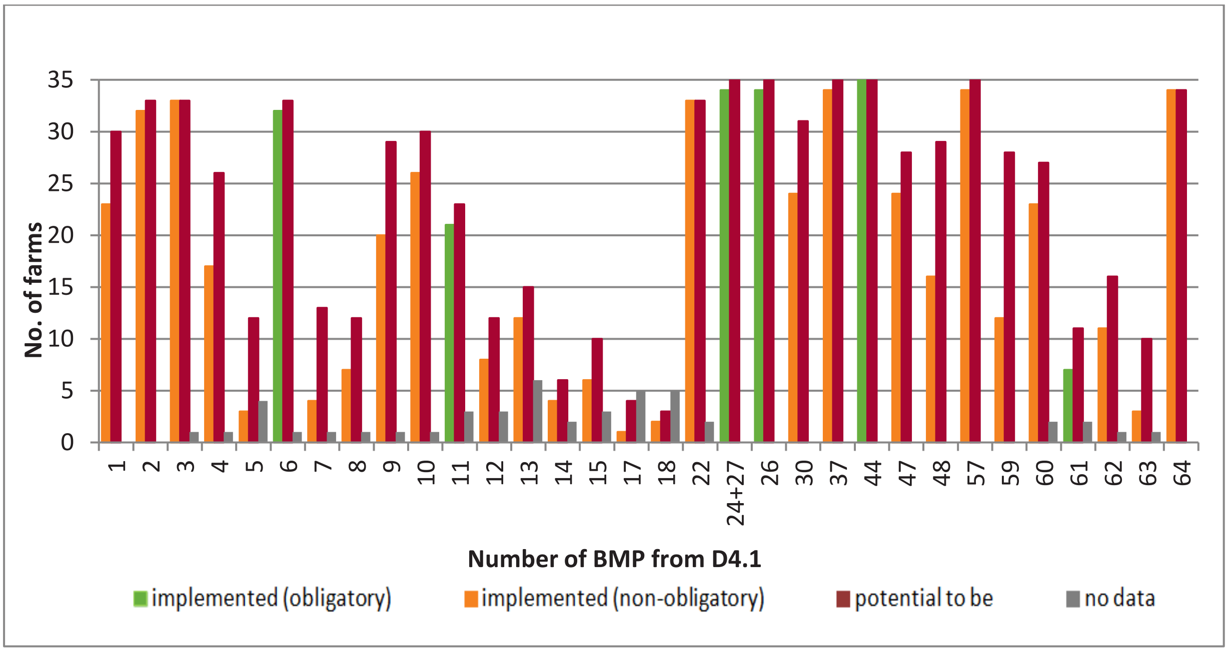

Figure 15: Ireland: Summary of survey results illustrating the number of farms currently using selected best management practice and their potential for implementation. See Annex 1 for BMP key.

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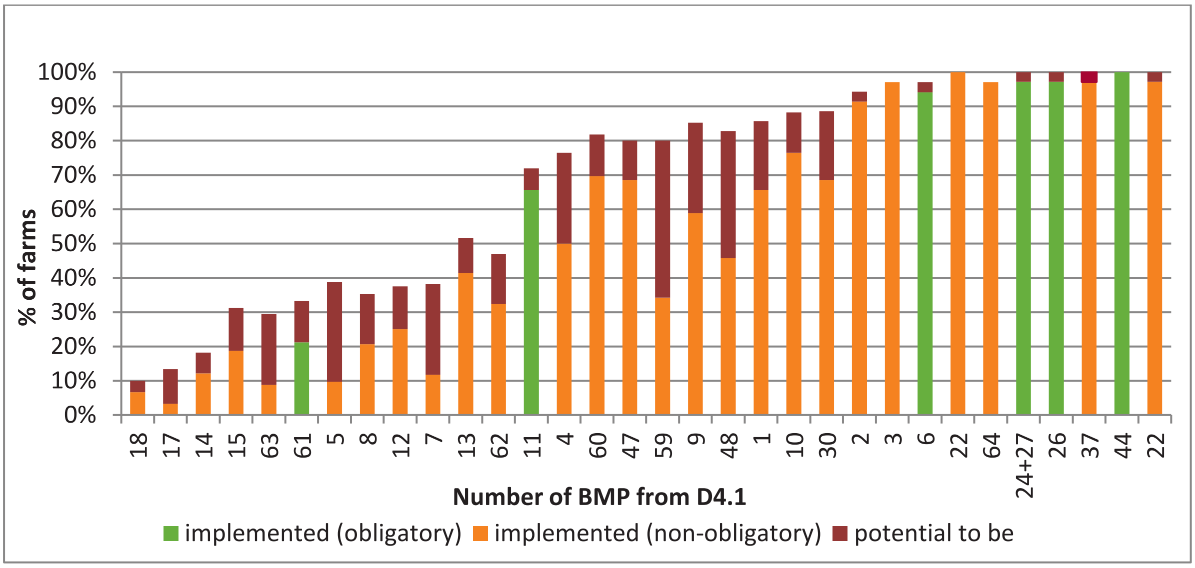

Figure 16: Ireland: Summary of survey results illustrating the percentage of farms currently using selected best management practice and their potential for implementation. See Annex 1 for BMP key.

While for most BMPs, the percentage of respondents willing to implement them was greater than the percentage that currently uses them, the difference in the percentages varied considerably. In particular, the use of GPS technology to manage inter field variability in crops (BMP 59) was currently used by 35% of respondents, it was deemed to have the potential to be implementable by 82% of respondents which yields a difference of 47%. Similarly, the use of GPS technology to support spraying applications of pesticides (BMP 48) had a difference of 37%. This potentially indicates that the implementation of these BMPs would be favourably received by farmers, which could make them easier to implement.

A significant range exists between BMPs in terms of their deemed potential for implementation. Differences in percentages of between 20-30% were observed for BMP 1 (calculation of nutrient balance on farm or field scale), BMP 7 (the use of treated urea), BMP 4 (incorporating organic manures immediately after application on cultivated land), BMP 5 (injection, trailing shoe or band spreader used for slurry), BMP 9 (crop rotation) and BMP 63 (estimation of the nutrient content of organic manure). BMPs related to pesticides are already largely implemented. However, BMP 30 Choose a safe filling and cleaning place for the spraying equipment has a significant potential to be implemented in the future. Similarly, these BMPs could be favoured by farmers, hence, aiding their implementation.

In contrast, for BMP 18 (phytase supplementation), currently 7% of farms use it while just 10% said they were willing to use it, yielding a difference of 3%. Similarly, for BMP 17 (phase feeding), currently 3% of farms use it while just 13% said they were willing to use it, yielding a difference of

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10%. It is apparent therefore that these BMPs, along with BMP 14 (use of controlled drainage), are not viewed as favourable by the respondents.

3.6 Conclusions

It is likely that these outcomes are a result of multiple economic, social and natural factors. While these intrinsic factors associated with the BMPs have not been quantified, it is likely that the BMPs which are currently implemented and those that were deemed to be implementable offer benefits that are clear and appreciable to the farmer. For instance, as 100% of farmers already avoid spraying at sensitive times (BMP 22) and to sensitive areas (BMP 44), the respondents must appreciate the importance of these BMPs, potentially for economic or environmental reasons.

Furthermore, the high current usage of liming to optimise soil pH (BMP 3), soil analysis (BMP 64), professional support when choosing pesticides (BMP 57), fertiliser programme (BMP 2) and an avoidance of fertiliser spreading during high risk periods (BMP 6) is again likely a result of a combination of environmental and economic factors. In contrast, the low current usage and low desire for future implementation of BMP 18 (phytase supplementation), BMP 12 (using artificial wetlands on farms) and BMP 14 (use of controlled drainage) are likely due to the perceived poor performance for the same criteria.

4 Italy - the Val Tidone catchment

4.1 Brief introduction to the action lab

In the Italian action Lab, already at the beginning of the project, a general questionnaire was developed in order to understand the case study in terms of distribution of vineyards, hydrology, existence on the territory of groundwater wells, existence on the territory of mitigation measures and best management practices to avoid ground water contamination by point sources and the interest of farmers to participate in the WaterProtect Project. After development of the common questionnaire in WP4, the second survey campaign was undertaken, involving the farmers that express their interest to participate the project. In this document we will refer to the second questionnaire as “common questionnaire”.

The Val Tidone Catchment (206.72 km^2/ 455 farmers) is placed in the north-west of Italy in Emilia Romagna region and is characterized by a mix of urban, peri-urban and rural areas. The area covers five municipalities: Ziano Piacentino, Castel S.Giovanni, Nibbiano, Pianello, and Borgonovo for 28 548 inhabitants.

It is a hilly area with elevations ranging between 100 and 350 m above sea level, which is known for deeply rooted tradition and vocation to viticulture. The main culture is the vineyard, with 2941 ha in 2016. Inhabitants of rural villages are mainly involved in grape and wine production, organised as private farms or as social wineries. Two types of farm structure are present:

1. Vineyard with a cellar. In this case, grape transformation to wine and wine retail is self-made. This is the case of 25% of the total vineyards present on the investigated area.

2. Vineyard without a cellar. In this case, farmers deliver their grapes to social wineries. This is the case of 75% of the total vineyards present on the investigated area.

The peculiar orographic features of the territory have determined the development and adoption of agricultural/hydraulic plumbing systems called "ritocchino" that already represent a sort of mitigation measures applied in order to limit the erosion and control water speed, slowing down the water flow and that shapes hills, turning them into an orderly sequence of longitudinal line.

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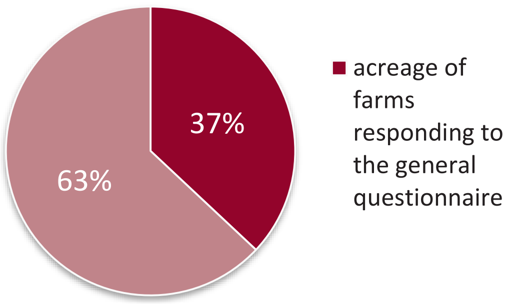

Figure 17: Percentage of farms area in the Val Tidone catchment responding to the general questionnaire

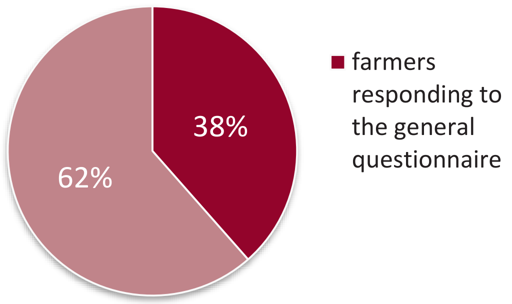

Figure 18: Percentage of farmers in the Val Tidone catchment responding to the general questionnaire

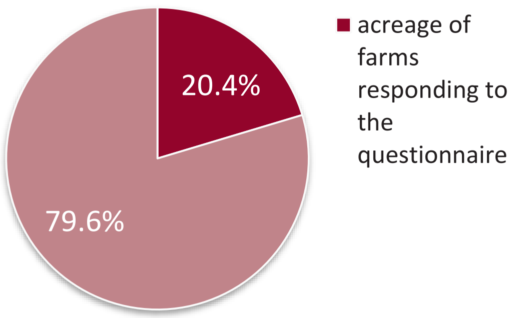

Figure 19: Percentage of farms area in the Val Tidone catchment responding to the common questionnaire

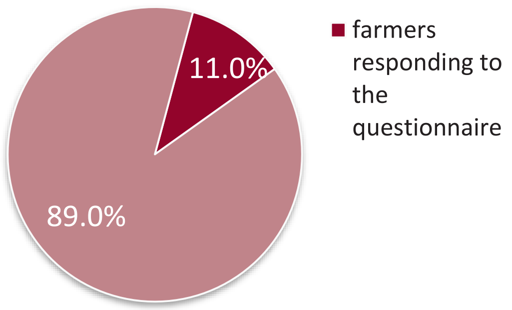

Figure 20: Percentage of farmers in the Val Tidone catchment responding to the common questionnaire

4.2 Water quality problems within the action lab

In the Italian Action Lab pollutants under investigation are nitrates and pesticides, both used in vineyards. Focus of the study is on groundwater. Until now, impact of grape cultivation on groundwater quality with respect to pesticides and nitrates contamination has never been investigated. The area under investigation is partially within the zone sensitive to nitrates, while concerning sensitivity to pesticides, the regional map/assessment is under development and therefore, no information is yet available.

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In more details, groundwater in the Val Tidone Catchment present significant concentrations of pesticides and nitrates as articulated by the local Environmental Agency and partner of the project ARPAE-ER. As previously described, groundwater contamination by pesticides and nitrates is caused by both diffuse and point sources. However, the most prevalent source of contamination is diffuse contamination. Point source contamination is mostly accidental. Therefore in addition to the analysis of mitigation measure to prevent point sources, an analysis of the mitigation measures and good agricultural practices for drift and runoff for hilly vineyards (with a slope> 2%) has been carried out using as a reference the MagPie toolbox and the latest available version of the Italian Ministry of Health Guidance Document on the subject (published the end of 2017).

Concerning nitrates presence in groundwater, part of it is naturally occurring, while an important part is produced by fertilization of agricultural lands. During a preliminary survey it was revealed that 70% of 175 farmers interviewed use nitrogen fertilizers in their vineyards, however they adhere to voluntary integrated production specifications that prescribe nitrogen doses according to the estimated production, and do not exceed specific values set by competent authorities. Therefore, in the Italian Action Lab fertilization is an important source of possible pollution.

Concerning groundwater pollution by pesticides, their use outside the agricultural sector is considered having an insignificant impact on ground water pollution.

Concerning groundwater pollution by nitrates, human activities, outside the agricultural sector, are considered having a very low impact on groundwater pollution.

Global temperature increase and changes in precipitation typology characterized by large downpours occurring in short periods determinate a decrease of water infiltrating from soil surface to groundwater. Therefore, groundwater levels decrease while concentrations of pollutants increase.

4.3 Methodology

There are 455 farms (total of 2941 ha) in the catchment with an average surface area of 6,5 ha. As already specified, in the Italian Action Lab two survey campaigns were undertaken. The first general questionnaire was undertaken between August - November 2017, and the second - the common questionnaire developed in the WP4 was done in the period of March - May 2018. Both of them were conducted by trained survey operators. In both cases respondents were informed about the survey goals before the interview and farmers were interviewed on the basis of their willingness to participate in the project. In order to reach a higher number of respondents, mixed tools and approaches were adopted. In addition to the face to face methods, a series of telephone interviews were conducted and, where judged possible, for farmers familiar with IT tools, an on-line questionnaire was used.

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Point sources contamination survey

Observation of good practices and correct behaviours in the pesticide management at a farm level and adoption of mitigation measures such as biopurification systems are considered the most effective action to prevent point sources contamination.

During the first survey (general questionnaire) 175 farmers were interviewed and results obtained revealed that 64% of vineyards have less than 10 ha of surface area, 25 % of vineyards have 11 to 39 ha of surface area, 7,5% of vineyards have more than 40 ha of surface area (and 3,5 % didn't give an answer). In the second survey (common questionnaire), when selecting farms for survey, size of vineyards was taken into account so that all types of vineyards were included into the survey. The total acreage of farms who responded to the general questionnaire was 1088,32 ha (37% of the catchment).

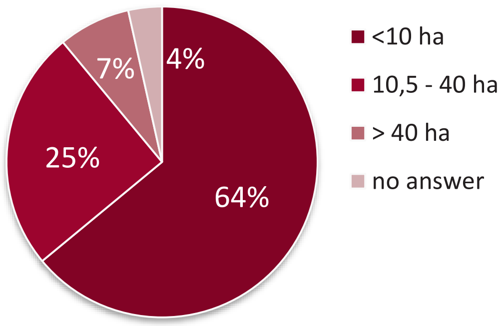

Figure 21: Percentage of surface area category of farms in the Val Tidone catchment responding to the general questionnaire

Four questions related to the management of point sources contamination were included in the general questionnaire, which contained 25 questions pertinent for different activities of the 7 working packages of the project and the relevant information were then extrapolated.

