Development of strategies to realise the improved take up of mitigation measures and BMPs

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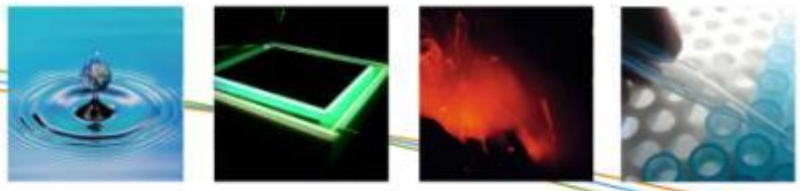

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CHANGE RECORD

Version	Date	Description
1.0	30/11/2018	First version
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List of abbreviations & acronyms

APCS	Associazione Piace Cibo Sano
BMP	Best Management Practices
CAP	Common Agricultural Policy
CPABLL	Consorci del Parc Agrari del Baix Llobregat
DWWTS	Domestic Waste Water Treatment Systems
ITPPIG-PIB	Instytut Technologiczno-Przyrodniczy (Institute of Technology an Life Science) Państwowy Instytut Geologiczny – Państwowy Instytut Badawczy (Polish Geological Institute – National Research Institute)
PPP	Plant Protection Product
UCSC	Universita Cattolica del Sacro Cuore
VITO	Vlaamse Instelling voor Technologisch Onderzoek (Flemish Institute for Technological Research)

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1 Introduction

This report presents an output of deliverable D4.4 that aims at developing recommendation regarding implementation of new mitigation measures and best management practices within seven action labs. Implementation of BMPs is required in order to improve water quality in pilot catchments of the project and is necessary to meet water governance strategies developed in work package 2 of the project. The report is the 2nd version of the report.

Two main factors have been identified as being most important for providing good and successful recommendations with respect to mitigation measures and best management practices. These are:

- proper understanding of physical system into which measures are going to be implemented; and
- understanding of needs and means/capabilities of users (farmers) which are perceived as actual BMPs implementers.

For the above reasons, the deliverable has been scheduled in a way that allows to gain information from work package 5 of the project, in which a conceptual understanding of the catchment is developed, as well as earlier deliverables of work package 4, in which various BMPs relevant to each action labs and willingness of farmers to implement them has been analysed.

Conceptual understanding of a catchment required gathering vast information about physical characteristics of the catchment, including geological and hydrogeological/hydrological setting, soils and morphology, land use and land cover, results of water quality monitoring and pressure analysis. In some cases, advanced numerical models were built in order to define water dynamics in the system (Poland, Denmark and Spain). All these was needed in order to define areas of the catchment most susceptible to pollution from agricultural sources, where implementation of mitigation measures and BMPs is foreseen to be most effective in combating water pollution problems of the catchment.

In total 77 different BMPs has been indicated by project partners as relevant in this study, all of which have been described in details in a standardise form providing information about type of water environment it is designed to protect, type of risk mitigated by the measure, type of pollutant combated by the measure, its benefits and limitations as well as cost of application and were delivered in form of a report in deliverable D4.1. Following that, questionnaires were performed within action labs to identify preference of farmers with respect to BMP implementation. This allowed analysing the actual situation of BMP implementation in local seven action labs being under investigation in the Waterprotect project. Each action have identified measures that have best chances for implementation on a local scale and have evaluated reasons for which other measures have lower chances for implementation. Although these measures vary between action labs, some general conclusions of this work suggest that there is still significant need for raising awareness among farmers about their contribution to environmental pollution problems and consequences of their behaviours. As such behavioural changes, as cheap and easy

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to implement, seem to have the highest importance in increasing the potential for effective uptake of BMP implementation. This however needs sociological changes and changing the perception that implementation of BMPs is more a responsibility than an obligation to farmers. Optimisation of economic benefits is still the most important goal in farming. It is clear that financial benefits introduced by the implementation of the CAP policy have helped in solving several water pollution problems on local scale, nonetheless the worrying observation is that farmers often do not understand the rationale that lies behind the CAP policy. A positive observation of the D4.2 work was that most stakeholders seem to understand that efforts need to be undertaken by all sides, and often cooperative approach between stakeholders or even group of farmers is the best way forward. This links further with the need of improving relations between institutions and farmers. The problem of large dispersion of institutions responsible for various elements of environmental and agricultural policies and control seem to be the problem in most if not all countries included in Waterprotect project. Farmers complained about the fact that institutions do not liaise between themselves and all impose requirements on farmers that sometimes contradict themselves and this causes chaos and also discourages farmers to take up actions. Farmers highlight that they need to see a partner in institutions, a partner who will not only control farmers' activities, but will also support them.

2 Methodology

The ultimate aim for this report was to provide recommendations on the implementation of new mitigation measures and BMPs with a focus on those measures that are most likely to be successfully implemented by farmers. An important factor in the development of these recommendations was good understanding of physical characteristics of catchments, so that measures could have been proposed adequately to environmental settings.

To provide a uniform approach for development of recommendations regarding selection of appropriate measures across seven action labs, the project partners worked together on developing a common strategy for selecting measures that will be most appropriate for combating water pollution resulting from various, nonetheless common to all, agricultural activities.

This work resulted in something that the team called the 'decision support trees', which at the latest stage have transformed into decision support tables. The general concept of these assumes an in depth analysis of conditions related to common agricultural practices utilized at farm and field levels, which may lead to water pollution. These include conditions of soils, its topography, location with respect to water courses, meteorological conditions, but also the way a farm is organized and individual habits of farmers. All this is analyzed for a defined type of agricultural activities and the appropriate mitigation measures are proposed.

Since the project focuses on combating both nutrients and pesticide pollution, the following agricultural activities were included in the report:

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1. Animal production
2. Manure management
3. Soil management & plant production
4. Point source pollution
5. Run-off &erosion source pollution
6. Drift source pollution

Decision support tables directing towards appropriate BMPs have been developed for further exploitation by project partners to decide upon strategies for each action lab to choose measures in order to enhance water quality in local catchments.