Several GAPs and MMs are selected and suggested to **reduce point sources** pollution:

- Machine washing in dedicated areas equipped with waste water recovery or disposal systems (BMP 30)
- Dedicated area for mixing and for filling the sprayer and cleaning the machine(BMP30 and BMP34)
- Storage of pesticides in appropriate places and proper disposal of containers (BMP28 and BMP35).
- Adoption of biopurification system (as biobed, heliosec etc) (BMP37)

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Diffuse contamination survey.

The aim of the work (development of the common questionnaire) was to select the measure(s) most fitting to Italian lab vineyard conditions and to obtain information from the questionnaire submitted as detailed below:

- to understand the knowledge level of farmers about factors influencing run off and drift,
- to acquire knowledge on which of the selected mitigation measures are already in place,
- the familiarity of farmers on the mitigation measure (MM) and skills acquired through experience or education, on MM efficacy in limiting the contamination,
- to suggest good practices or effective mitigation measures in reducing diffuse contamination and to understand the will to implement the MMs suggested and, if not , to understand the motivations and barriers.

After a state of the art evaluation and literature screening and review, Good practices (GAPs) and MMs were selected using the following criteria:

- applicability at our lab landscape conditions,
- ready to implement,
- sufficient knowledge/ level of confidence and strength of scientific evidence,
- possibility to demonstrate or measure the efficacy of the GAPs and MMs to support their implementation.

The MMs and GAPs selected and therefore linked to the Waterprotect project BMPs are listed below.

GAPs to understand the level of *knowledge about factors influencing run off* and skills or ability to identify specific risk situations.

The knowledge of the factors involved in the contamination processes allow to adopt behaviors or structural changes aimed at limiting and controlling the contamination

- proximity of field to the water bodies (adjacent, not adjacent), presence or observed concentrated runoff or moderately concentrated run off in the field, knowledge on slope and influence of soil texture on run off

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MMs selected and suggested to *reduce run off and erosion* in vineyard with slope >2%

In sloping soils the problem of run-off and erosion needs to be tackled in a more articulated way than flat land. In our action lab we can have two types of runoff: one that tends to move uniformly down the whole or part of the field as diffuse sheet runoff, and one that tends to concentrate into discrete flow channels, due to localized flow restrictions or channeling at the soil surface or due to converging water flow in the larger landscape.

From the literature analysis the selected MMs, listed below, have a high level of efficacy as they are located near the runoff source or where runoff/erosion starts (as for vegetative filter strip (VFS)), and/or may provide additional benefits as for soil conservation and erosion prevention and for reduction of nitrate leaching.

- Vegetated filter strip (VFS) at edge-of-field or in field VFSs as grassed talwegs at landscape level (BMP 65 and 66)
- Artificial wetland or retention pond (BMP 12)
- Vegetated diches (BMP 55)
- Inter-row processing and weeding on the row (BMP 67)
- Permanent grassing in the row and weeding on the row (BMP 68)
- Optimize irrigation timing and rate using Decision Supporting System (BMP 56)

MMs and GAPs selected and suggested to *reduce drift* in vineyard with slope >2%

Two type of drift reduction strategies are identified: no spray zones and use of spray drift reduction technology. From the literature analysis the selected MMs could allow a high percentage of drift reduction.

The indirect MMs selected to manage **spry drift** generated by sprayers in our context are:

- Buffer strip of size (width) not less than 5 meters and not more than 15 meters depending on the type of spraying material (BMP 44)
- Adoption of vertical barriers able to intercept the drift (hedges, trees, artificial windbreak) in addition of the buffer zone (BMP47)
- Anti-hail net (BMP 69)

The direct MMs selected to manage **drift exposure** generated by sprayers in our context are:

- Adoption of several technical devices for drift reduction and special equipment to reduce spray drift as Air Injection Drift Reducing Nozzles (DRN), and other machinery equipment (BMP 38/39)
- Last row sprayed from the outside towards the inside (BMP 40)

MMs selected and suggested to *reduce nutrient pollution* in vineyard with slope >2%:

- Physical chemical analysis of soil for pH, nutrients, and organic matter (BMP64)

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50 selected farmers were interviewed on the basis of their willingness to participate in the project, the size of vineyards, proximity to wells subjected to pesticides and nitrates monitoring campaigns. Respondents were informed about goals of the survey before an interview took place.

Total acreage of farms that responded to the questionnaire was 599 ha (20% of the catchment area).

From the 50 vineyards surveyed, areas of 30 of them were less than 10 ha and this represents 60% of the total farms surveyed. Areas of 19 vineyards were between 10,5 ha to 40 ha, and this represents 38% of all farms surveyed. Only 1 vineyard surveyed was bigger than 40 ha, representing 2% of the surveyed farms.

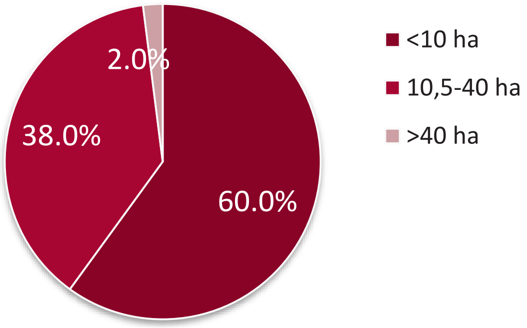

Figure 22: Percentage of surface area category of farms in the Val Tidone catchment responding to the common questionnaire

4.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

Summary of BMPs point sources contamination questionnaire outcomes (general questionnaire)

In total 4 BMPs where selected and used in the survey. Figure 23 presents the summary of the survey results (175 farmers interviewed). Results allowed to have a picture of the extent of the proposed mitigation measures already being implemented, but not on their potential to be implemented or willingness to adopt.

Results of the survey are as follows:

- Machine washing in dedicated areas equipped with waste water recovery or disposal systems are present in 39% of farms (BMP30).
- Dedicated areas for mixing and filling sprayers are present in 44% of the farms. Of these, in 19% of interviewees this area is used for both sprayer washing and waste management at the end of the treatment. 28% use this area for external sprayer washing (BMP34).

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- Storage of pesticides in appropriate places and proper disposal of containers (BMPs 28 and 35). These BMPs are applied by 90% of respondents. Correct handling and appropriate storage of plant protection products and for treatment of their packaging and remnants is compulsory. By 1 January 2015 all professional users had to comply with provisions of Annex VI of the Italian National Action Plan.
- 40% of the interviewees are interested in the adoption of bio purification system (as biobed, heliosec etc) (BMP37).

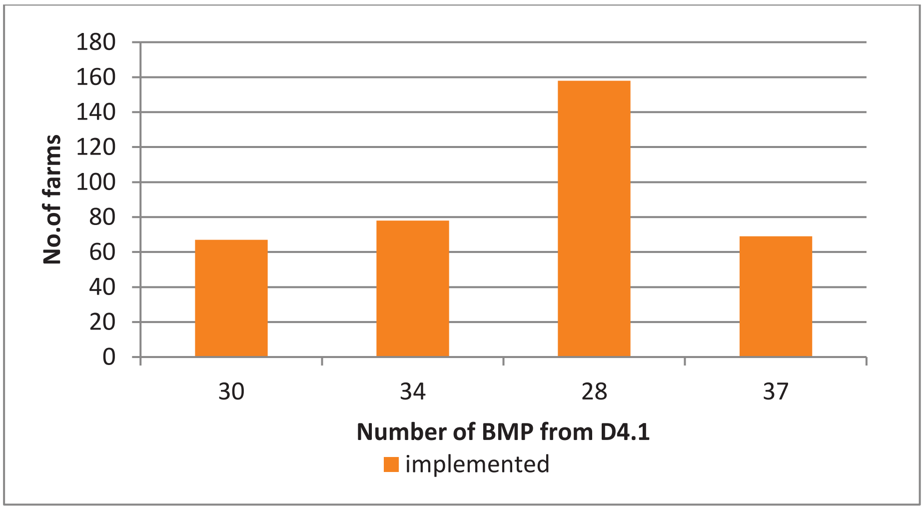

Figure 23: Italy: Summary of survey results for point sources contamination illustrating the number of farms currently using selected best management practices. See Annex 1 for BMP key.

Summary of BMPs point diffuse contamination questionnaire outcomes

In total 14 mitigation measure/GAPs were considered. Among these, 10 are implemented in almost all farms (Figure 24).

A detailed analysis of the survey data (50 farmers interviewed) allows to state the following:

- 88% of respondents are familiar with factors that affect runoff, eg. slope and soil type and 58% recognize the need for a water body/well to be safeguarded from a runoff. In Italy professional farmers undertake compulsory trainings in these issues by certified training companies.
- The Vegetated filter strip (VFS) at edge-of-field is applied in 52% of farms, in some cases it is used for passage of vehicles (inaccurate knowledge) in other cases it was already present as hydraulic arrangements (BMP 65).

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- Vegetated ditches are present in 78% of farms and are considered effective in containing runoff (BMP 55).
- In general respondents are not concerned about runoff that is perceived of moderate intensity. Respondents believe that measures taken (hydraulic arrangement, drainage channels, good field practice such as Inter-row processing and weeding on the row) are sufficient to contain the phenomenon.
- Barriers are present in 24% of farms and are considered effective in containing drift (BMP 47).
- A buffer strip of size (width) not less than 5 meters and not more than 15 meters is applied by 97% of respondents. Non spray buffer zone is compulsory in Italy if indicated on the label (BMP 44).
- Regular technical inspection of pesticide application equipment is compulsory by Article 12 of Legislative Decree No 150/2012, and shall be performed by dedicated Test Centres. In addition to that, professional users shall conduct adjustments and calibrations of equipment used to ensure pesticide mixtures are sprayed in correct amounts, and to keep the equipment in a proper working order, thus ensuring high level of safety and protection of human health and the environment. For this reasons questions on this topics were not included in the questionnaire.
- In general, technical devices for drift reduction and special equipment to reduce spray drift are considered effective in reducing drift exposure. Air injection drift reducing nozzles are used by 52% of the respondents (BMP 38).
- Regarding nutrient soils analysis for pH, macro elements, organic matters and C/N, these are performed by almost 50% of respondents and this correlates to the fertilization planning (BMP 64).
- Respondents that declared to control weed are 44% of the sample. Of these 73% apply a good practice of inter-row processing and weeding on the row, while the rest use permanent grassing in the inter row and weeding on the row (BMP 67,68).

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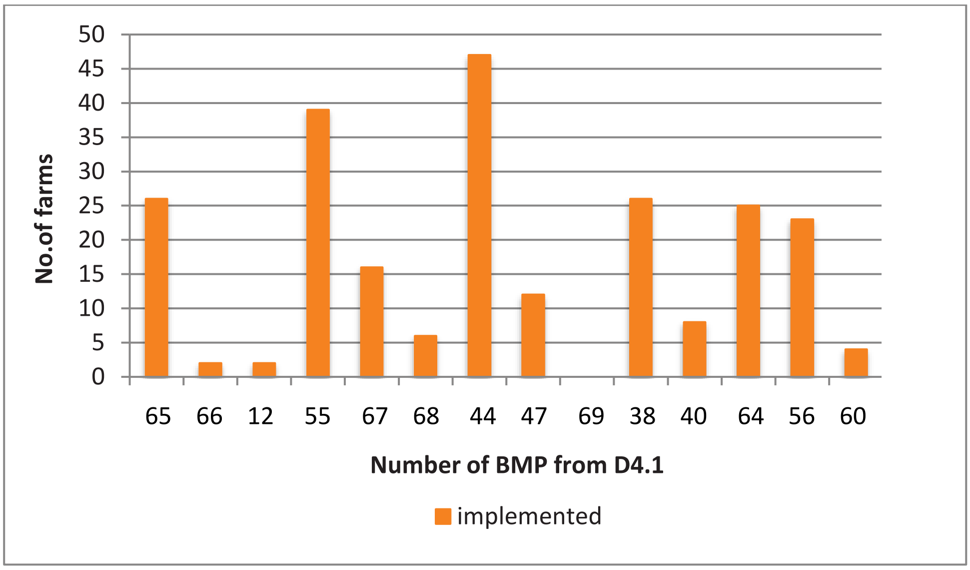

Figure 24: Italy: Summary of survey results for diffuse sources contamination illustrating the number of farms currently using selected best management practices. See Annex 1 for BMP key.

4.5 Potential for uptake of new mitigation measures

Point source pollution

Results allowed to build up a picture of the extent of the proposed mitigation measures already being implemented, but not on their potential to be implemented or willingness to adopt. However analyzing the data **all the proposed mitigation measure have the potential for uptake**.

Proper pesticide storage and handling as treatment of their packaging and remnants are compulsory but improvements and actions could be implemented to ensure that handling, storage and disposal of pesticides and their containers are performed correctly. While 56% of respondents declare they don't have a dedicated area for mixing and filling the sprayers, actions supporting farms to upgrade or create equipped product mixing areas and for filling the sprayer could be of interest. The use of Biopurification systems to treat the pesticides containing water coming from sprayers internal and external washes in Italy is limited as a specific environmental impact authorization is required; however there is an interest of 39% of farmers in their adoption. Indeed several meetings between UCSC and Monitoring Unit of ARPAE (partner of the project) and Authorisation Unit of ARPAE (not involved in the WaterProtect project) were undertaken in order to evaluate the complexity of the authorisation process and the possible roles of WaterProtect partners (UCSC and ARPAE), farmers and farmer's associations. However, none possible solutions were found in order to follow the authorisation process during the WaterProtect Project. Therefore, the use of such treating systems will not be further evaluated as a possible solution to avoid water contamination in Italian Action Lab.

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Diffuse pollution

Several considerations can be stated based on the survey results (Figure 25):

- 10 farmers would be interested in having information what is the percentage of runoff reduction at the edge of their fields when using a vegetated buffer strips (BMP 65).
- To minimize risk for moderately concentrated runoff and erosion with all viable in-field measures, edge-of-field buffers and landscape measures are not considered necessary for the majority of farmers interviewed while the phenomenon was observed only by 18 respondents (36%) and as explained before there is the feeling that measures already taken are sufficient to prevent or contain the phenomenon. However 4 farmers (of which one of 31.4 ha and one of 70 ha) expressed their interests in obtaining more information on how to mitigate this phenomenon and on the mitigation measure proposed at field level and landscape level (BMP66).
- 34 respondents (68%) considered the adoption of vertical barriers to intercept the drift (hedges, trees, artificial windbreak) useful tools, in addition to buffer zones, to manage spray drift generated by sprayers (BMP 47).

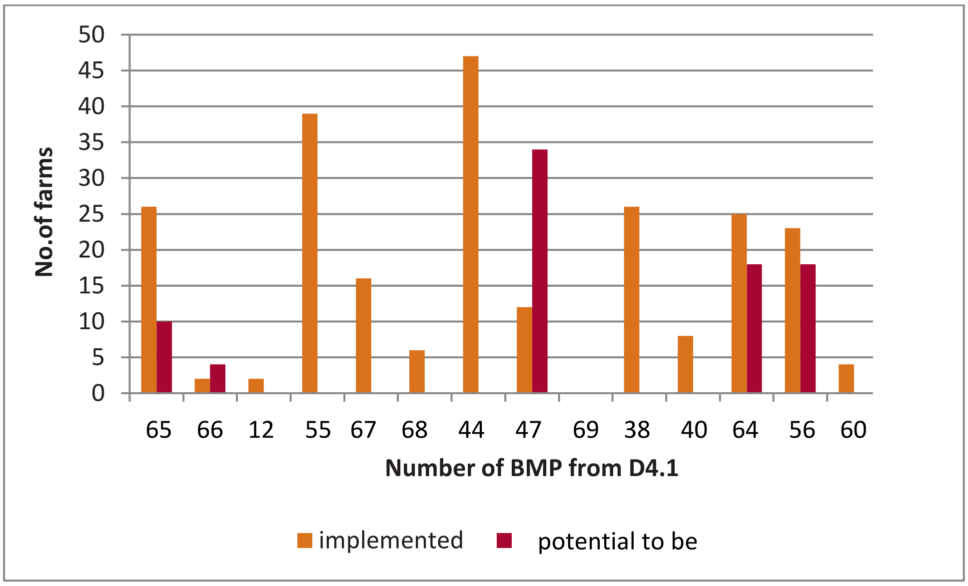

Figure 25: Italy: Summary of survey results illustrating the number of farms currently using selected best management practice and its potential for implementation. See Annex 1 for BMP key.

The observed runoff in our survey except few cases tends to move downslope in a uniform manner (diffuse) down a whole field or part of a field. To be compliant with the legislation, farmers have to reduce runoff within their fields first and then buffer the rest of it. However 4 farmers (of which one vineyard is 31.4 ha and another – 70 ha) expressed their interests in obtaining more information on how to mitigate run off on both field and landscape levels.

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Vegetated buffer strips at the edge of a field or within a field enhance water infiltration in grassed/vegetated areas, sedimentation of eroded soil and are beneficial for in-situ erosion prevention. Vegetated buffer strips could also be linked to indirect benefits as improvement of biodiversity and landscape quality. However, placement near runoff source and loss of land for agricultural production could be critical for their implementation.

The adoption of barriers in addition of buffers could be perceived as eco-friendly by local community of farmers and easily implemented if not associated to significant financial investments.

Soil analysis can be implemented without generation of any/excessive costs as dedicated area for mixing and filling.

Spray drift could also be improved taking into account age of sprayers, improving knowledge how to better manage droplets and on actions and factors that limit drift (as driving speed, crop density, wind direction and velocity, pressure and air flow….).

4.6 Conclusions

In the Italian Action Lab the study focuses on groundwater and pollutants under investigation are nitrates and pesticides, both used in vineyards.

In our study area, until now, impact of grape cultivation on groundwater quality with respect to those pollutants has never been investigated. More in details, concerning sensitivity to pesticides, the regional map/assessment is under development and therefore, no information is yet available. Moreover the area under investigation is characterized by a prevalence of vineyard with slope >2%. In sloping soils the problem of run-off and erosion needs to be tackled in a more articulated way than flat land. Therefore in addition to the analysis of BMPs to prevent point sources, more related to groundwater, an analysis of BMPs for drift and runoff for hilly vineyards (with a slope> 2%) has been carried out.

Although several BMPs are recognized effective in the reduction of pollution, some of them are not considered interesting or applicable without significant financial investments. For example respondents are familiar with factors that affect runoff and recognize the need for a water body/well to be safeguarded from a runoff but are not concerned about it, that is perceived of moderate intensity. Respondents believe that measures taken are sufficient to contain the phenomenon.

Regarding point sources contamination, despite proper pesticide storage and handling (treatment of PPPs packaging and remnants are compulsory by low), improvements and additional actions must be implemented to ensure that these operations are performed correctly.

In conclusion, after a deep examination of territorial characteristics, groundwater and surface water exposure routs (runoff/erosion is an important diffuse entry route of PPPs into surface

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water) and farmers' behaviour, we identify **the management of pesticides in farms as a critical issue,** with high impact on groundwater contamination on the area. Therefore, **actions, supporting upgrade farmers' knowledge and behaviours and to improve or implement equipped areas (impermeable fix/mobile platforms) for mixing the product, filling the sprayer, management of wastewater resulted from internal and external sprayer washing and empty container washing, are mandatory and of great interest for farmers.**

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5 Poland - the Gowienica river catchment

5.1 Brief introduction to the action lab

The Polish Action Lab, the Gowienica river catchment is located in the North-West Poland and has the surface of 63.65 km^2. The Gowienica river, which is 15,6 km long and of the average flow 0,15 m^3/s being one of the lake Miedwie inlets, is mostly regulated. The average catchment height is 34 m, altitude - 40 m., and the average slope is 5.01 m/km. The average annual rainfall in the catchment area is about 500 mm, the average annual temperature is 7.5-8.0 0C, and the vegetation period lasts 210-230 days. Within the catchment area there are fertile soils formed of clay and water-based silt. The dominant types of soils are the black soils (*Gleyic Phaeozems*) occurring mainly in the western part of the catchment and brown soils (*Eutric Cambisols*) occurring in the raised basin areas, mainly in the western part of the basin.

Occurrence of fertile soils and favorable climatic conditions make the catchment area intensively utilized in agriculture, nearly 96% of the area is agricultural land. Forests occupy an area of less than 2.5% of the catchment. In the catchment area plant production dominates - 86% of agricultural land is arable land, meadows and pastures - 10%, a large part of land is reclaimed, and drainage water flow to melioration ditches or directly to the river. In addition to the production of crops including mainly cereals (wheat and barley) and industrial plants (sugar beet and rape), animal husbandry is also carried out in the catchment area. There is a large farm for cattle breeding, with 913 heads of cattle in 2016. In addition to that individual farmers own 115 heads of cattle and a total of 290 pigs (2016). Manure and slurry handling and storage is still not well solved on some farms.

Since recent years large area farmers use monocultures and grow industrial plants (e.g. corn) using very high doses of fertilizers and pesticides, causing high risk for environment, especially water quality. A new problem is the import of various types of wastes (eg biogas plant waste) used as natural fertilizers. Gowienica catchment was included to the first Nitrate Vulnerable Zone delineation in 2004.

The total acreage of the Gowienica Action Lab is 6365 ha, of which 5917 ha was surveyed. At least 120 farmers have fields in the catchment and 72 of them were surveyed. 30 best management practices (BMPs) that seem to be best suited to the Gowienica catchment area and would give the best chance of implementation (specificity of the area, costs, etc.) were selected.

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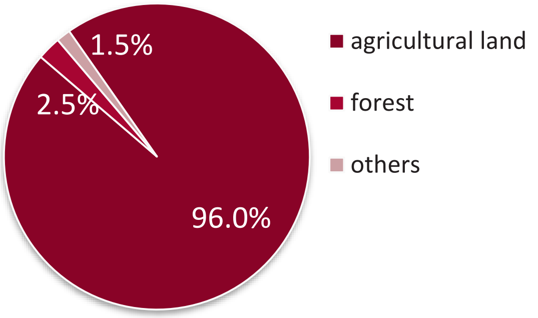

Figure 26: Percentage of land use in the Gowienica catchment

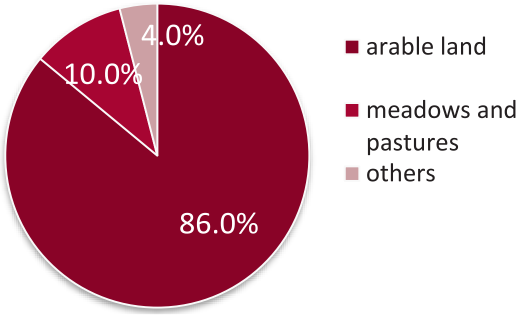

Figure 29: Percentage of agricultural land use in the Gowienica catchment

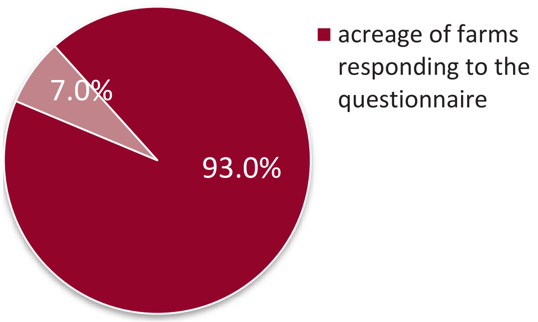

Figure 27: Percentage of farms area in the Gowienica catchment responding to the questionnaire

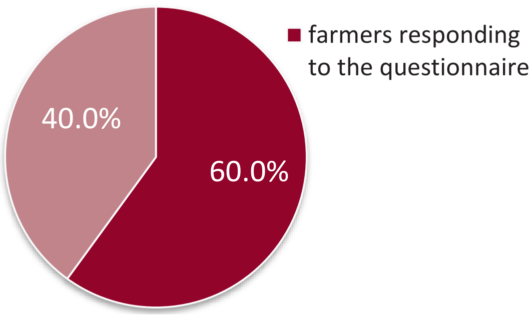

Figure 30: Percentage of farmers in the Gowienica catchment responding to the questionnaire

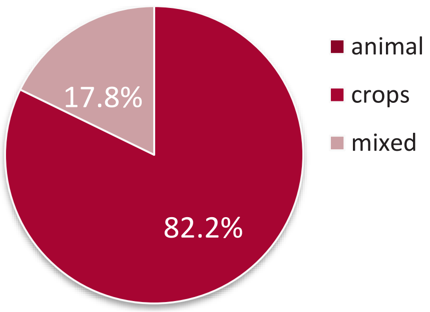

Figure 28: Percentage of farms area used for animal, crop and mixed production in the Gowienica catchment responding to the questionnaire

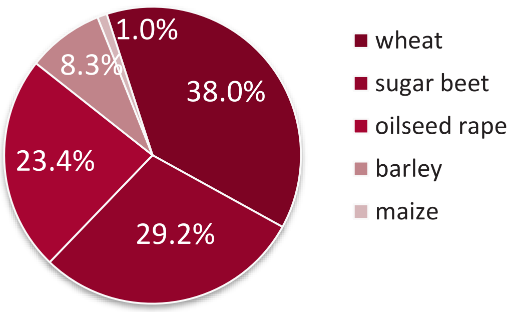

Figure 31: Percentage of crop cultivated (to all crops) in farms in the Gowienica catchment responding to the questionnaire

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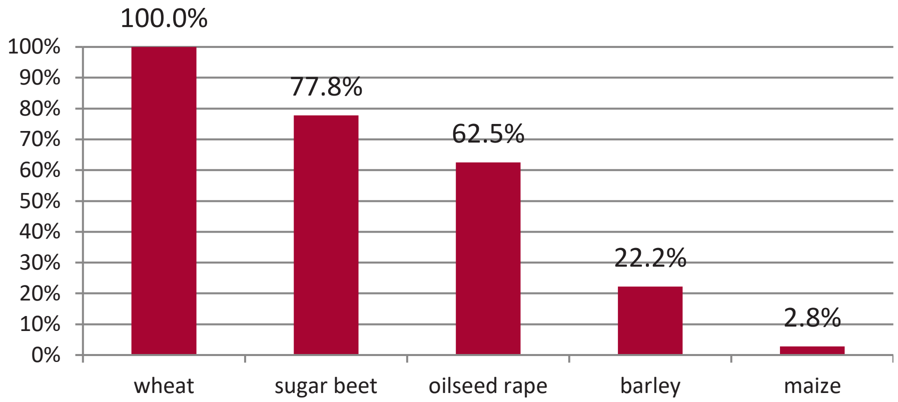

Figure 32: Percentage of farms with crops cultivated in the Gowienica catchment responding to the questionnaire

5.2 Water quality problems within the action lab

Numerous studies have already proven poor quality within the Gowienica basin reflected in elevated levels of NO3-, NH4+, PO43-, conductivity and K+ content. Current studies indicate that the average amount of pollutant load associated with waters of the Gowienica into the lake Miedwie depends on precipitation and is about 18.0 T/year for NO3-, 0.48 T/year for NH4+, 23.6 T/year for K and from 0.48 to even a few tonnes per year for PO43-. The river is contaminated already at its source, it undergoes a certain self-purification, but subsequent point-source discharges of water from tributaries significantly reduce quality of the Gowienica river. Studies show that waters and soils within the catchment are additionally polluted with nutrients from atmospheric precipitation, which further contributes to soil degradation and accelerate leaching of fertilizers from soil when rainfall is acidic.

Studies also have shown water pollution with nutrients, sulphates, chlorides, manganese, zinc and iron in individual wells. The main threats to water quality in the catchment area are contaminants associated with intensive agricultural production (mineral fertilization), as well as point sources such as livestock manure storage and unregulated wastewater management in some localities and farms (no sewerage, leaky septic tanks, uncontrolled export of filthiness). In years 1994-1997, a number of investments related to improvement of infrastructure such as implementation of manure water tanks and manure gutters. Despite of that, water pollution problems remained.

5.3 Methodology

Farmers were approached by e-mail, phone, during farmers trainings and face to face meetings. E-mail and phone questionnaire occurred inefficient thus almost 100% of information were collected by F2F meeting with farmers and during farmers trainings. Questionnaires were performed by local farmer's advisors (ZODR, 72%) and ITP (18%).

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At least 120 farmers have fields in the catchment. Surveys started with large area farms which can have relatively significant influence on water quality. 72 farmers were contacted (9 refused). The total acreage of the Gowienica Action Lab is 6365 ha, of which 5917 ha were surveyed. The catchment's boundaries did not always coincide with farms' boundaries, hence minor differences could have occurred. When large farm's main location was outside the catchment, only information about activities taken within the catchment were collected.

5.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

On the day of 5 June 2018, the Council of Ministers of the Republic of Poland adopted new regulation establishing the "Program of measures to reduce the pollution of waters with nitrates from agricultural sources and preventing further pollution" for implementation and throughout the whole country (Journal of Laws of 2018, item 1339). This regulation implements Council Directive 91/676 / EEC of 12 December 1991 concerning the protection of water against pollution caused by nitrates from agricultural sources, pursuant to the provisions of the Act of 20 July 2017 - Water law (Dz. 2017 item 1566). The implementation of the regulation imposes an obligation on farmers to apply the requirements in the field of protection of waters against nitrates from agricultural sources:

- BMP 6. Fertilizers are not used on frozen soils or soils covered with snow as well as flooded and water- saturated soils. Application of mineral fertilizers and liquid manure on arable land is allowed from 1 March to 15 or 20 October (depending on the location of the commune) and application of solid manure from 1 March to 31 October. Application of liquid manure for permanent grassland, follow in an adequate view of the following dates March 1 - October 31 and March 1 - November 30.
- BMP 61. Obligation of liquid manure storage in reservoirs with a capacity ensuring the possibility of their collection and storage for a period of 6 months. Storage of solid manure is obligatory on manure pads with a surface that allows them to be stored for a period of 5 months. It is possible to store the solid manure on the ground/field for a period not longer than 6 months. An appropriate distance from watercourses must be kept (BMP 72, BMP 73). It is not allowed to store a poultry litter directly on the ground.
- BMP 2. A farmer has to apply a fertilizer program in case of breeding poultry above 40,000 posts or breeding pigs above 2,000 positions for pigs weighing over 30 kg or 750 posts for cows. A fertilizer program is also obligatory for those farmers, who have a farm with an area of more than 100 ha of agricultural land, or cultivate specific (in the program) intensive crops, on arable lands over 50 ha, or maintain the stocking density of more than 60 DJPs according to the average annual level.

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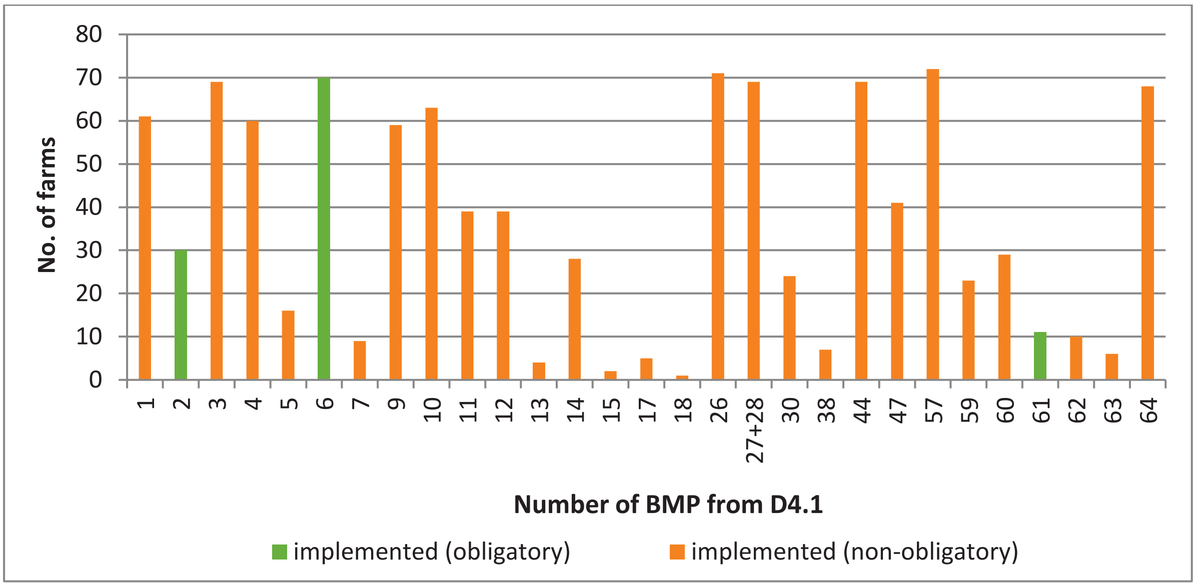

Figure 33: Poland: Summary of survey results illustrating the number of farms currently using selected best management practices. See Annex 1 for BMP key.