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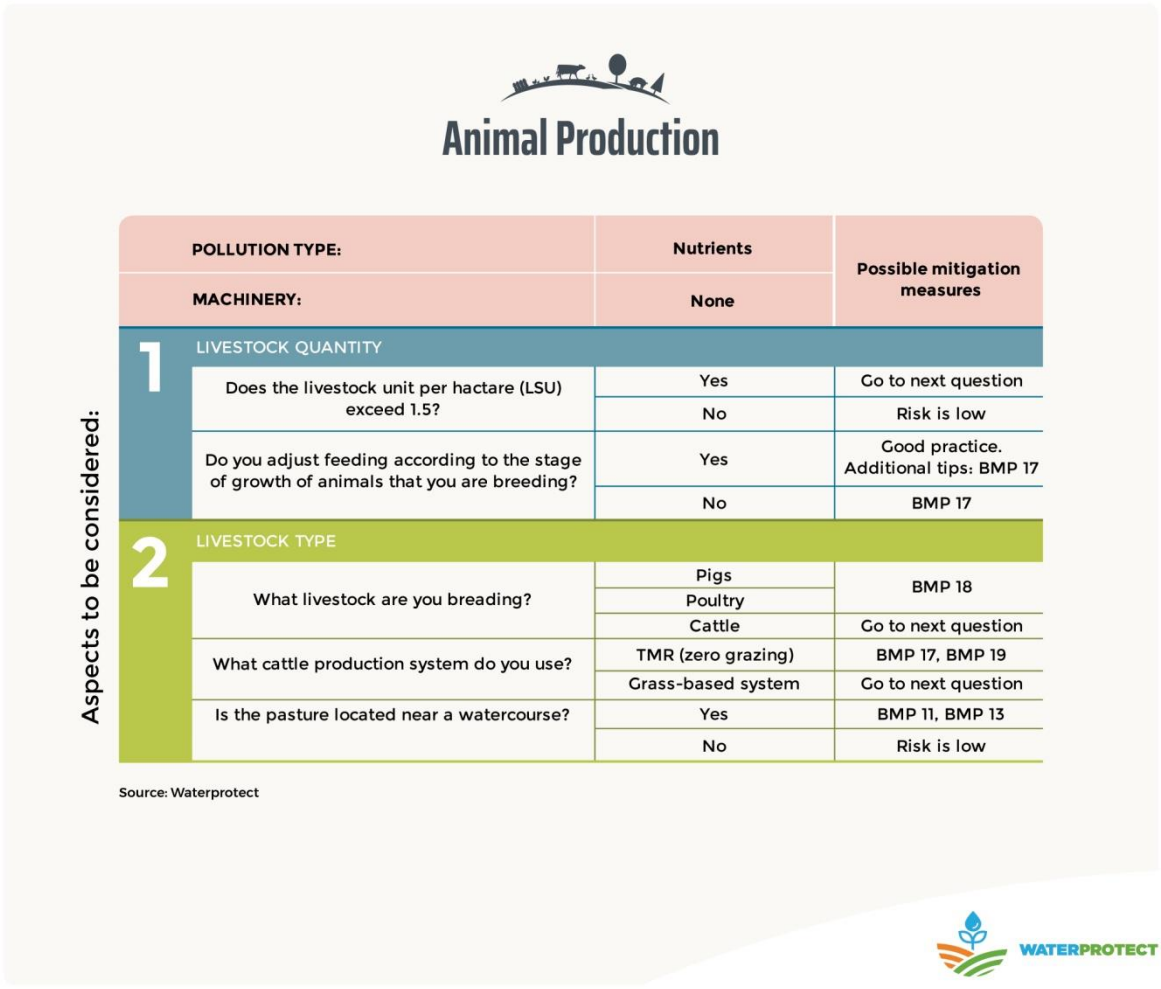
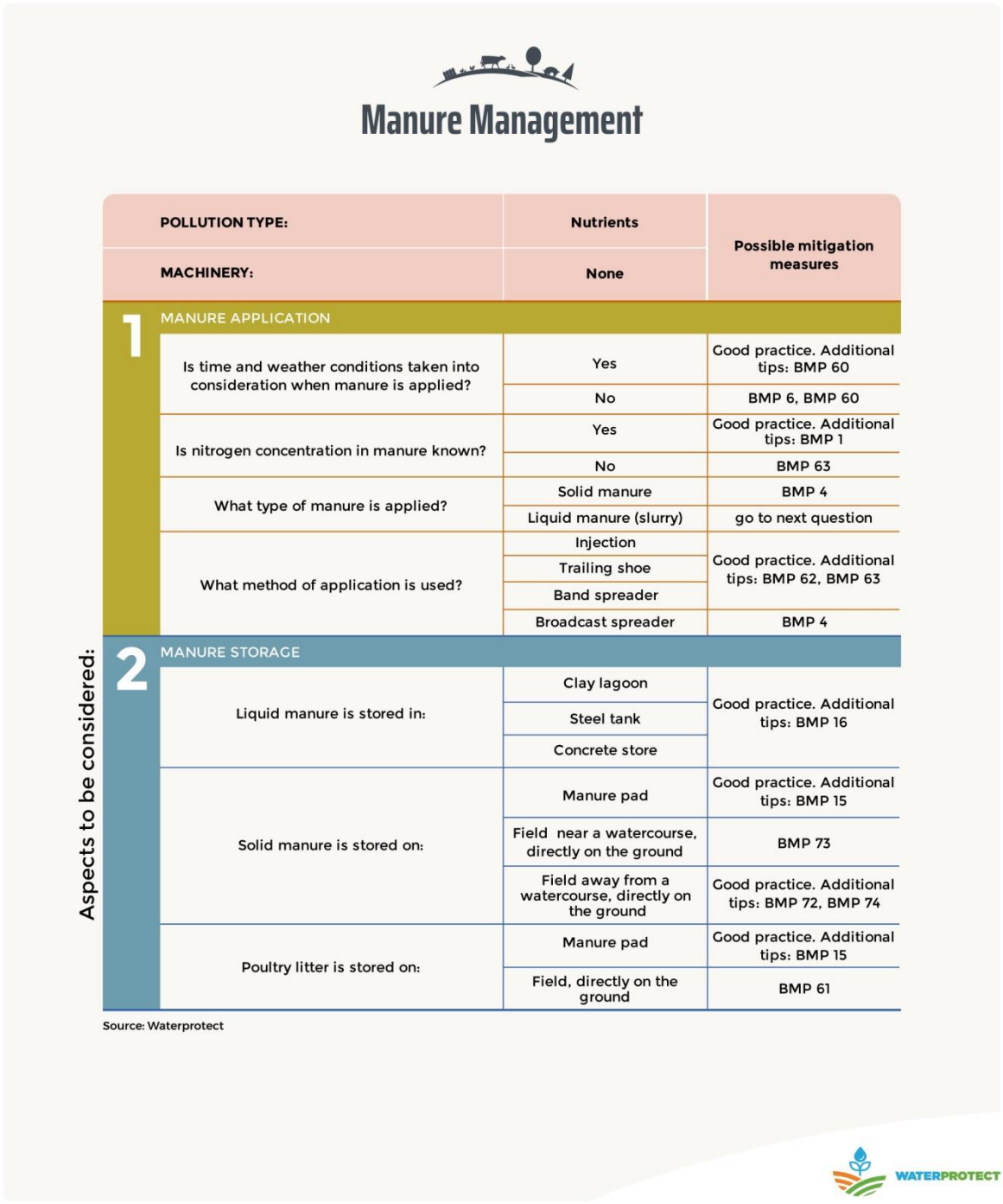
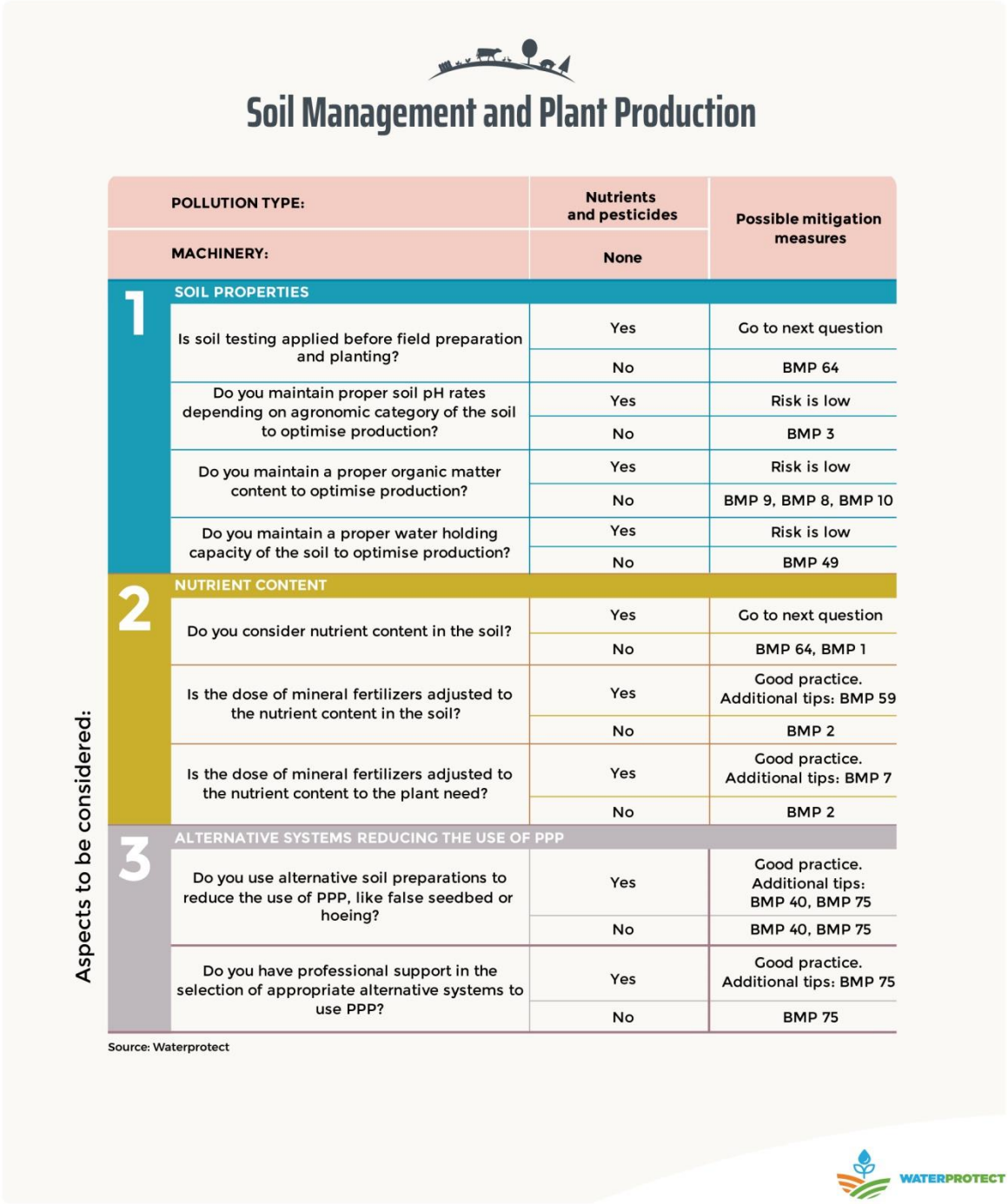
2.1 Animal production