Most of BMPs were selected on the improvement of the water quality in case of pollution with nutrients. However some BMPs relate to pesticides as well.

Application of best management practices and mitigation measures differed significantly between farms and fluctuated from 1,4% up to 100%. For instance, BMP 18: phytase supplementation was one of the less popular practices. In contrast BMP 57: professional support in selection of appropriate plant protection product was the most common one. Generally, practices concerning animal production were less popular. The reason is that within last years animal production profitability decreased and many farmers quit breeding and production of milk. There are no farms with animal production only in the basin and only 18% of farms reported to have a mixed production. 82% of investigated farms concentrated only on crop production. “Crop” farmers answered “no” when asked about BMPs related with animal production (manure, slurry handling and storage, animal nutrition).

Most common practices (up to 100% answered yes) are practices and measures concerning plant protection products. This is due to the fact that PPPs companies provide specialized trainings and consulting when selling its’ products. Implementation of BMP 38: use drift reducing nozzles (sprayers with auxiliary air jet) involves a large investment and is therefore not yet strongly applied –only 10% of farmers apply this). Also BMP 30: safe stands (dedicated area) for sprayers washing and filling are used by 33% of farmers because of investment costs. There is a similar problem with other practices requiring investment expenditures like new, better sprayers (above), use of treated urea with urease inhibitor(BMP 7)-12,5%, BMP 5: injection, trailing shoe or band spreader used

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for slurry (22%), BMP 59: use of Global Positioning System (GPS) to manage inter field variability in crops-31% of respondents.

5.5 Potential for uptake of new mitigation measures

Most of currently implemented practices have a potential to be used in future on a larger scale. For instance, BMP 59: use of Global Positioning System (GPS) to manage interfield variability in crops is used by 31% of farmers, and have a potential to be implemented by another 18 % of farmers in the future. Similarly BMP 30: safe stands (dedicated area) for sprayers washing and filling is used by 33% of farmers and additional 18% indicated its willingness to uptake this BMPs. BMP 7: use of treated urea could be potentially implemented by 12,5% and the same amount of respondents reacted positively to a proposition of implementation of this BMP. The same amount of farmers are willing to implement BMP 38: field sprayers with auxiliary air jet (now used by 10% of farmers), despite high costs of implementation.

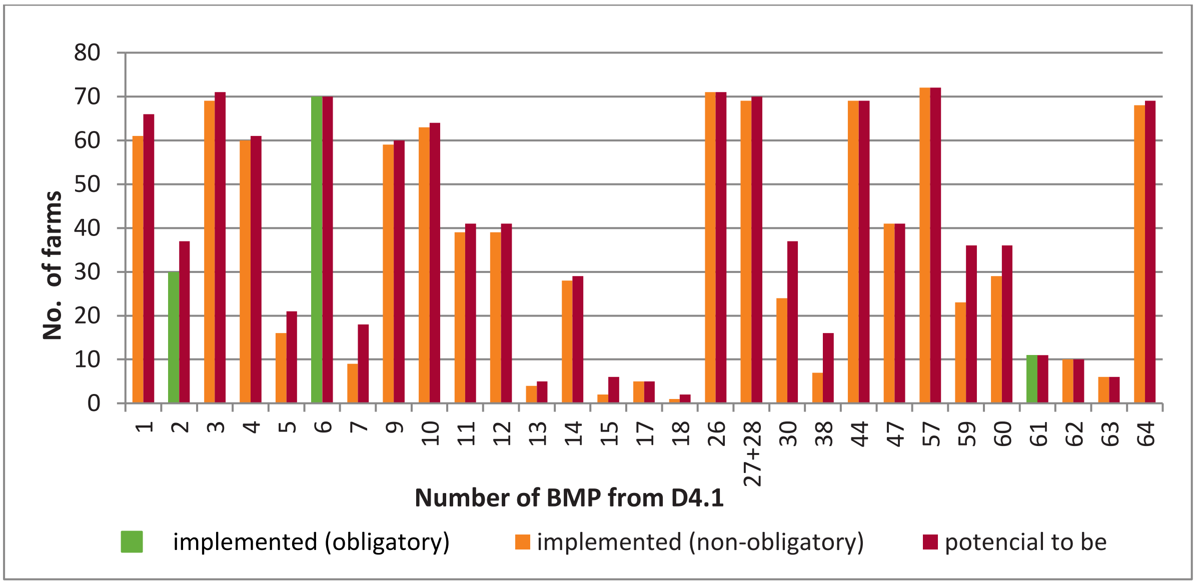

Figure 34: Poland: Summary of survey results illustrating the number of farms currently using selected best management practices and their potential for implementation. See Annex 1 for BMP key.

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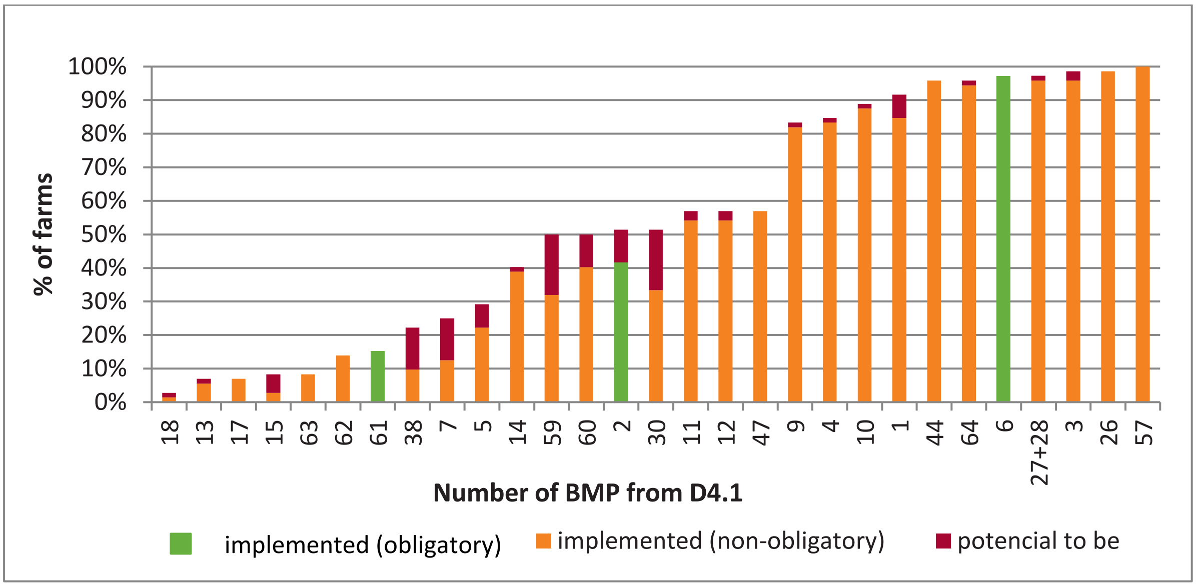

Figure 35: Poland: Summary of survey results illustrating the percentage of farms currently using selected best management practice and their potential for implementation. See Annex 1 for BMP key.

5.6 Conclusions

The Polish Action Lab has its focus on nutrients. The main threats to water quality in the Gowienica Catchment are contaminants associated with intensive agricultural production (mineral fertilization), as well as point sources such as livestock manure storage and unregulated wastewater management. BMPs were selected to improve groundwater and surface water quality .

The aim of the work was to select practices suited to the conditions of the Polish Action Lab and to obtain information from the questionnaire, such as farmers' knowledge level on the factors affecting water pollution as well as their knowledge level of measures to reduce this pollution. Practices already implemented in the catchment and farmers' willingness to implement new practices were also identified. In addition, attempts were also made to understand the will to implement the proposed measures, and if not, understand the motivations and barriers.

Conducted surveys have shown that several practices and measures that have protective value for agriculture and water quality have been already implemented in the Polish Action Lab, but **mostly for the productivity and incentive reasons**. **Farmers openly admit that the implementation of BMPs is not related to environmental aspects such as protection of water quality, but rather to the financial benefits**. They are willing to implement BMPs which not generate high cost, but can bring savings in the future, e.g. soil analysis and liming. Measures that require higher investments, entail a loss of income for the farmer, e.g. grass buffer zones and constructed wetlands, or are not

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easily feasible in practice are not very popular. For these measures, subsidies and financial incentives would be necessary to increase their implementation.

However, **measures giving farmers long term financial benefits have relatively high potential** for implementation, e.g. BMP 59 use of GPS technology in farming. The cost of purchasing specialized equipment is high, but it decreases with the growth of the farm's area and may cause significant savings in the production process in the future.

Nonetheless, effective implementation of BMP must be initiated on a voluntary basis, trainings or good examples showing benefits. Farmers should have substantive and financial support, but **rising of the awareness is a key to improve implementation of these measures.**

Along with the implementation of the Nitrate Directive, new obligations for farmers are introduced. Unfortunately, it is not always correlated with fast, comprehensive information and trainings. Farmers pay attention to the lack of financial and substantive support in the implementation of new obligations. In this case, **the cooperation between framers and supervising institutions in a key factor**.

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6 Romania - the Maramures catchment

6.1 Brief introduction to the action lab

Romanian action lab is located in the Mara catchment (20 km^2), Maramures County and it is representative for small scale/ subsistence farming systems in the Carpathian Mountains – cattle and sheep breeding. The study area is a typical cultural landscape shaped by traditional practices. Main village of the study area, Breb is located in the central-northern part of the Maramures depression, in the upper part of the Mara river basin on the northern piedmont of the volcanic Gutâi massif, 25 km from Sighetu Marmatiei and 52 km from the Baia Mare county capital. Average elevation is of 562 m altitude above sea level. Together with Hoteni and Sugatag, the village of Breb belongs to the village of Ocna Şugatag. The village hosts 378 households totalizing 1096 inhabitants; there are 140 agricultural exploitation (small scale).

Water coming from the action lab area enters Mara River. The quality of the water is considered good, according to official data. Source of the creeks from action lab is not considered nitrate sensitive. Destination of the water courses has a concentration of nitrates due to crossing of the village where farmers use manure as fertilizer. The water quality of the Mara River is affected by the diffuse pollution sources originating from the agricultural and forestry sector, even if the effect is moderate. In rural households located in the Mara River Basin, traditional agriculture is practiced on small areas, and the fertilization of crops is done only with organic fertilizers. There is a risk of contamination with nitrates but its impact is not significant on the aquatic life.

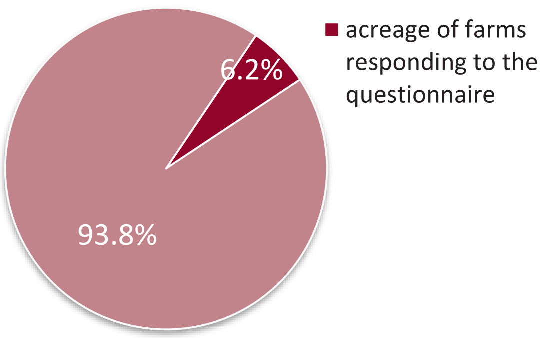

Figure 36: Percentage of farms area in the Maramures catchment responding to the questionnaire

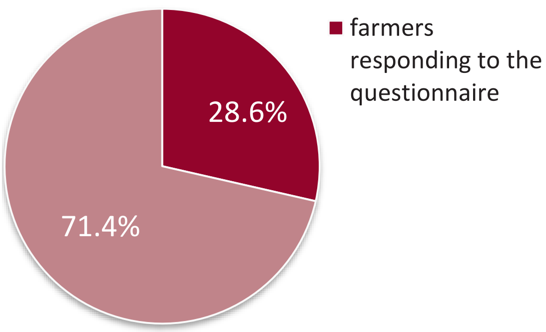

Figure 37: Percentage of farmers in the Maramures catchment responding to the questionnaire

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The area is dominated by animal husbandry (poultry, cows, pigs, sheep, horses, rabbits) and cereal production; many households own hayfields and orchards in the proximity of the village. Farmers usually have 2-4 cattle (left grazing on the fields in summer time during day), some sheep, 2-3 pigs and poultry, horses. The farmers having sheep take their animals to communal sheepfolds (there are 4 sheepfolds in Breb in 2018).

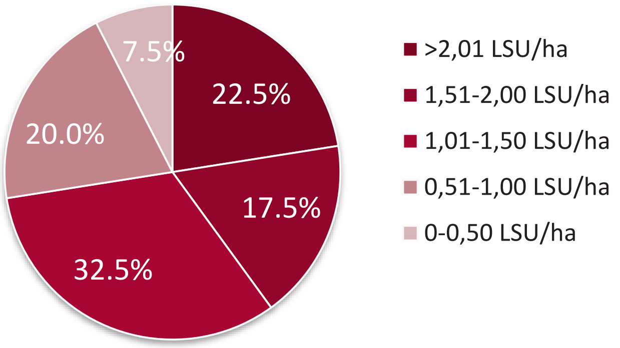

Figure 38: Percentage of farms category depending on the Livestock Unit per hectare

The Livestock Unit (called LU, LSU) is a reference unit which facilitates the aggregation of livestock from various species and age as per convention, via the use of specific coefficients established initially on the basis of the nutritional or feed requirement of each type of animal. It is assumed that due to the protection of water quality, the stock density on the farm should not exceed 2 LSU per hectare of UAA (arable land). In the system of sustainable agricultural production it is assumed that the stock density should not exceed 1,5 LSU/ ha UAA.

6.2 Water quality problems within the action lab

Nitrate pollution is relevant for the area due to manure leakages from small scale farms and lack of a centralized sewage system.

Water quality of the Mara River is affected by diffuse pollution sources originating from the agricultural and forestry sector, even if the effect is moderate. In rural households located in the Mara River Basin, traditional agriculture is practiced on small areas, and the fertilization of crops is done only with organic fertilizers. There is a risk of contamination with nitrates but its impact is not significant on the aquatic life.

Cattle and sheep breading in the catchment area affect drinking water quality but also surface water quality since manure is used as a fertilizer on a large scale and leaks from barns at most of households. Nitrates and nutrient levels are monitored only in surface water downstream on two sections of the Mara River. There is no centralized sewage system in the case study, which poses major problems for surface and groundwater quality.

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6.3 Methodology

Methodology for surveying farmers in Maramures action lab included:

- Initial research phase of available recommendations and obligations at national level related to use of fertilizers in Romania, good environmental and agricultural practices used by farmers in the field of environment, climate change and good agricultural conditions of fields.
- Development of questionnaire using the agreed BMP list and adapting it to Romanian context of the action lab; questionnaire included general questions related to location, age, surface of land owned by farmers; the central section of the questionnaire included 18 BMPs that were tested on a sample group of 40 farmers from a target area of Breb village; in the village there are 140 families involved in agricultural work (animal breeding, cereal production, potatoes mainly for family consumption).
- Farmers were selected using data from the Ocna Sugatag agricultural registry where all farmers are registered. Discussions included meetings with representatives of sanitary and veterinarian experts in the village, who have a database on farmers owing animals in their farms.
- Questionnaire was applied face to face, directly to farmers in the target area; during three site visits (7.02.2018, 21.02.2018, 12.03.2018) project team (from EcoLogic and UTC) visited the target area of Breb and after presenting the WaterProtect project there were discussions with interviewees of farmers with respect to their daily farm activity with a focus on BMPs which they apply and would like to apply.

As a conclusion, all farmers use organic fertilizers from their farms on their agricultural fields; the use of organic manure is a traditional practice for small scale mountain farms in Romania in Maramures. Farm animals are kept in barns close to households for most of the year. For example, pigs are usually permanently housed, cows graze during summer months but return to barns at night, and sheep spend 4-5 months away whilst grazing at pastures. At some point manure from all types of livestock that are kept in barns accumulates. This is regularly cleaned out (often daily) into a "store" located close to barns where it usually remains for 6-12 months – sometimes for a shorter period of time (1-6 months). Majority of households apply manure to hay fields, orchards and crops. 84% of households surveyed had manure "stores" which consisted of a carefully constructed heap adjacent to buildings, in which farm animals are kept. Less than 5% of manure stores in the survey have a hard base, but approximately 10% do have some form of a retaining wall – most commonly made of stone or brick, but also wooden. Unfortunately, the combination of human and animal waste is a common problem that was observed in over half of the households surveyed – commonly due to the construction of households' toilets directly next to the manure stores.