2.2 Manure management



2.3 Soil management & plant production



Soil Management and Plant Production

Aspects to be considered:

	POLLUTION TYPE:	Nutrients and pesticides	Possible mitigation measures
	MACHINERY:	None	
1	**SOIL PROPERTIES**		
	Is soil testing applied before field preparation and planting?	Yes	Go to next question
		No	BMP 64
	Do you maintain proper soil pH rates depending on agronomic category of the soil to optimise production?	Yes	Risk is low
		No	BMP 3
	Do you maintain a proper organic matter content to optimise production?	Yes	Risk is low
		No	BMP 9, BMP 8, BMP 10
	Do you maintain a proper water holding capacity of the soil to optimise production?	Yes	Risk is low
		No	BMP 49
2	**NUTRIENT CONTENT**		
	Do you consider nutrient content in the soil?	Yes	Go to next question
		No	BMP 64, BMP 1
	Is the dose of mineral fertilizers adjusted to the nutrient content in the soil?	Yes	Good practice. Additional tips: BMP 59
		No	BMP 2
	Is the dose of mineral fertilizers adjusted to the nutrient content to the plant need?	Yes	Good practice. Additional tips: BMP 7
		No	BMP 2
3	**ALTERNATIVE SYSTEMS REDUCING THE USE OF PPP**		
	Do you use alternative soil preparations to reduce the use of PPP, like false seedbed or hoeing?	Yes	Good practice. Additional tips: BMP 40, BMP 75
		No	BMP 40, BMP 75
	Do you have professional support in the selection of appropriate alternative systems to use PPP?	Yes	Good practice. Additional tips: BMP 75
		No	BMP 75

Source: Waterprotect

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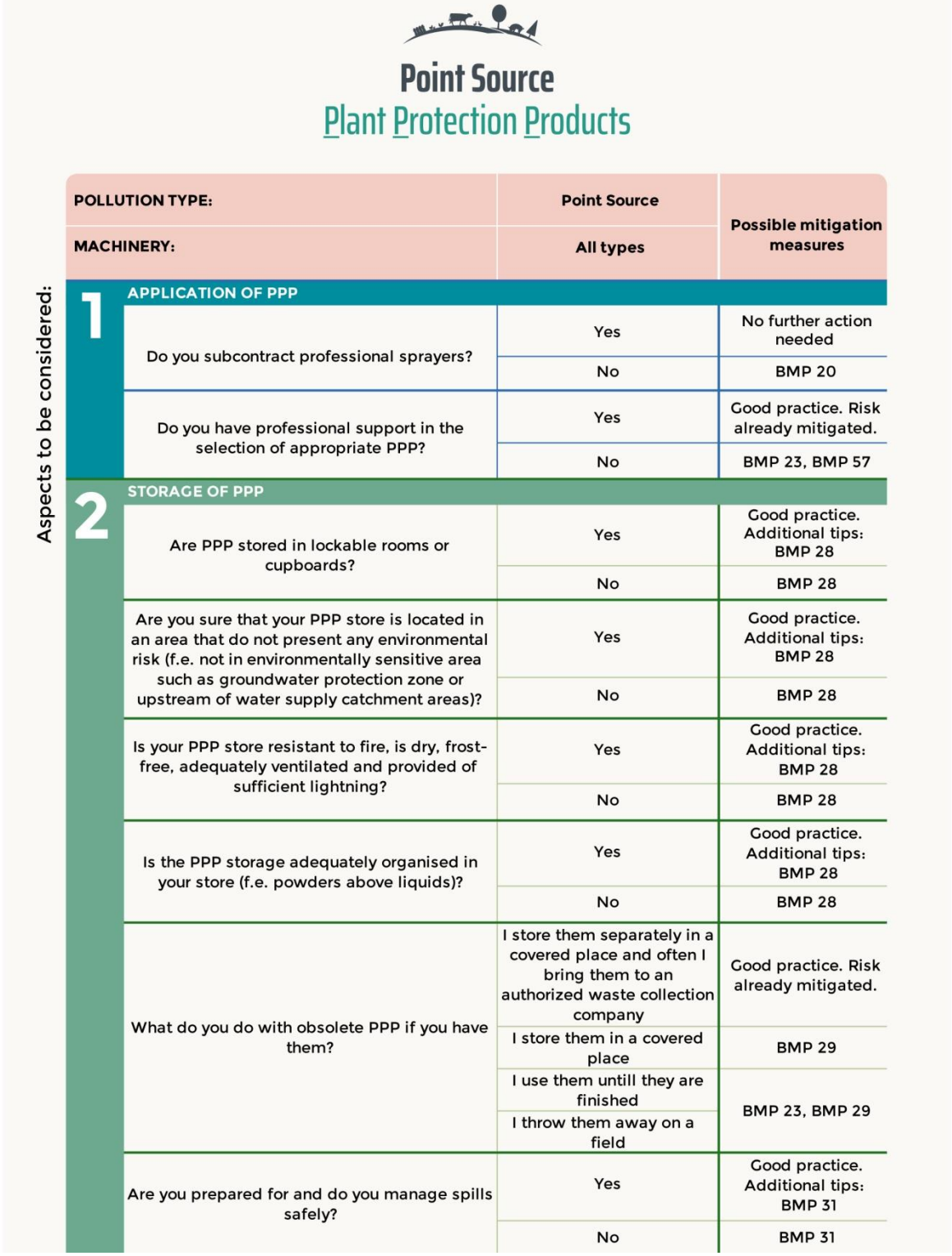
2.4 Point source pollution



Point Source
Plant Protection Products

Aspects to be considered:

POLLUTION TYPE:		Point Source	Possible mitigation measures
MACHINERY:		All types	
1	APPLICATION OF PPP		
	Do you subcontract professional sprayers?	Yes	No further action needed
		No	BMP 20
	Do you have professional support in the selection of appropriate PPP?	Yes	Good practice. Risk already mitigated.
		No	BMP 23, BMP 57
2	STORAGE OF PPP		
	Are PPP stored in lockable rooms or cupboards?	Yes	Good practice. Additional tips: BMP 28
		No	BMP 28
	Are you sure that your PPP store is located in an area that do not present any environmental risk (f.e. not in environmentally sensitive area such as groundwater protection zone or upstream of water supply catchment areas)?	Yes	Good practice. Additional tips: BMP 28
		No	BMP 28
	Is your PPP store resistant to fire, is dry, frost-free, adequately ventilated and provided of sufficient lightning?	Yes	Good practice. Additional tips: BMP 28
		No	BMP 28
	Is the PPP storage adequately organised in your store (f.e. powders above liquids)?	Yes	Good practice. Additional tips: BMP 28
		No	BMP 28
	What do you do with obsolete PPP if you have them?	I store them separately in a covered place and often I bring them to an authorized waste collection company	Good practice. Risk already mitigated.
		I store them in a covered place	BMP 29
		I use them untill they are finished	BMP 23, BMP 29
		I throw them away on a field	
	Are you prepared for and do you manage spills safely?	Yes	Good practice. Additional tips: BMP 31
		No	BMP 31