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6.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

In Maramures action lab, Romania, all farmers use primarily animal manure (solid manure, which comprises material from animal houses and consists of excreta mixed with the bedding materials e.g. straw) as fertilizer for their agricultural fields. In addition, there may also be varying amounts of slurry, which consists of liquid or semi-liquid excreta produced by livestock in a yard or areas of a building where there is little bedding used (e.g. passageways).

The following BMPs in the survey in Romanian action lab are obligatory, according to legislation for all farmers/agricultural exploitations:

- BMP 73: Depositing manure on the field with taking into consideration certain distances from water courses for preventing pollution of water (min 20 m from rivers, min 50 m from wells/springs, min 250 m from wells used for drinking water).
- BMP 74: Use of impermeable folia where the location of manure is possible to lead to water pollution (proximity of water courses).
- BMP 72: Temporary depositing on the field, taking into consideration proximity of waters or BMP 15: Manure platforms in the farms (diverse materials: wood, concrete etc).
- BMP 11: Grass buffer zones (strips of land covered with permanent vegetation located between agricultural land and watercourses and reservoirs).
- BMP 4: Incorporate organic manures immediately after application on cultivated land.
- BMP 71: Directing manure towards special ponds (for sedimentation of organic substances for extraction of nutrients), for bigger agricultural exploitations.
- BMP 6: Respect calendar for spreading of manure on the fields (temperature below 5 degrees; period November-March); respect quantity of N, max 170KG N/ha in one year.

Some of the obligatory best management practices are fully implemented, e.g. BMP 4 and BMP 6 or BMP 72. As far as impermeable folia (BMP 74) is concerned only 25% of the interviewed farmers use this BMP, but the rest are ready to use it for the future. Most farmers take into consideration recommendations related to timing of placing manure on the fields as well as distance from water courses. 92,5% of respondents (37 farmers) take precaution measures for preventing pollution of water maintaining recommended distance between manure heaps and water courses.

Since 2015 all farmers applying for direct payments from the European funds and from the national budget, as well as those seeking European funds through certain measures of the 2014-2020 National Rural Development Program (NRDP), must also comply with eco-conditionality (cross-compliance) norms. These norms include verifiable standards which are derived from the Code of Good Agricultural Practices for the protection of water from pollution caused by nitrates from agricultural sources (CoGAP). Compliance with the CoGAP has been made a mandatory obligation for all farmers in Romania since 2015.

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Results of survey are presented in *Figure 36.* The percentage of farm where BMPs are implemented is presented in *Figure 38*.

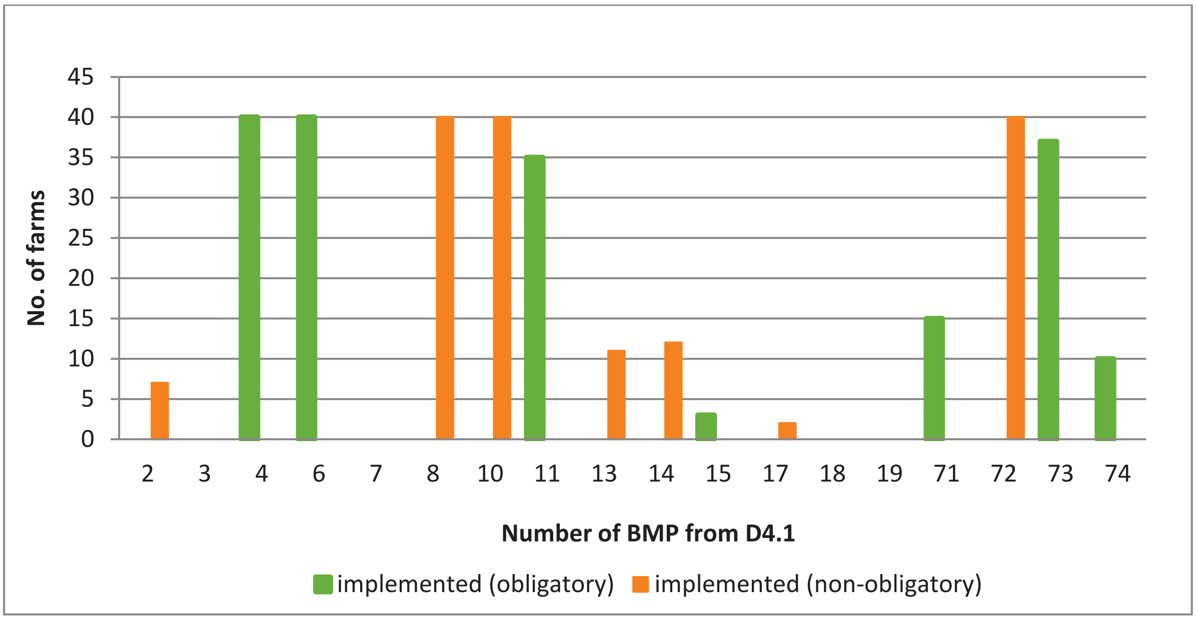

Figure 39: Romania: Summary of survey results illustrating the number of farms currently using selected best management practices. See Annex 1 for key.

6.5 Potential for uptake of new mitigation measures

Below is the list of BMPS that were identified as having a good potential to be implemented in future:

- BMP 2: Fertilizer program. Implementation is considered by 20% of farmers, but if they would have more animals, the potential to apply this BMP was quite high (82.5%).
- BMP 71: Direct manure towards special ponds (for sedimentation of organic substances for extraction of nutrients), (62%)
- BMP 13: Separation of pastures from water courses and reservoirs (via electric fences for eg), (72.5%)
- BMP 15: Use of cover manure storage system (platform etc), (95%)
- BMP 17: Adopt phase feeding of livestock (less protein in periods of lower demand – corresponding to the animal development phase), (92.5%)
- BMP 19: use of computer feeding programs for reducing dietary nitrogen and phosphorus intake – if the farm would be bigger and for selling of products to market (66%).

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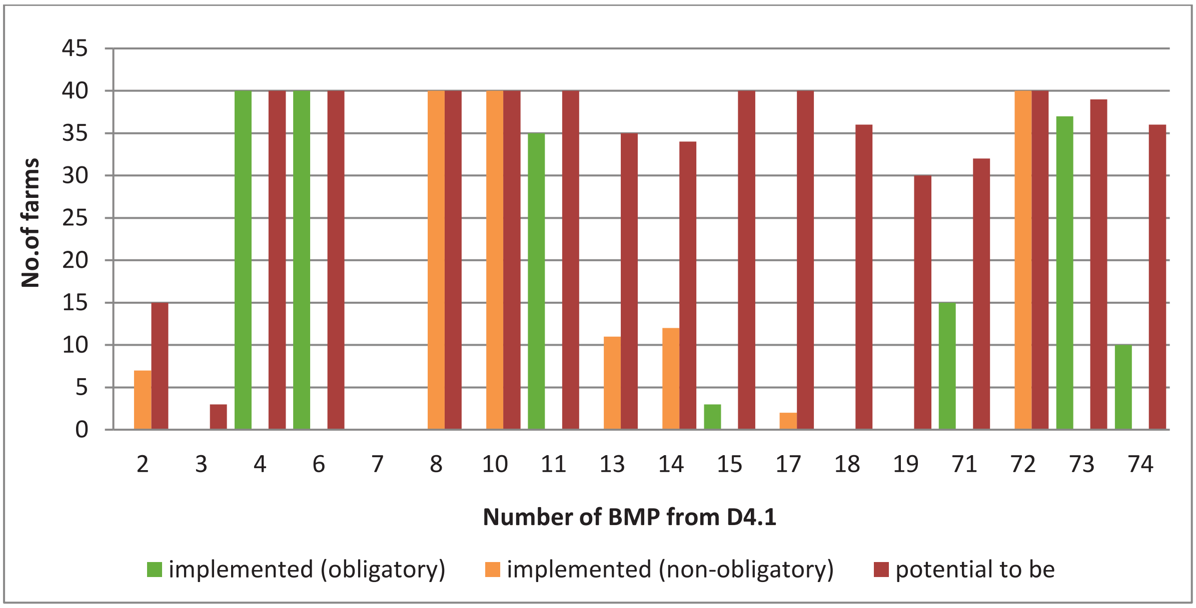

Figure 40: Romania: Summary of survey results illustrating the number of farms currently using selected best management practices and their potential for implementation. See Annex 1 for BMP key.

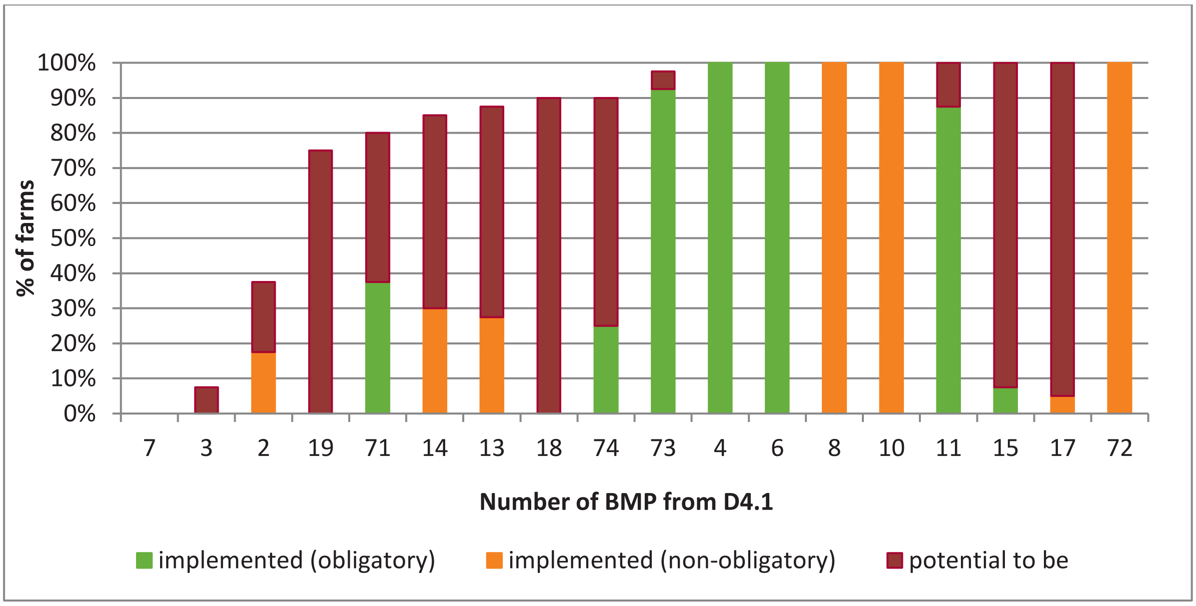

Figure 41: Romania: Summary of survey results illustrating the percentage of farms currently using selected best management practices and their potential for implementation. See Annex 1 for BMP key.

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As a result of the survey some general guidelines were given to farmers:

- Locate manure stores close to livestock housing and away from any watercourse or a well.
- A simple open-fronted store with a concrete base and impermeable walls should be sufficient for the storage of manure from animals kept by most households and small farms.
- Glass, plastic and other in-organic domestic waste must be kept separate from manure stores.
- Do not allow run-off from livestock buildings or manure stores to enter any drain, ditch, stream, river, lake, wetland or nearby well.
- Do not allow any rainfall from roofs or yards to enter a manure store.
- Do not allow human waste from your toilet to enter a manure store!
- Consider composting solid manure by regularly turning it and mixing it with vegetable and crop waste.

6.6 Conclusions

Romanian action lab is representative for small scale/ subsistence farming systems in the Carpathian Mountains – cattle and sheep breeding. Nitrate pollution is relevant for the area due to manure leakages from small scale farms and lack of a centralized sewage system. Within the Romanian case lab area, all farmers use organic fertilizers from their farms on their agricultural fields; the use of organic manure is a traditional practice for small scale mountain farms in Romania in Maramures.

There are some good practices and measures used by farmers in Romanian case lab area that have a protective value both for agriculture and for water quality. In general, these methods are the traditional ones, they are obligatory under national legislation and in plus they do not involve high financial investment (BMP 73 depositing manure on the field with taking into consideration certain distances from water courses for preventing pollution of water, BMP 73 temporary depositing on the field, BMP 4 incorporate organic manures immediately after application on cultivated land, BMP 6 respect calendar for spreading of manure on the fields etc). As far as impermeable folia (BMP 74) is concerned only 25% of the interviewed farmers use this BMP, because many of farmers do not have lands in the proximity of rivers, they do not see a big benefit for using it and there are some financial costs associated and because there are small subsistence farms they do not see the measure feasible.

Testing the attitude towards the desirability or opportunity of applying alternative protective methods does not meet very high quotas, the vast majority of those surveyed attribute values below average (on a scale of 1 to 10, most of the proposed methods average values 2-3) which indicates a rather reserved attitude towards the applicability or utility of these methods. **The possible causes of these attitudes mainly relate to lack of information, reduced flexibility due to**

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anchoring in traditions, lack of financial availability.). The availability for implementing best practices or protective measures does not appear to be significantly influenced by variables such as the age of the subjects, the number of animals in the household or the land occupied by the surveyed subjects.

Main challenge for Romanian action lab relates to encouraging the construction of simple, improved facilities for storing animal manure (BMP 15) that would greatly reduce the risk of water pollution – whilst also helping improve environmental quality (including water quality) and living conditions in many private households and villages, and greatly improving the recycling of nutrients to the land. According to Romanian legislation there are several recommended models (simple or more elaborated using different materials) for such manure management systems. Such an initiative needs correlation with raising awareness in local community on importance of preventing water pollution related to agriculture. Nevertheless, there are financial implications for implementation of this measure and lack of money in many households in rural areas is the main obstacle in improving animal waste management system in rural areas.

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7 Spain - the lower Llobregat River catchment

7.1 Brief introduction to the action lab

The lower Llobregat River basin is an alluvial plain that covers an area of 486.1 km^2 (29 municipalities) and extends in direction NW-SE from the Montserrat mountain range to the Llobregat River mouth, where a delta is formed.

The Baix Llobregat and particularly the Agrarian Park, where most irrigation farmland of the area is located, present very soft slopes. They are between 7 and 15 % in the Vall Baixa area (the lower fluvial terraces), and between 0 and 7% in the Delta area.

The Vall Baixa (river valley) divides the Catalan Coastal Range that runs in parallel to the Mediterranean coast and is formed by Quaternary sediments. Erosive processes dominate in this area. The Delta is formed by the sedimentation of the eroded materials.

As for the soils, the Agrarian Park presents Entisols and Alfisols (USDA Soil Taxonomy). Entisols are low developed soils, with no diagnostic horizons. They are basically unconsolidated sediments. There are three main groups of Entisols in the area (Xerofluvents, Xeropsamments, and Xerorthents). Alfisols are developed soils that present a clay-enriched horizon. They have a relatively high native fertility. There are two main groups of Alfisols in the area (Haploxeralfs and Palexeralfs).

The climate is the typical Mediterranean. Due to its proximity to the sea, the temperature does not experience big oscillations. Average annual temperature is 15.6ºC. The lowest temperature (extreme median value of -2 ºC) takes place during January whereas the highest temperature (extreme median value of 32 ºC) is recorded during August. Frost free period extends from the end of February until mid of December.

Average annual pluviometry is 583 mm. Minimum rainfall occurs during winter and summer and maximum rainfall occur during spring and autumn. Whereas in spring the overall amount of rainfall is lower than in autumn, the rain is more constant and rainy periods are longer.

Out of the 3200 Hm^3/year of rainwater that fall on the Llobregat river basin, only 530 Hm^3 flows into the Mediterranean sea. This indicates the low drainage capacity (and high infiltration capacity) of the basin. The Delta lagoons and some arid extraction pits converted into ponds due to high level of the superficial aquifer of the Delta are other surface water bodies in the area.