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Aspects to be considered:

3	**MACHINERY STORAGE**		
	Do you store your machinery inside, sheltered from rain, when not used?	Yes	Good practice. Risk already mitigated.
		No	BMP 35
4	**MACHINERY MAINTANCE**		
	Is your sprayer inspected by an authorized inspection company?	Yes	Good practice. Risk already mitigated.
		No	BMP 25
	Do you make a correct calibration for the appropriated and optimized application of PPP?	Yes	Good practice. Risk already mitigated.
		I don't know / I'm not sure	BMP 26
		I don't calibrate my sprayer	BMP 26
	Do you have professional support for a correct sprayer calibration?	Yes	Good practice. Risk already mitigated.
		No	BMP 26
	Do you regularly perform technical checks and maintainance of your spraying equipment?	Yes	Good practice. Risk already mitigated.
		No	BMP 26, BMP 33

Aspects to be considered:

5	**FILLING OF THE SPRAYER WITH PPP**		
	Where do you fill your sprayer?	On a field	Good practice. Additional tips: BMP 30, BMP 31, BMP 32
		On a permeable surface on the farm	Additional tips: BMP 30, BMP 31, BMP 32
		On an impermeable surface on the farm with separate collection and purification of remnant water	Good practice. Additional tips: BMP 30, BMP 31, BMP 32
		On an impermeable surface on the farm without collection of remnant water	BMP 30, BMP 31, BMP 32, BMP 37
6	**FILLING OF THE SPRAYER WITH WATER**		
	Is the sprayer ever filled from surface water (water course, reservoirs, etc.)?	Yes	Go to next question
		No	No risk
	Is the suction pipe of the sprayer equipped with a backflow prevention device?	Yes	Good practice. Additional tips: BMP 30, BMP 31, BMP 32
		No	BMP 30, BMP 31 BMP 32

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Aspects to be considered:

7	**SPILLAGE MANAGEMENT**		
	Do you remove spillage when preparing the spraying solution?	Yes	Go to next question
		No	BMP 31
	How do you treat spillage of your PPP?	By rinsing with water	BMP 31
		With absorbent material	Good practice. Absorbent material to be removed by authrorised company.
8	**MANAGEMENT OF PACKAGES, SEALS AND CAPS**		
	Is the sprayer equipped with an induction hopper with rinsing system for empty cans?	Yes	Good practice - Risk already mitigated
		No	BMP 35
	Do you rinse out empty packages?	Yes	Go to next question
		No	BMP 35
	Where do you pour out rinse water?	Into the sprayer tank	Good practice - Risk already mitigated
		Into the storage tank for remnant water	
		Into the field or water collector to a sewer/watercourse	BMP 35
	What do you do with empty packages, seals and caps?	Collect them separately for collection by an authorised waste collection company	Good practice - Risk already mitigated
		Throw them away with household waste	BMP 35
		Throw them away in the field	
9	**CLEANING OF SPRAYERS**		
	9a. Treatment of remaining PPP solutions		
	What do you do with the remaining solution after treatment?	Leave in the sprayer tank and reuse it for the next treatment	Good practice. Additional tips: BMP 21, BMP 34, BMP 36
		Store in barrels and reuse it	Good practice. Additional tips: BMP 21, BMP 34, BMP 36
		Dilute the remaining spraying solution and spray it on the treated field	Good practice. Additional tips: BMP 21, BMP 34, BMP 36
		Dilute and spray it on an impermeable surface on the farm with collection and purification of remnant water	Good practice. Additional tips: BMP 21, BMP 34, BMP 36
		Dilute and spray it on a permeable surface on the farm	BMP 34 BMP 36
		Dilute and spray it on an impermeable surface on the farm without collection and purification of remnant water	BMP 34 BMP 36

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Aspects to be considered:	9b. Rinsing of the sprayer		
	Where do you rinse your sprayer?	On a field	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
		On a permeable surface on the farm	Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
		On an impermeable surface on the farm with a separate collection and purification of remnant water	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
		On an impermeable surface on the farm without a collection of remnant water	BMP 30, BMP 31, BMP 32, BMP 37
	Is the sprayer equipped with a rinse tank?	Yes	Go to next question
		No	BMP 34
	Is the sprayer equipped with rinsing nozzles for internal cleaning of the sprayer?	Yes	No need - risk already mitigated
		No	BMP 34
	Is the sprayer equipped with anti-drip devices?	Yes	Good practice
		No	BMP 81

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Aspects to be considered:

9c. Cleaning of the interior		
Where do you clean the interior of your sprayer?	On a field	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On a permeable surface on the farm	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On an impermeable surface on the farm with a separate collection and purification of remnant water	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On an impermeable surface on the farm without a collection of remnant water	BMP 30, BMP 31, BMP 32, BMP 37
9d. Cleaning of the exterior		
Is the sprayer equipped with cleaning equipment (spray lance) for external cleaning in the field?	Yes	Good practice - Risk already mitigated
	No	BMP 34
Where do you clean the exterior of you sprayer?	On a field	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On a permeable surface on the farm	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On an impermeable surface on the farm with a separate collection and purification of remnant water	Good practice. Additional tips: BMP 30, BMP 31, BMP 32, BMP 37
	On an impermeable surface on the farm without a collection of remnant water	BMP 30, BMP 31, BMP 32, BMP 37