There are two main aquifer systems in the area: one formed by alluvial gravels (Llobregat valley) and one formed by detritic sediments of gravel, sand, and lime (Delta). Groundwater has been crucial for economic development in the area. There are more than 700 wells at the Vall Baixa and Delta aquifers that extract about 105 Hm3/year for human consumption, and industrial and agricultural uses. Groundwater quality is affected by the industrial and urban activity. Waters

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historically has presented a medium-high level of mineralization, and high content of chloride ions (due to salt mining activities upstream the Llobregat River and also seawater intrusion due to aquifer overexploitation). Different actions have contributed to reducing water salinity.

The aquifer of the Llobregat Low Basin is considered a strategic water body as it represents a water reservoir for ensuring continuous supply to the population when surface water does not meet the minimum quality or quantity requirements for potabilization. Preserving its integrity is thus a primary interest of all stakeholders.

All water resources are under high pollution pressure from urban and industrial activities since the area is highly urbanized and densely populated (e.g., the Llobregat River receives the effluent discharges of 63 wastewaters treatment plants.

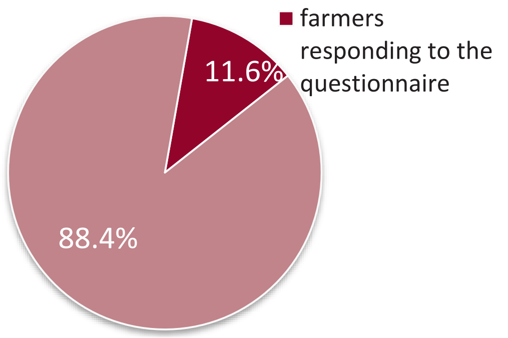

Figure 42: Percentage of farmers in the Llobregat River catchment responding to the questionnaire

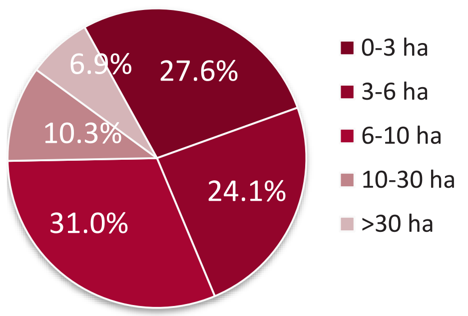

Figure 43: Percentage of surface area category of farms in the Llobregat River catchment responding to the questionnaire

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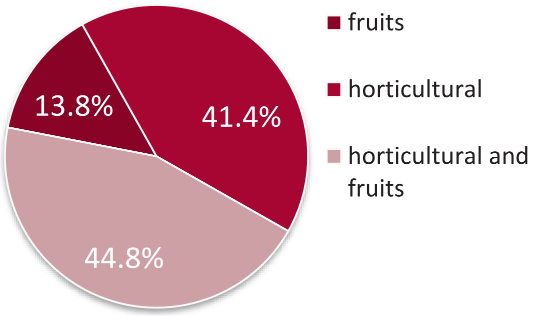

Figure 44: Percentage of crops cultivated in farms in the Llobregat River catchment responding to the questionnaire

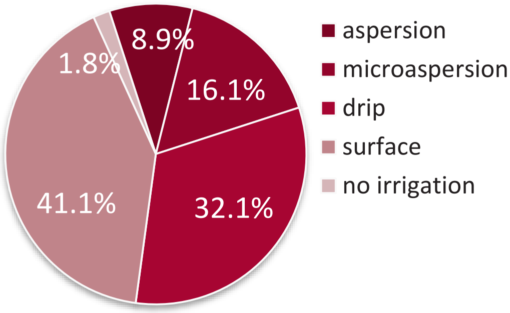

Figure 45: Percentage of crop irrigation methods used in farms in the Llobregat River catchment responding to the questionnaire

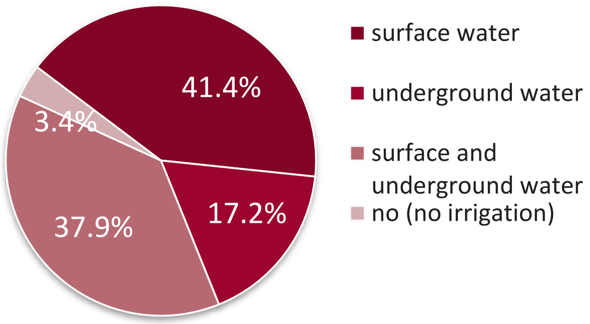

Figure 46: Percentage of water sources for irrigation in farms in the Llobregat River catchment responding to the questionnaire

7.2 Water quality problems within the action lab

The most important water pollutants in the catchment are:

- Wastewater-derived organic pollutants
- Industry-derived pollutants: volatile organic compounds.
- Pesticides and nitrates
- Chloride

Impact of human activities on the level of pollutant is also high. Mining activity upstream the Llobregat River is related to the increase of surface water salinity.

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Overexploitation of the aquifer for different uses led to seawater intrusion (this problem is currently managed with a hydraulic barrier created by injecting reclaimed water into the aquifer using injection wells (confined aquifer).

As the catchment is a very densely populated area, hence industrial and domestic uses have tremendous impacts on water quality. The catchment of water for agrarian uses is lower than for industrial or domestic uses. In consequence, salinization risks due to agriculture in not relevant in the area.

Mediterranean climate results in high river flow fluctuations and drought periods. In the drought period, there is an increase of seawater level and consequential flooding of part of the Agrarian Park with effects on water quality and quantity. During low river flow conditions, wastewater treatment effluent discharged into the Llobregat River are not diluted and concentrations of pollutants in surface waters increase. During these periods water resources will be reduced and increased with reclaimed water. Indirect reutilization of wastewater for drinking water production is a very likely scenario (the Catalan Water Agency and AB have been already doing pilot studies for such scenario).

On the other hand, the Llobregat Delta (natural wetland) could be considered as a buffer zone where pollutants may degrade to some extent.

7.3 Methodology

The methodology used for surveying the farmers has been set out from three basic premises:

- those related to professional farmers

  Integrated Pest Management (IPM) System is mandatory to professional farmers from the 1st of January 2014. IPM includes the implementation of different measures addressed for the rational use and control of plant protection products: farmers must have a license of plant protection product applicator in order to apply plant protection products, review of the machinery, measures to reduce pollution and foster the protection of water, storage and management of empty containers, farmers must register all plant protection products and fertilizers' applications in a special holding register (cuaderno de explotación). Farmers are currently adjusting to these new rules.

  Plant Protection Association (Agrupacions de Defensa Vegetal) are private entities that group farmers and whose purpose is to collaborate with the Administration to collectively fight against harmful plant agents, in accordance with the principles of integrated pest management and the rational utilization of phytosanitary products and other phytosanitary defence means. They do this through the establishment of a program of action and the hiring of technical staff adviser in Integrated Pest Management. There are two Plan

Protection Associations in the Spanish action lab. They are co-financed by farmers, the Catalan Agrarian Department and Parc Agrari Consortium. They are very active in the promotion and implementation of Good Practices in the area. They integrated 110 farmers (around 45% of Parc Agrari professional farmers):

- Crop Plant Protection Association of Baix Llobregat: With more than 30 years' experience in working in the territory with the farmers that mainly, produce conventional crop agriculture and green houses. Two agrarian engineers are employed in the Crop PPA of Baix Llobregat.
- Fruit Plant Protection Association of Baix Llobregat: members are farmers that produce crops and fruits. Of them, 37% farmers are certified in ecological agriculture. Three agrarian engineers are employed in the Fruit PPA of Baix Llobregat.

- non-professional agriculture: around 15% of agrarian surface is managed by non-professional (retired, part time farming and gardeners) in the action lab. Non-professional farmers are not members of any Plant Protection Association and they do not follow the IPM System.

Initially, it was consider to interview workers of the two Plant Protection Associations because they have a general overview of best management practices used by farmers associated with them (110 farmers). However, information needed to fulfil questionnaires was very detailed and hence it was required to interview farmers themselves.

To have a representative sample of the agrarian diversity that is characteristic in the area the following group of farmers were considered:

- Farmers who are members of one of the two Plant Protection Association of Baix Llobregat.
  - 16 farmers of the Crop PPA (ADV HORTA). From these, 7 were done and 1 did not answered.
  - 18 farmers of the Fruit PPA that have also a crop production: from these, all 18 were done, but some parts were not fully answered.
- Farmers who are not associated with any Plant Protection Association of Baix Llobregat but they can have a private advice.
  - 10 farmers: From these, 5 were done, 5 refused participation
- Non-professional farmers (Part time farmers, retirees and family gardens)
  Municipality of Sant Feliu de Llobregat was chosen to be surveyed as high concentration of this type of farmers resides there. However, the survey was abandoned due to difficult local political situation. These farmers are currently outside rules of urban planning. The municipality is in process to regulate this situation. The conflict with non-professional farmers is at that moment very high.

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7.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

In the Spain Action Lab BMPs were selected on the improvement of the water quality in case of pollution of pesticides and nitrates, as well as BMP's related with irrigated water and avoid runoff waters. The BMPs were selected taking into account the type of crops in the area and the farmers' usual practices, based on the conversations held with the ADV's technicians. In total 35 best management practices were considered. Among these 9 BMPs related to fertilization and 2 BMPs related to irrigation were selected and used in the survey. 24 BMPs were selected in case of pollution of Plant Protection Products. Note, as several non-responses were observed in respondent surveys.

All of the BMPs related to fertilization included in the survey were currently implemented on at least one farm. Some of BMPs are already applied in a large extent. For instance, 93% of farmers (27 of 29 respondents) do soil analysis for pH, nutrients or organic matter (BMP 64) and avoid the spreading of chemical fertilisers and manure during high-risk periods (BMP 6). Furthermore, 12 farmers consider the period of growth of crops before spreading fertilisers. The high current usage of BMP 4 Incorporating organic manures immediately after application on cultivated land was observed. 22 respondents incorporate in the land organic manure to reduce the losses of nutrients in their farmland. BMP 9 Crop rotation is applied by 21 farmers. Most of them use this practice for productive reasons. In contrast, only 3 farmers use treated urea with urease inhibitor (BMP 7) when they apply a fertilizer. A covered manure storage system (BMP 15) was practiced in2 farms, but 6 of respondents apply organic manure directly.

For BMPs related to irrigation, BMP 49: Improved soil management to increase water holding capacity of the soil has been implemented in 22 farmers. BMP 56: Optimize irrigation timing and rate has been applied by 14 farmers. Most of them are based on their own experience. However, some farmers use additional support systems, e.g. pressure monitors or technical website. Moreover, farmers use some measures to avoid runoff during watering, 13 of them applied BMP 50: Inter-ridge bunding.

BMPs related to the Integrated Pest Management (IPM) System are mandatory. Farmers must have a license of plant protection product applicator in order to apply plant protection products. They have to fulfill holding register. In this part of surveys as several non-responses were observed.

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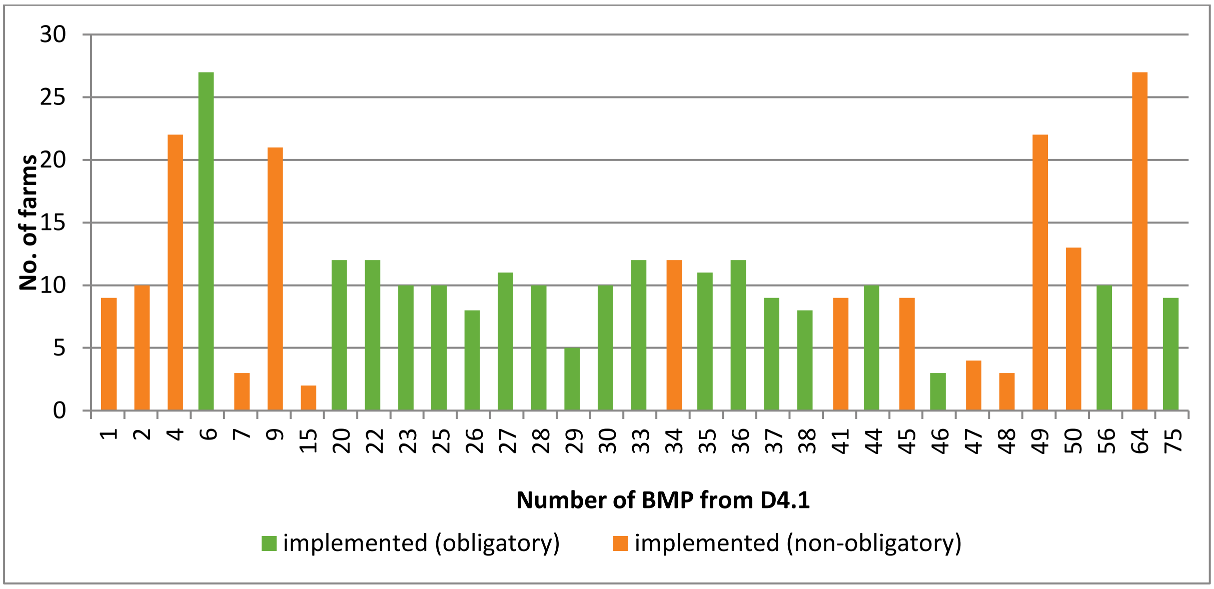

Figure 47: Spain: Summary of survey results illustrating the number of farms currently using selected best management practices. See Annex 1 for key.

7.5 Potential for uptake of new mitigation measures

All BMPs related to the Integrated Pest Management (IPM) System have a high potential to implement because they are mandatory. Farmer's Holding register is one of the BMP's that can have more problems because farmers do not have time and expertise to fulfill the register. Other positive BMP is that farmers must have a license of plant protection product applicator in order to apply plant protection products. However, this measure face with a labour market with temporary employment and employees for other countries which difficult getting the license. These BMP have positive impact on the natural and social arena whereas it implies more costs for farmers in terms of money and time.

BMP's related with irrigated water to avoid runoff water is highly suitable because the action lab is located in a plain surface. The BMP has a positive impact on the natural arena and it benefits indirectly to the community. From BMPs related to fertilization Nutrient balance (BMP 1), Fertilizer program (BMP 2) and Use treated urea (BMP 7) could be potentially implemented by the farmers. A covered manure storage system (BMP 15) could be potentially implemented by 14 of respondents, those who do not apply organic manure directly.

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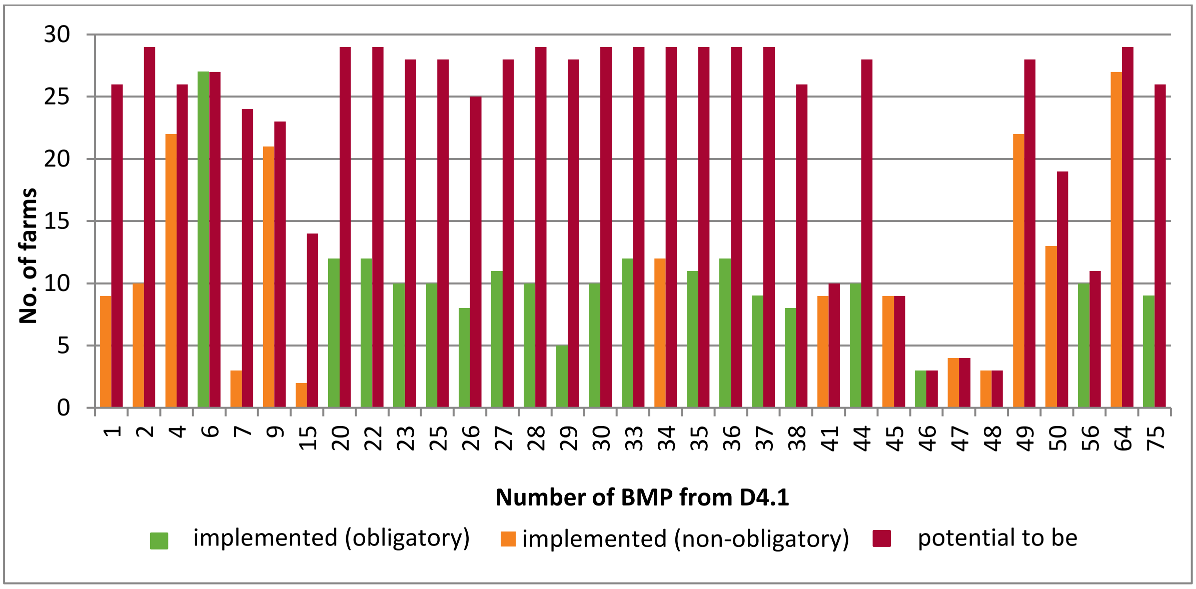

Figure 48: Spain: Summary of survey results illustrating the number of farms currently using selected best management practices and their potential for implementation. See Annex 1 for key.