Source: Based on TOPPS Water Protection

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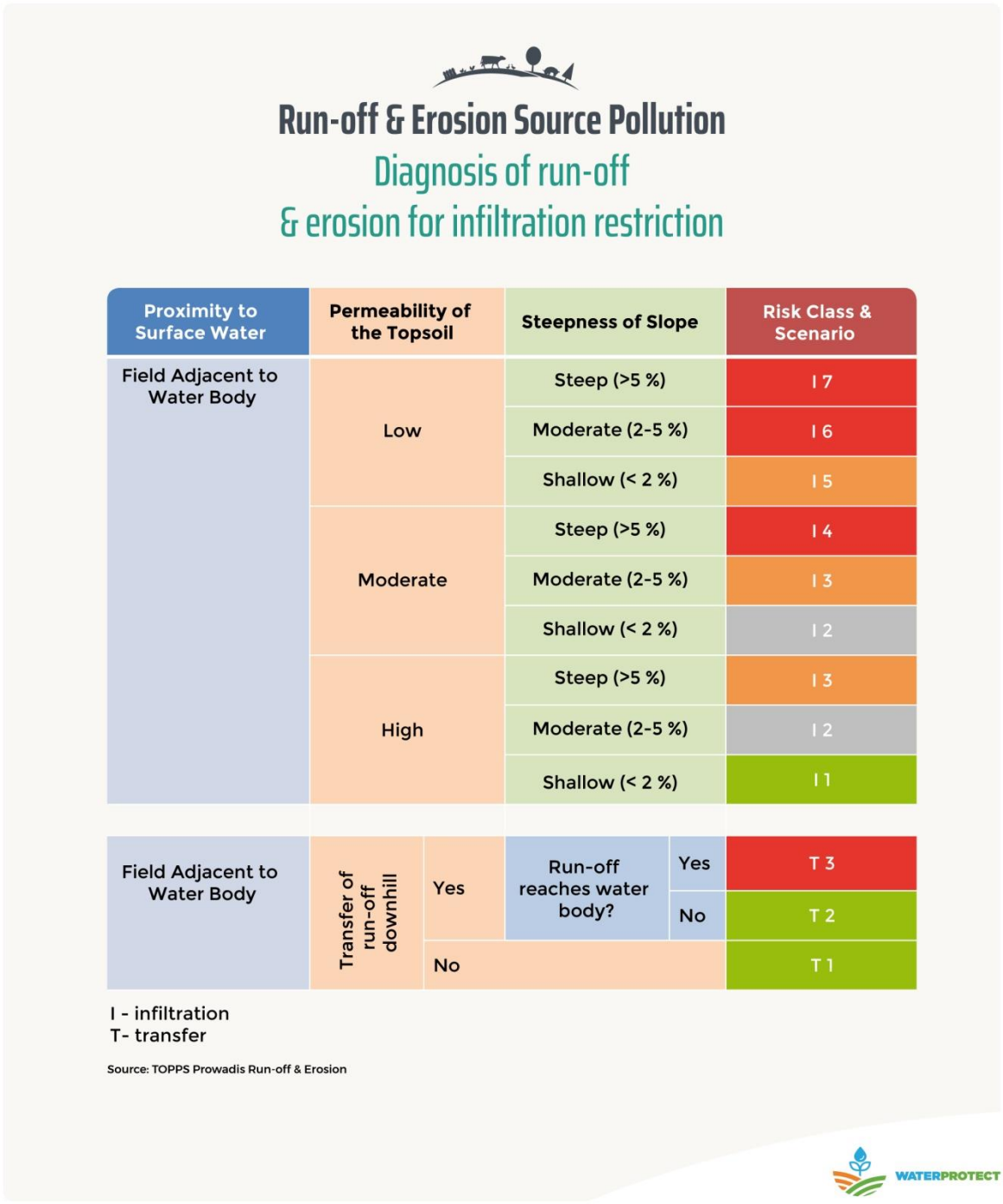
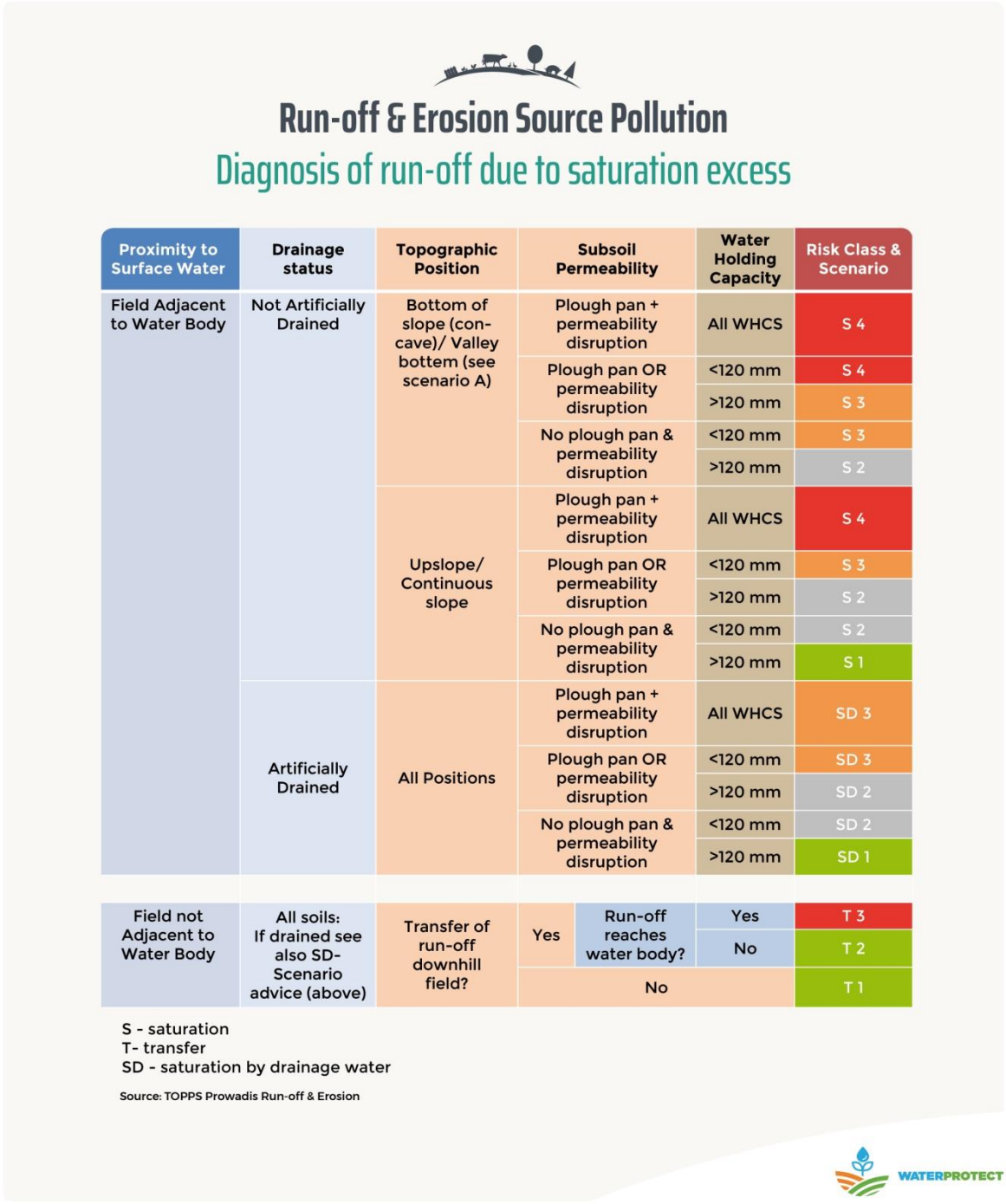
2.5 Run-off & erosion source pollution





Run-off & Erosion Source Pollution

Diagnosis of run-off due to saturation excess

Proximity to Surface Water	Drainage status	Topographic Position	Subsoil Permeability		Water Holding Capacity	Risk Class & Scenario
Field Adjacent to Water Body	Not Artificially Drained	Bottom of slope (con-cave)/ Valley bottem (see scenario A)	Plough pan + permeability disruption		All WHCS	S 4
			Plough pan OR permeability disruption		<120 mm	S 4
					>120 mm	S 3
			No plough pan & permeability disruption		<120 mm	S 3
					>120 mm	S 2
		Upslope/ Continuous slope	Plough pan + permeability disruption		All WHCS	S 4
			Plough pan OR permeability disruption		<120 mm	S 3
					>120 mm	S 2
			No plough pan & permeability disruption		<120 mm	S 2
					>120 mm	S 1
	Artificially Drained	All Positions	Plough pan + permeability disruption		All WHCS	SD 3
			Plough pan OR permeability disruption		<120 mm	SD 3
					>120 mm	SD 2
			No plough pan & permeability disruption		<120 mm	SD 2
					>120 mm	SD 1
Field not Adjacent to Water Body	All soils: If drained see also SD-Scenario advice (above)	Transfer of run-off downhill field?	Yes	Run-off reaches water body?	Yes	T 3
					No	T 2
			No			T 1