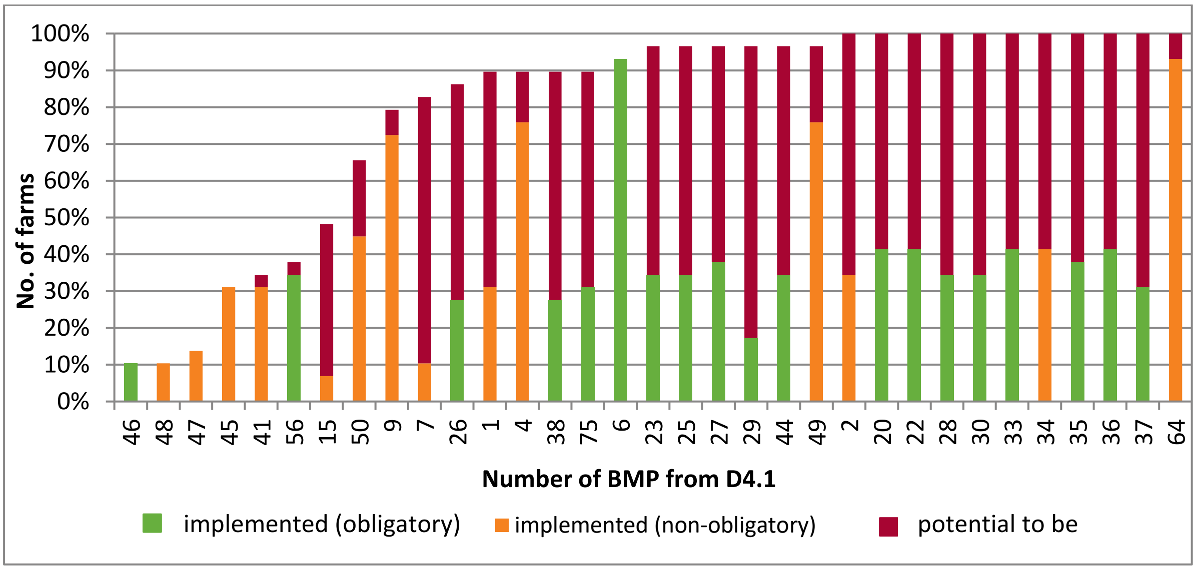

Figure 49: Spain: Summary of survey results illustrating the percentage of farms currently using selected best management practices and their potential for implementation related to the fertilization and the irrigation. See Annex 1 for key.

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7.6 Conclusions

PPPs out of date and Plastic packaging are a big problem for farmers and environment. Farmers demand a feasible solution for famers. PPAs of Baix Llobregat are working on that area. For the action lab it will be very positive to facilitate a safe filling and common cleaning place for the spraying equipment. **Economic costs are the most important barrier**. **Other barrier is the effort to make a consensus among farmers to work together.** Agrarian consortium and PPAs of Baix Llobregat can give some help in order to reduce that problem.

From the total number of farms surveyed, the most used BMP's are the 20, 22, 33, 34, 35 and 36 (all them concerning PPP use optimisation), with the 90% or 100% of total farms implementation. Also, these BMP's have a high potential to be implemented.

On the contrary the less BMP's used are 46, 47 and 48 (these BMP's are about the Sprayer Settings and vegetation windbreaks). Of these BMP's with small use, number 48 is which have more potential implementation.

In general, all BMP's related to the *Integrated Pest Management* (IPM) System have a **high implementation potential because they are mandatory,** and farmers have to write all the applications they make on the Farmer's Holding register. Furthermore, these BMP's could represent product savings for the farmer because they contribute to adjust the quantity of product they need, and sometimes it could represent money saving.

Also, small and simple BMP's applications have a big potential to be implemented. Larger and more expensive applications are more difficult to implement.

Maybe financial compensation would be necessary, with feasible conditions for implementation of the most expensive BMP's application.

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8 Denmark – Vester Hjerk

8.1 Brief introduction to the action lab

The Danish Action Lab is located on the peninsula Salling in the north-western part of Denmark, where the local waterworks Vester Hjerk (in the municipality of Skive) has an abstraction license of 30,000 m^3/year and supply the local community of approximately 80 households with drinking water purely based on groundwater. Apart from agriculture there are no industries or companies present with significant water consumption. The settlement is scattered across the area with farmsteads, former farms and only a few households gathered in villages or smaller groups of 2-3 houses.

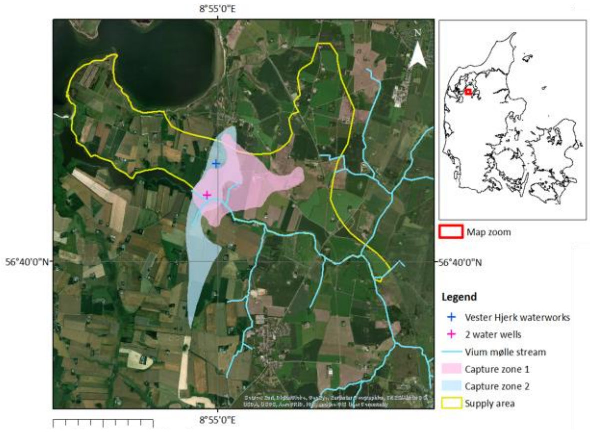

Figure 50: Localisation map of the Vester Hjerk Action Lab including information on the extent of groundwater catchment zone

Covering 85% of the area, intensively managed agriculture is the dominating land use. The soils within the supply area as well as the capture zone are generally better suited for agriculture than the remaining part of the peninsula. In the capture zone 58.5% of the area has fine sandy clay in the topsoil, 34.9% fine loamy sand and 6% organic soils. Only a few full-time professional farmers are located within the supply area, including two large dairy farms. Further livestock, beef cattle, sheep and deer, are present at farms run by part-time, hobby farms and pensioners. However, a large share of the area within the capture zone is managed by farms outside the local supply area. The majority of these are large pig farms (production of piglets as well as pigs for slaughtering), which are very dominant across the area of the peninsula Salling. The major crops are in the supply area as well as in the capture zone are cereals and maize. At the most western end of the supply areas grassland dominates the areas close bordered by the fiord.

The geology in the area generally consists of a quaternary sequence of limited depths overlaying nearly impermeable pre-quaternary clays. Close to the waterworks, buried valleys are found to substantial depth with varying clay and sand in-fill. Water is abstracted from two wells screened in a shallow sandy aquifer between 20 and 30m below the surface. The capture zone for the abstraction wells has been delineated by two versions of a groundwater model, resulting in the identification of two different capture zones, as displayed in the figure. The origin of the water abstracted is thus uncertain, which poses a large challenge in designing a local protection plan that can be accepted by all actors.

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8.2 Water quality problems within the action lab

The geology in the area generally consists of a quaternary sequence of limited depths overlaying nearly impermeable pre-quaternary clays. Close to the waterworks, buried valleys are found to substantial depth with varying clay and sand in-fill. Water is abstracted from two wells screened in a shallow sandy aquifer between 20 and 30m below the surface. The capture zone for the abstraction wells has been delineated by two versions of a groundwater model, resulting in the identification of two different capture zones, as displayed in the figure. The origin of the water abstracted is thus uncertain, which poses a large challenge in designing a local protection plan that can be accepted by all actors.

The aquifer utilized for abstraction is only moderately protected by a capping clay layer, and since the 1980'ties the nitrate concentration has been steadily increasing. In recent years, the nitrate concentration has exceeded 50 mg NO^3/l in a few samples and in the past 10 years it has generally been above 37.5 mg NO^3/l, which is the limit at which actions must be taken according to the WFD. Pesticides is not considered to be a problem, as there have been no instances of pesticides or other hazardous substances above the detection limit in the drilling.

Changing the trend in increasing nitrate concentrations will require a different land use, either by changing the agricultural praxis, e.g. crop rotation, introduction of new crops or by changing to a new land use type, e.g. afforestation. The abstraction wells are located at the edge of a field and the waterworks has an agreement with the farmer not use fertilizer on a hectare surrounding the wells. This is, however, not sufficient, but due to its size, the waterworks has limited resources and are unable to fund a general groundwater protection.

8.3 Methodology

The survey in Vester Hjerk was conducted in two stages. The first step was a telephone call to farmers managing land within the capture zone, but with the farm located outside the supply area. In the second stage farmers managing land in the capture zone and with the farm in the supply area plus full- or part-time farmers in the supply area was visited and interviewed on their farms. In both stages the farmers a questionnaire on 13 BMPs on nitrate management were presented to the farmers. In the second stage the interview was combined with another WaterProtect survey on consumer attitudes and preferences.

- In total 7 of 8 farmers managing land in the capture zone have been interviewed. One farmer did not want to contribute.
- To supplement the information from the management within the capture zone additional 1 full-time farmer and 2 part-time farmers managing land within the supply area has contributed to the survey.
- A few pensioners and hobby-farms are also managing land in the supply area, but are not included in the survey.

- The included BMPs are not relevant for all farming systems. Included farming systems are pigs, beef cattle, dairy cattle and plant production. Farming systems with sheep, Christmas trees and deer are not included in the survey, but none of these are located in the capture zone.
- All the interviewed farmers manage crop production including fertilization and crop protection themselves.

The coverage of the agricultural land within the capture zone (app. 150 ha) is high. Only one farmer, managing app. 15 ha within the capture zone, did not want to contribute to the survey. It is very difficult to assess the representativeness of the farms included in the survey in relation to the supply area. Only two farms have the majority of their land in the capture zone and only 4 farms have the majority of the land in the supply area. The 7 farmers managing land in the capture zone in total manage more than 3 000 ha, but most of the farms are not located in the local area and by far the largest share of their land is located outside the local area across the peninsula of Salling.

The results in the Danish survey might not be completely comparable with the results from other Action Labs regarding potential BMPs. The farmers indicating interest in BMPs not already practiced had considered this prior to the survey. This might produce relative low results on the potential of different BMPs compared to other surveys.

8.4 Summary of the BMPs questionnaire outcomes & applied mitigation measures

BMPs were selected for improvement of the water quality in relation to nitrate leaching.

A number of BMPs from the common list (see Annex 1 for BMP key) were left out as they are considered irrelevant in Vester Hjerk Action Lab.

The reasons to leave these common BMPs out in the Danish case are:

- Obligatory according to Danish regulations: BMP 2 (Fertilizer program), BMP 4 (Incorporating organic manures immediately after application on cultivated land), BMP 5 (Injection, trailing shoe or band spreader used for slurry), BMP 6 (Avoiding the application of chemical fertilizers and manure during high-risk periods), BMP 10 (Cover crops) and BMP 15 (Covered manure storage system).
- Not relevant in the specific context (Nitrate leaching to groundwater): BMP 9 (Crop rotation and its role in rebuilding and preservation soil organic matter), BMP 11 (Grass buffer zones), BMP 13 (Separation of pastures from water courses and reservoirs), BMP 18 (Phytase supplementation) and BMP 19 (Reducing dietary nitrogen and phosphorus intake).
- Likely to be illegal: BMP 16 (Slurry bags).

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BMP 10 (Plant cover in autumn and winter) is also included in obligatory regulation in Denmark, but is included in the survey as the farmers have different options. The standard choice is 'ordinary' cover crops sown in August and possible plowed late October. The alternative choices were also included in the survey (Interim crops, sown late July – harvested late September, early sowing of winter crops early September, energy crops). Additionally, set aside and afforestation (often used to protect groundwater in Denmark) was also included as N-leaching mitigation options.

The final selection of BMPs in the Danish survey is listed below. BMPs with numbers refer to the common list; BMPs with letters are specific to the Danish study.

1.	Nutrient balance on farm and/or field level
3.	Liming
7.	Use treated urea (with urease inhibitor)
8.	Conservation tillage
12.	Constructed wetlands
14.	Controlled drainage
17.	Adopting phase feeding of livestock
59.	Use of Global Positioning System to manage inter field variability in crops
77.	Energy crops
78.	Set-aside
79.	Afforestation

The results on uptake of non-obligatory BMPs are shown in Figure 51, for 8 relevant common indicators and the 3 Action Lab specific BMPs (77-79). Notable is that 4 non-obligatory BMPs are not taken up by the farmers at all. This is the case for BMPs on nutrient balances (BMP 1), constructed wetlands (BMP 12) and controlled draining (14). In relation to BMP 2 it should be mentioned, that it is obligatory for the farmers to do fertilizer planning at field level, but no balances are calculated. Also the BMPs on conservation tillage (BMP 8), energy crops (BMP 77) and afforestation (BMP79) is not very popular by the farmers, as only one farmer in the survey has taken up each of these BMPs. Slightly more popular are BMPs on urease inhibitor (BMP 7) and precision farming (BMP 59) with 2 farmers each. However, note that only a small part of the fertilizers used are commercial and that some of the farmers do practice elements of precision farming. The two most widely practiced BMPs are liming (BMP 3) with 6 farmers and phase feeding (BMP 17) also with 6 farmers. The responses on phase feeding reflect the high share of pig-farmers in the survey as this is normally connected to this sector. Dairy farmers use some of the same approaches, but do not necessarily refer to phase feeding. It should also be noted that even though

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liming appears to be very popular, it is a practice that is not applied to all fields and sometimes in 5-10 years intervals.

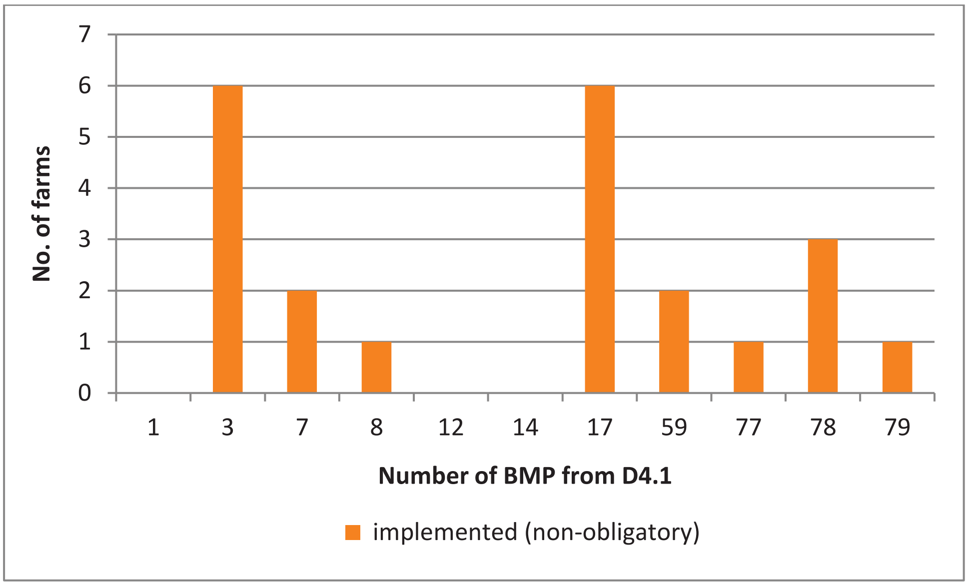

Figure 51: Denmark: Summary of survey results illustrating the number of farms currently using selected non-obligatory best management practices voluntarily. See Annex 1 and text above for BMP key.

8.5 Potential for uptake of new mitigation measures

As described under methods, the results on potential uptake of non-obligatory BMPs are presented for farmers that actively considered these options before the survey. This is reflected in the results presented in Figure 52, where farmers have expressed interest in only 3 of the 8 common indicators and 1 of the 3 specific Action Lab BMPs. So, no additional farmers are in the short term likely to take up liming (BMP 3), urease inhibitor (BMP 7), controlled draining (BMP 14), phase feeding (BMP 17), energy crops (BMP 77), set-aside (BMP 78), afforestation (BMP 79) and precision farming (BMP 59). Conservation tillage (BMP 8) has been considered positively by one farmer, however, on a limited area only. Two farmers expressed interest in afforestation, but not as an N-mitigation measure. Three of the farmers expressed a positive interest in calculating N-balances (BMP 1). Finally, constructed wetlands (BMP 12) showed potential being backed by 3 farmers. Constructed wetlands are currently supported financially and promoted by authorities and organizations.