S - saturation
T- transfer
SD - saturation by drainage water

Source: TOPPS Prowadis Run-off & Erosion

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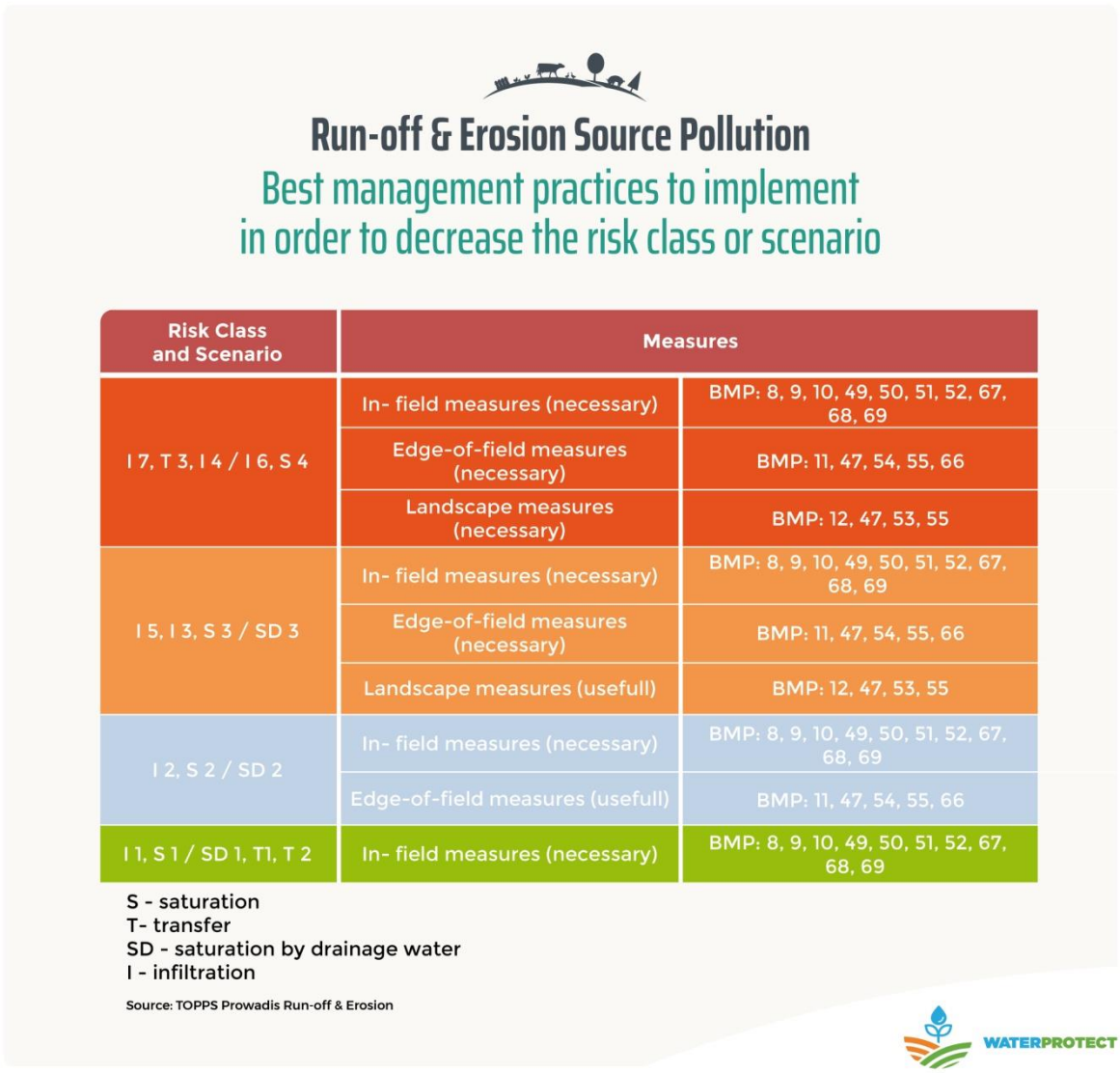

Run-off & Erosion Source Pollution

Best management practices to implement in order to decrease the risk class or scenario

Risk Class and Scenario	Measures	
I 7, T 3, I 4 / I 6, S 4	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (necessary)	BMP: 11, 47, 54, 55, 66
	Landscape measures (necessary)	BMP: 12, 47, 53, 55
I 5, I 3, S 3 / SD 3	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (necessary)	BMP: 11, 47, 54, 55, 66
	Landscape measures (usefull)	BMP: 12, 47, 53, 55
I 2, S 2 / SD 2	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69
	Edge-of-field measures (usefull)	BMP: 11, 47, 54, 55, 66
I 1, S 1 / SD 1, T1, T 2	In- field measures (necessary)	BMP: 8, 9, 10, 49, 50, 51, 52, 67, 68, 69

S - saturation
T- transfer
SD - saturation by drainage water
I - infiltration

Source: TOPPS Prowadis Run-off & Erosion

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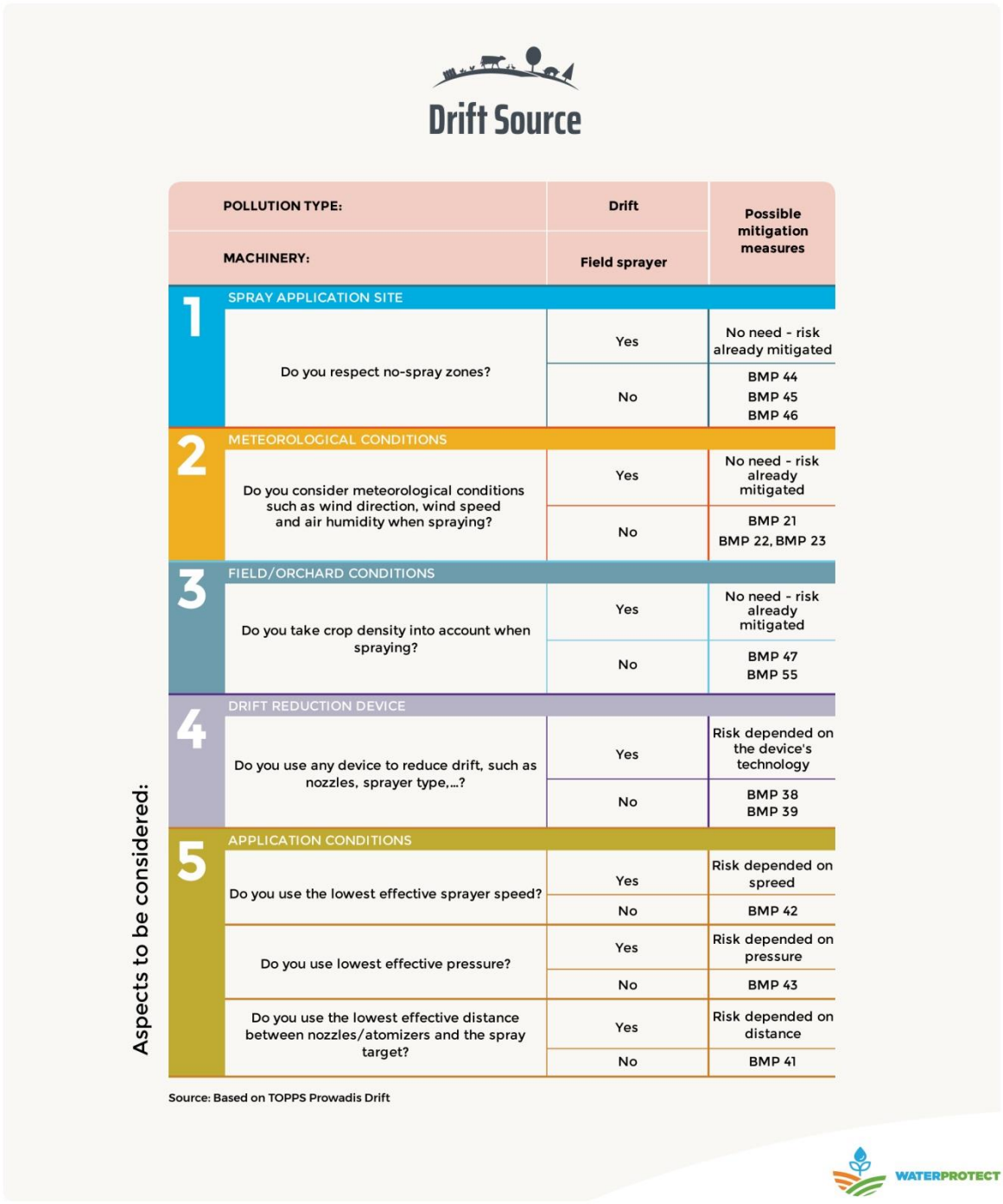
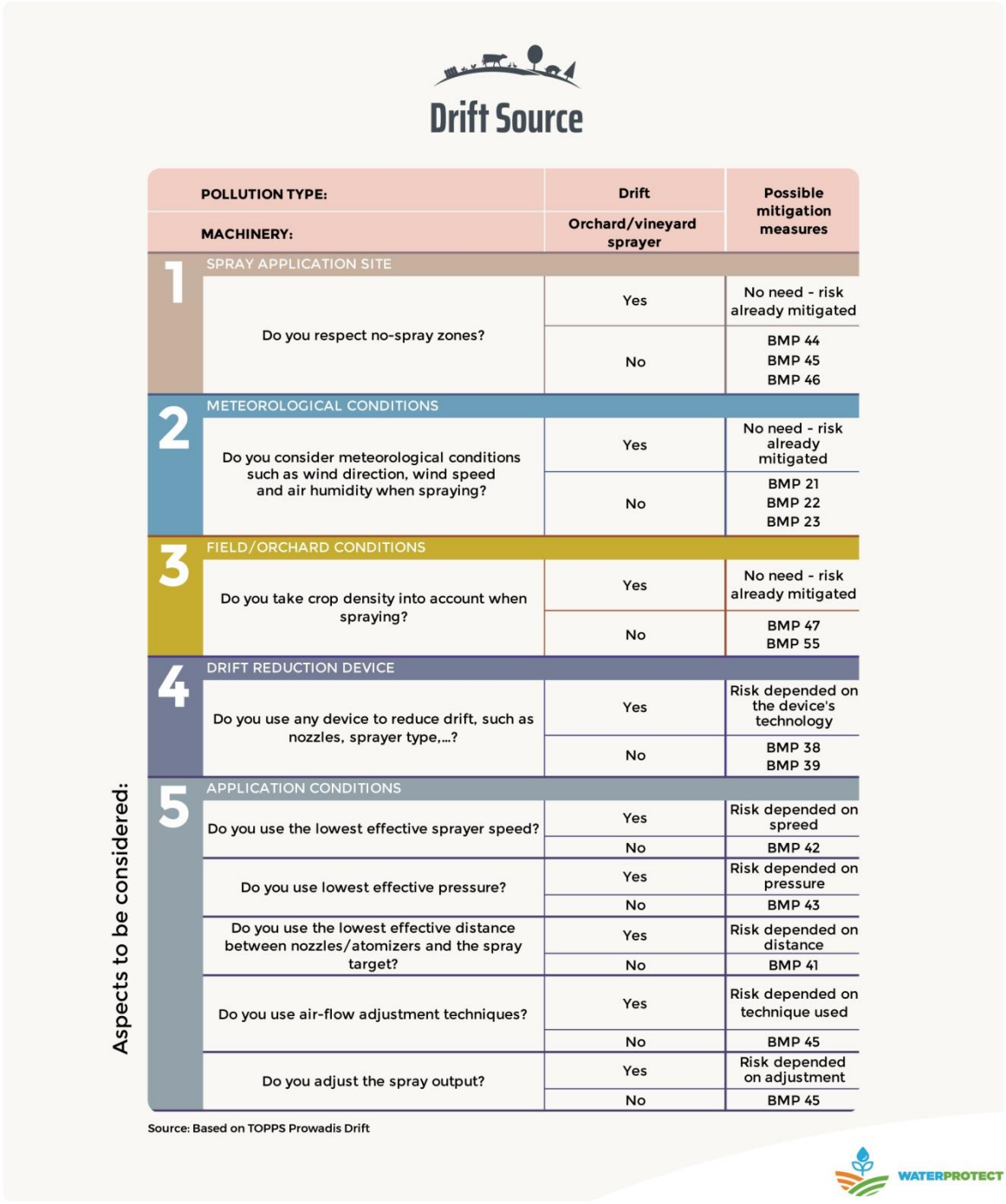
2.6 Drift source pollution





POLLUTION TYPE: / MACHINERY:		Drift: Orchard/vineyard sprayer	Possible mitigation measures
1	SPRAY APPLICATION SITE		
	Do you respect no-spray zones?	Yes	No need - risk already mitigated
		No	BMP 44 BMP 45 BMP 46
2	METEOROLOGICAL CONDITIONS		
	Do you consider meteorological conditions such as wind direction, wind speed and air humidity when spraying?	Yes	No need - risk already mitigated
		No	BMP 21 BMP 22 BMP 23
3	FIELD/ORCHARD CONDITIONS		
	Do you take crop density into account when spraying?	Yes	No need - risk already mitigated
		No	BMP 47 BMP 55
4	DRIFT REDUCTION DEVICE		
	Do you use any device to reduce drift, such as nozzles, sprayer type,...?	Yes	Risk depended on the device's technology
		No	BMP 38 BMP 39
5	APPLICATION CONDITIONS		
	Do you use the lowest effective sprayer speed?	Yes	Risk depended on spreed
		No	BMP 42
	Do you use lowest effective pressure?	Yes	Risk depended on pressure
		No	BMP 43
	Do you use the lowest effective distance between nozzles/atomizers and the spray target?	Yes	Risk depended on distance
		No	BMP 41
	Do you use air-flow adjustment techniques?	Yes	Risk depended on technique used
		No	BMP 45
	Do you adjust the spray output?	Yes	Risk depended on adjustment
		No	BMP 45

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3 Development of recommendations

Since recommendation of best management practices were made in light of physical characteristics of catchments, a short synthesis of these is presented for all action labs. Detailed characteristics can be found in deliverables D4.2 and D5.3.

3.1 Belgium – the Bollaertbeek catchment

3.1.1 Conceptual understanding of the catchment

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. Mainly arable and vegetable crops are grown in this region.

The main soil type is sandy loam (68 %), which is prone to capping and runoff and erosion of PPP due to capping. Besides sandy loam, you can find clay (10%), loam (14%), sand (1%) and antropogen (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).

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.

The main focus in the project is on reducing pesticide pollution.

3.1.2 Agricultural sector

In the Bollaertbeek area, the typical farm structure is small. The mean acres of the farms at the Bollaertbeek area is 31.4 ha. Mainly arable crops (such as corn, wheat and potatoes) and vegetables (such are cauliflowers, brussel sprouts, leeks, carrots, onions, …) are produced in the area. Some farms have crop and animal production.

3.1.3 National regulations & current BMP implementation

Regulations:

- The Belgian national action plans developed under the Directive 2009/128/EC aiming to achieve a sustainable use of pesticides in the EU.
- The 'decreet integraal waterbeleid' developed under the The Water Framework Directive.
- Directive 91/414/EEC concerning the placing of plant protection products on the market.

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Obligatory requirements:

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 sprayer operators 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.
- Maintaining the minimal grass buffer strip of 1m along water courses (BMP 44)
- Disposal of obsolete PPPs by an authorized waste collection company (BMP 29)
- Safe management of empty containers/packages, seals and caps (BMP 35),

All farmers respect these obligatory BMPs, since they are controled and not respecting these BMPs has consequences for them. The consequence depend on the legislation that requires the BMP. It may be a financial penalty or retaining a percentage of the direct payments for farmers or a withdrawal of their 'Vegaplan' or 'global gap' quality standard, which is required to market their products.

Subsidies and financial incentives:

There are already some compensations for farmers e.g. investment fund for farmers from the rural development programmes for filling and cleaning places for the sprayer (15% for filling and cleaning area at the farm and 30% for remnant purification system) and management agreements for buffer strips from the rural development programmes. However, the conditions to obtain the funding are strict and/or the fundings are relatively small. Therefore, not many farmers are really stimulated by the subsidies to take these measures.

Implementation:

Popular BMPs in Belgium are:

BMP 10: Plant cover in autumn and winter: most farmers do it, but not always on all their fields. They implement this measure since sowing cover crops is one of the measures that can be chosen by farmers to fulfil their greening obligation of 5% Ecological focus area, required to receive the greening payments of the EU. Some farmers are sowing the cover crops although they do not need the cover crops for their greening or they sow more cover crops than necessary to fulfil their greening obligations. They are convinced about the positive effects of cover crops such as the increase of OM content in the soil and to prevent run-off and erosion from their field.

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BMP 49: Improved soil management to increase the water holding capacity of the soil. This BMP results in a better yield of the cultivation, so there is a direct return of investment. It is also a very actual issue, since the 2 last summers were very dry in Belgium and the problem will probably increase.

BMP 21: Always plan and organize your spray activities. When the farmer can make a planning, PPP will be used in an optimum way and losses will be minimal (accurately calculate the required amount to use a minimum amount and have maximum effectivity of the product, order of the sprayings,...). So if weather conditions permits to make an adequate planning, farmers try to do as much as possible. By using this BMP, losses are minimal both economic (by optimising product use) and to the environment.

BMP 24: Do store sprayers safely. In Belgium, the sprayer is expensive material, so they also handle it with care and store them inside, out of rainstorms or frost.

BMP 32: Prevent overflow and foam escape during filling. Again, PPP are expensive, so the farmer has benefit that no PPP will get lost by overflow or foaming. Therefore, they all say that this is a BMP that they already follow.

Some farmers realize that they need to take action to prevent water pollution. Therefore, BMPs 30and BMP 37, Choose a safe filling and cleaning place for the spraying equipment has a big potential of implementation. Many farmers want to 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 the installation of a fully equipped cleaning and filling place is an expensive measure, which prevents farmers to take action. Some farmers also have interest in a public cleaning place for cleaning their sprayers.