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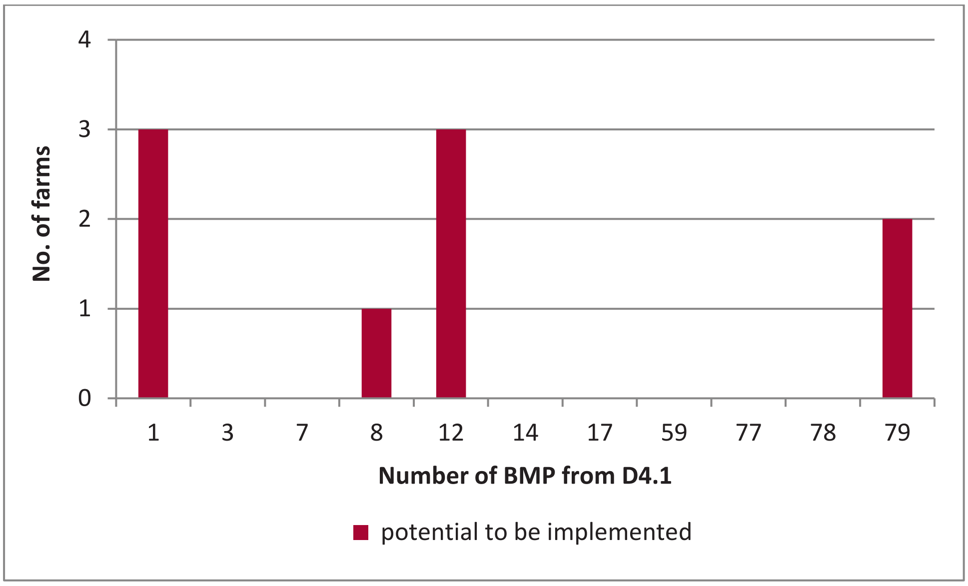

Figure 52: Denmark: Summary of survey results illustrating the number of farms interested in taking up selected non-obligatory best management practices. See Annex 1 and text above for BMP key.

Figure 53 summarized the results for uptake as well as potential for non-obligatory BMPs in the Vester Hjerk Action Lab. The 12 BMPs can be grouped in:

- BMPs with no uptake and potential: Controlled drainage (BMP 14)
- BMPs with low uptake and potential: Energy crops (BMP 77), urease inhibitor (BMP 7), conservation tillage (BMP 8) and Use of Global Positioning System to manage inter field variability in crops (BMP 59).
- BMPs with medium uptake and potential: N-balances (BMP 1), constructed wetlands (BMP 12), set aside (BMP 78) and afforestation (BMP 79).
- BMPs with high uptake and potential: Liming (BMP 3) and phase feeding (BMP 17)

It is worth noting that much of the potential is linked to the third group of BMPs with medium uptake and potential.

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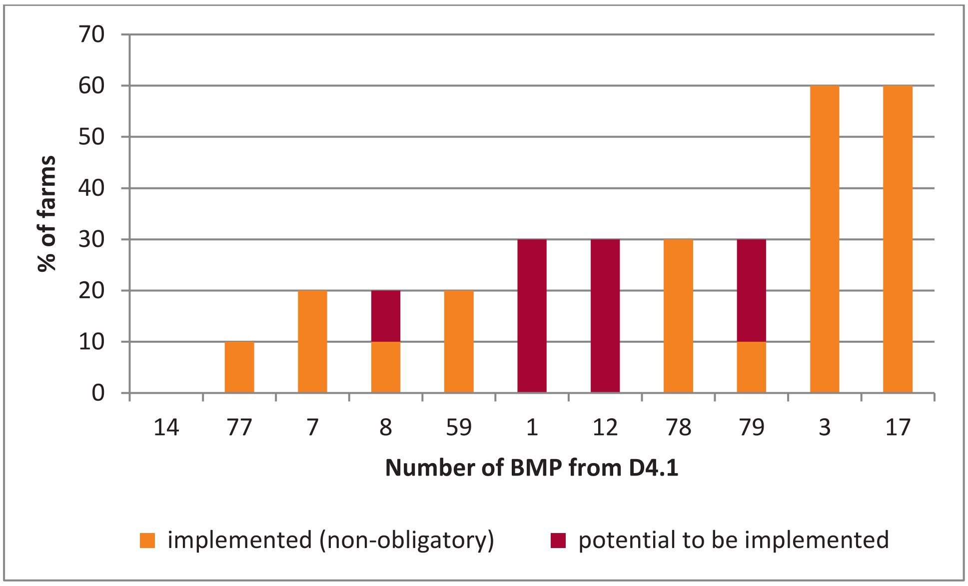

Figure 53: Denmark: Summary of survey results illustrating the percentage of farms currently using selected non-obligatory best management practice and their potential for implementation. See Annex 1and text above for BMP key.

8.6 Conclusions

Within the Action Lab Vester Hjerk we have surveyed BMPs targeting a reduction in nitrate leaching to the groundwater. Only a limited number of farmers are included in the survey and, even though the results in general are in line with common opinions at a larger scale, should be interpreted with caution.

The results should also be interpreted taking into account that 6 of the 11 suggested common indicators of relevance for nitrate leaching to the groundwater are already obligatory according to Danish law. The nitrate issue has been high on the agenda for almost three decades and regulation on for example winter-green fields dates back to the early 1990ies.

One observation to be made is that a reduced N-quota is not popular amongst the farmers. This is an issue that has been high on the agenda in the discussion on a new targeted approach to the regulation of nitrogen. In these discussion differentiation is a key word as compared to the standard N-norms that have been a key component in the Danish regulation until now.

There is no clear picture as to the farmer's preferences for BMPs targeting field versus farm and landscape level.

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It is also worth noting that none of the included BMPs necessarily are in conflict with the present farming systems. It is measures that can be applied (fully or partly) without requiring systemic changes like, for example, a general reduction in the livestock numbers.

A final observation is that **landscape level BMPs such as constructed wetlands, set aside and afforestation, that sometimes requires collaboration between farmers, seems to have a relatively high potential.** In future workshops in the Action Lab we will also explore BMPs in collaborative solutions such as constructed wetlands, land consolidation, common crop rotations, uncultivated land and afforestation. Additionally, we will also look for new ideas from the farms on innovative BMPs.

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9 Summary

As a result of Task 4.2, information on existing mitigation measures and BMPs was gathered in all seven action labs. In addition, an assessment of farmers' willingness to implement additional, innovative measures, depending on costs and benefits was undertaken

Information collected covers different climatic conditions, different types of farming systems, different legal frameworks, larger and smaller water collection areas. Due to the fact that different water quality problems were analyzed in different action labs, BMPs selected for the study varied between case studies and were developed by action lab leaders to reflect conditions characteristic to catchments, which make the comparison between action labs very difficult.

BMPs were selected to improve water quality in case of pollution with nutrients and Plant Protection Products. While some of measures can provide solution for a wide range of pollution problems, such as grass buffer zones or constructed wetlands, other are more problem specific such as phytase supplementation or drift reducing nozzels. Often reduction of water pollution can be achieved by changes in behavior of operators, which can usually be applied cheaply. Other BMPs require new or improved technologies or infrastructure, which is more expensive. Many of these measures are well known in EU countries but were not fully implemented. There is also a large variation as to what is used within countries. Below we summarized main conclusions of the analysis in bullet points:

1. BMPs which are currently implemented and those that were deemed to be implementable mostly are small and simple measures that **do not require big investments or big adaptations** in the farming system and/or offer **clear benefits to farmers**.

2. Farmers admit that they implement BMPs mostly for productivity and incentive reasons. Environmental aspects such as need for minimization of the risk of drift of PPPs or nutrient losses to the environment **are poorly recognized by farmers** in most, but not all cases (Denmark).

3. Range of obligatory BMPs and MMs vary a lot between countries the same as perception of effectiveness and usefulness of different BMPs. For example, results of the survey in Ireland suggest poor performance of constructed wetlands and therefore low potential for implementation of this measure. In contrast to that, in the Danish case study landscape level BMPs such as constructed wetlands, set aside and afforestation seem to have a relatively high potential.

4. Larger and more expensive measures are more difficult to implement; nonetheless measures perceived as being beneficial for farmers (giving long term financial benefits) have relatively high potential for implementation. For example the use of GPS technology in farming show high potential for implementation in Ireland, Poland and Denmark.

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5. Other measures recognized as effective but not giving direct benefits to farmers, e.g. anti-hail net are not considered interesting or applicable, mainly due to the excessive costs. For these measures, financial incentives would be necessary to increase their implementation.

6. Implementation of measures that require land area, such as for example vegetated buffer strips at the edge of a field or within a field, are not welcomed by farmers due to loss of land for agricultural production. **However farmers in Poland indicated that they would be in favor of them if given land tax exemptions for these areas and/or state/commune support in maintaining weed spread in these areas.**

5. Some countries (Denmark, Belgium, Poland) indicate **a positive approach to collaborative solutions**, where more farmers and stakeholders are involved. For example farmers indicated they would welcome a solution where a common, public cleaning place for cleaning sprayers was provided. Organising these solutions needs facilitation of dedicated institutions and/or a leader with good communication skills, as making a consensus among farmers themselves to work together has also been identified as a potential barrier.

6. Some countries (Italy, Belgium) highlighted that farmers showed to be open for cooperation and expressed their interest in obtaining more information about specific BMPs or how to mitigate defined problems. In other (Poland) farmers admitted to participate in many trainings related to BMPs, however these were very theoretical and hence were not effective. Our observation is that farmers are often forced to participate in trainings without having their inner need for understanding the problem. This leads to the most important conclusions of this study that:

- **There is still very high need for raising awareness among farmers about environmental problems, their contribution to them, consequences of their behaviors as well as measures to combat the problem;**

- **Perception of implementation of BMPs needs to be turned from an obligation to a responsibility;**

- **Effective implementation of BMP seems to be more successful if initiated on a voluntary basis, based on good understanding of the problem;**

- **Farmers still need support in trainings including practical good examples showing benefits of BMP implementation;**

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- **Cooperation between stakeholders, involving many partners seems a good approach to combat common problems; however this needs dedicated institutions/local leaders with good communication skills that will facilitate the process;**

- **The problem is also the large dispersion of institutions that do not always cooperate with each other and all impose requirements on farmers. This causes some information chaos. It is necessary to improve relations between institutions and farmers. The farmer should be aware that the institution is also a partner who will help fulfill requirements and obligations.**

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Annex 1

Table 2: List of Best Management Practices analysed in the project

	Nº	Name of Best Management Practice or mitigation measure	Type of pollutant combated by the measure
Animal production & Manure management	6	Avoiding the application of chemical fertilizers and manure during high-risk periods	Nutrients
	4	Incorporating manures immediately after application on cultivated land	Nutrients
	5	Injection, trailing shoe or band spreader used for slurry	Nutrients
	63	Estimation of nutrient content of organic manures (hydrometer for slurry)	Nutrients
	62	Spreading slurry in early growing season to maximize crop uptake	Nutrients
	16	Slurry bags	Nutrients
	61	Manure store with tank	Nutrients
	15	Covered manure storage system	Nutrients
	71	Directing manure towards special ponds (for sedimentation of organic substances for extraction of nutrients)	Nutrients
	72	Temporary depositing of organic manure on the agricultural field	Nutrients
	74	Use of impermeable folia under the pile of solid manure deposited on field	Nutrients
	73	Precaution measures (solid manure distance from rivers, well etc deposited on field) for preventing pollution of water	Nutrients
	13	Separation of pastures from water courses and reservoirs	Nutrients
	17	Adopting phase feeding of livestock	Nutrients
	18	Phytase supplementation	Nutrients
	19	Reducing dietary nitrogen and phosphorus intake	Nutrients

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Soil management & Plant production		1	Nutrient balance on farm and/or field level	Nutrients
		2	Fertilizer program	Nutrients
		7	Use treated urea (with urease inhibitor)	Nutrients
		3	Liming	Nutrients
		64	Soil analysis for pH, nutrients or organic matter	Nutrients
		9	Crop rotation and its role in rebuilding and preservation soil organic matter	Nutrients
		78	Set-aside	Nutrients
		79	Afforestation	Nutrients
		77	Energy crops	Nutrients
		14	Controlled drainage	
		59	Use of Global Positioning System to manage inter field variability in crops	Nutrients
	PPP runoff	60	Use Decision Supporting Systems or Forecasting Systems	Nutrients, pesticides
		56	Optimize irrigation timing and rate	Nutrients, pesticides
		49	Improved soil management to increase the water holding capacity of the soil	Nutrients, pesticides
		11	Grass buffer zones	Nutrients, pesticides
		12	Constructed wetlands	Nutrients, pesticides
		10	Plant cover in autumn and winter	Nutrients, pesticides
		8	Conservation tillage	Nutrients, pesticides
		50	Inter-ridge bunding	Nutrients, pesticides
		51	Enlarge headlands	Nutrients, pesticides
		52	Double sowing	Nutrients, pesticides
		53	Manage field access areas	Nutrients, pesticides
		54	Avoid accelerated run-off of water and PPP by tramlines or short cuts	Nutrients, pesticides
		55	Establish retention structures (fascines, edge of the field bunds, vegetative ditches, …)	Nutrients, pesticides

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	65	Vegetated filter strip (VFS) at edge-of-field	Nutrients, pesticides
	66	In field vegetative filter strips (VFS) as talwegs	Nutrients, pesticides
	67	Inter-row processing and weeding on the row	Pesticides
	68	Permanent grassing in the inter row and weeding on the row	Pesticides
	75	Alternatives systems to chemical fights to pest control	Pesticides
PPP point source	24	Do store sprayers safely	Pesticides
	25	Use inspected sprayers	Pesticides
	26	Calibrate sprayer for the appropriate and optimized application of PPP	Pesticides
	27	Safe transport of PPP	Pesticides
	28	Store PPP within lockable rooms/containers or cupboards	Pesticides
	29	Dispose obsolete PPP by an authorized waste collection company	Pesticides
	30	Choose a safe filling and cleaning place for the spraying equipment	Pesticides
	31	Be prepared for and manage spills safely	Pesticides
	32	Prevent overflow and foam escape during filling	Pesticides
	33	Rectify/Adjust any equipment problem immediately	Pesticides
	34	Adequate cleaning of sprayers to minimize the amount of spray remnants	Pesticides
	35	Clean and safely manage empty containers/packages, seals and caps	Pesticides
	36	Seal and secure partly used containers/packages immediately after use	Pesticides
	37	Safe disposal of spraying liquid residues	Pesticides
	81	Anti- drip devices	Pesticides
PPP spray drift	38	Use drift reducing nozzles	Pesticides
	39	Use sprayer types allowing spray-drift reduction	Pesticides
	40	Use application techniques allowing PPP reduction if appropriate	Pesticides
	41	Use the lowest effective distance between nozzles/atomizers and the spray target	Pesticides

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	42	Use the lowest effective sprayer forward speed	Pesticides
	43	Use the lowest effective pressure	Pesticides
	44	Do not spray no spray zones and other non-target areas	Pesticides
	45	Adjust sprayer settings according to application conditions, crop density and canopy to minimize spray drift	Pesticides
	46	Do not use cannon sprayers next to sensitive areas	Pesticides
	47	Keep existing vegetation or establish windbreaks/retention structures between sensitive areas and fields being sprayed	Pesticides
	48	Use new technologies to apply PPP more precisely	Pesticides
	69	Anti-hail net	Pesticides
General measures	57	Professional support in selection of appropriate PPP	Pesticides
	20	Ensure the sprayer operator is adequately trained and prepared for Plant Protection Product use	Pesticides
	21	Always plan and organize your spray activities.	Pesticides
	22	Only spray when weather and field conditions allow safe and effective PPP use	Pesticides
	23	Only use approved PPP and comply with all their conditions of Use	Pesticides

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