BMP 50, inter-ridge bunding is already implemented by 32 farmers and has the potential to be used by 45 farmers. This is an upcoming BMP since more planting machines are equipped with devices to do inter-ridge bunding. On high erosion sensitive areas it is an obligatory BMP, but farmers also become interested to implement this measure on less erosion sensitive fields.

BMP 11, Grass buffer zones is not much implemented and has a potential to be implemented. However, this BMP causes economical/financial losses due to the loss of land. This reason withheld many farmers to implement a grass buffer strip. There are financial compensations, but farmers do not want or can use this because they find it to low or they 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.

3.1.4 Recommendations

The Belgian action lab focuses on pesticides in the Bollaertbeek. Based on the water monitoring results, we clearly see that point pollution remains an issue in the Bollaertbeek. The monitoring

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results also show runoff and erosion of pesticides. Therefore, we decided to work further to prevent these two main sources of water pollution.

By using questionnaires and the decision tree of point pollution (2.4), we found out that filling and cleaning of the sprayer are the most critical steps for point pollution. Therefore, we give recommendations and work further on BMP 30 and BMP 37: choose a save filling and cleaning place and save disposal of liquid spraying residues. Since a fully equipped cleaning and filling place is too expensive for many farmers, we try to find on cheaper solutions together with the farmers. For BMP 30 and 37, we focus on farmers having their farmyard in the catchment since the water quality in the Bollaertbeek is directly influenced if point pollution occurs on these farms.

We also try to stimulate farmers to take measures to prevent runoff and erosion of PPP. Mainly BMP 11 (grass buffer strip) and BMP 50 (interridge bunding) are promoted, since these are effective measures to be implemented to reduce runoff and erosion, and have the biggest potential to be implemented. For BMP 11, we also focus on searching for alternative fundings and better/easier conditions for funding for farmers in order to stimulate this BMP. For BMP 11 and 50, we focus on the farmers having fields with high risks of runoff and erosion of PPP (purple and red fields on Figure 1).

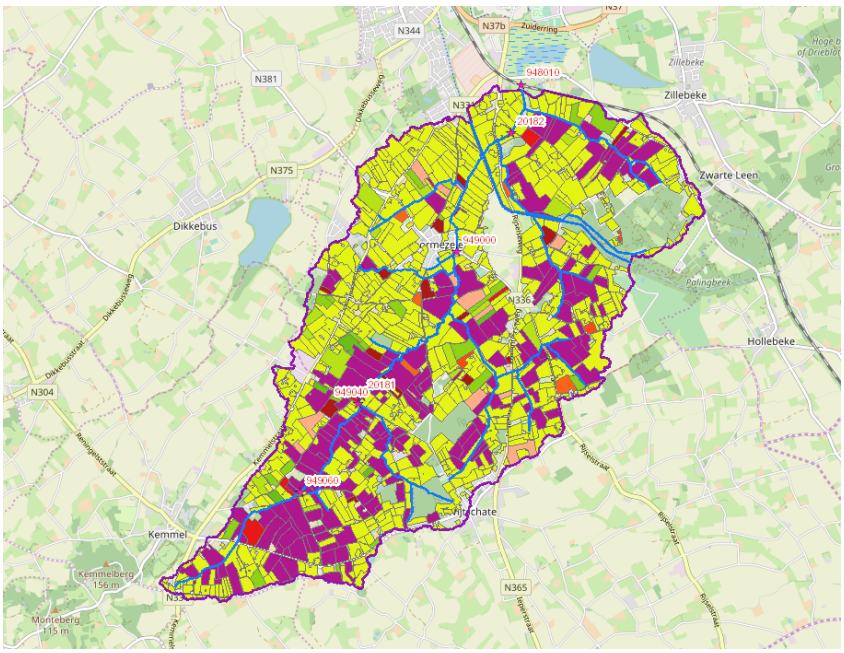

Figure 1: Risk of runoff and erosion of the fields of the Bollaertbeek catchment.

Based on our questionnaires and conversations with farmers in the Bollaertbeek catchment, we found out that there also may be some interest in mechanical weed control (BMP 75: alternatives systems to chemical fights to pest control). Therefore, we also focus on promotion of this measure.

We also put a lot of effort in further raising the awareness and upgrading farmer's knowledge by giving information (personal meetings, trainings, demonstrations) (BMP20).

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3.2 Ireland - the Ballycanew and the Castledockerell catchments

Work in the Irish Action lab is centred upon two established study catchments, Ballycanew and Castledockrell, located in the south east of the country in County Wexford (Figure 2). Both catchments have been extensively studied since 2009 as part of the on-going Teagasc Agricultural Catchments Programme (ACP). While in relative proximity, both study catchments are distinct in terms of their geological settings. These dissimilarities give rise to important differences in terms of agricultural land use and hence contaminant types and sources.

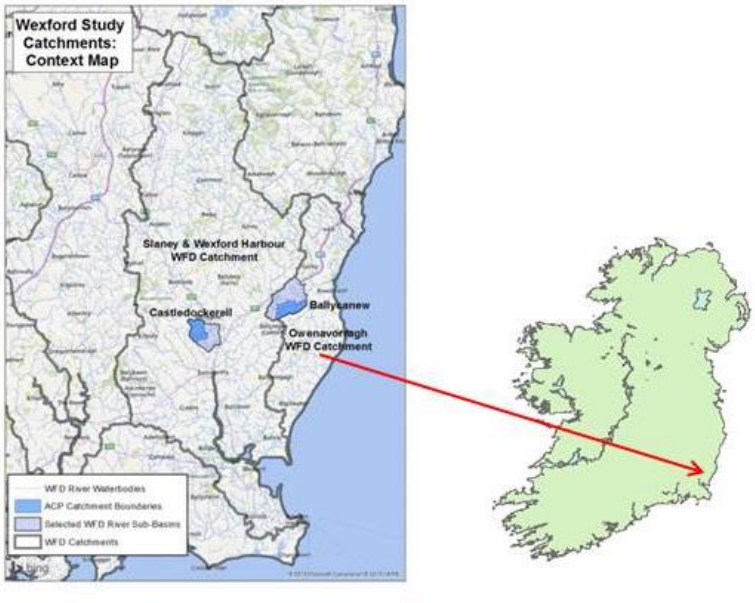

Figure 2 Context maps of the two study catchments Ballycanew and Castledockerell placed within the larger Water Framework Directive catchments Slaney/Wexford Harbour and Owenavoragh, County Wexford

3.2.1 Conceptual understanding of the catchment

Ballycanew Catchment

The Ballycanew catchment is located north of the village of Ballycanew, near Gorey in Co. Wexford. The catchment is 11.9 km^2 and drained by a 2nd Strahler order stream draining in an easterly direction and has an altitudinal range of 25 – 230 m a.s.l. Thirty-seven per cent of the land has slopes greater than 5% (mostly within the south and south-west of the catchment).

The catchment is dominated by agricultural land with 77% grassland and 20% arable land. The main farm enterprises are beef and dairying (mean livestock unit of 1.28 ha^{-1}) and spring barley as the main tillage crop. The average organic N and P loading was 88 and 13 kg ha^{-1} yr^{-1} respectively based on livestock numbers in 2014. The chemical N loading is estimated to be 132 kg ha^{-1} yr^{-1} (average 2010-2013). Herbicides, MCPA in particular, are used for weed control on the poorly drained and

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wet fields in the lowlands. Pesticides and herbicides are also used for crop production in the uplands.

County Wexford has a cool maritime temperate climate with an annual mean temperature of 10.6°C (mean daily max 13.1°C and mean daily min 8.1°C) and a mean annual total rainfall of 906 mm (Met Éireann, Rosslare, 1978-2007 average). The mean annual total rainfall monitored within the Ballycanew catchment is 1031 mm and the mean annual total potential evapotranspiration is 547 mm, leading to a net rainfall of 484 mm (Oct 2010 – Oct 2017). The hydrology is "flashy" (high ratio of storm flow to base flow magnitudes) due to soil sensitivity to surface runoff and quick shifts in weather. Of the total annual rainfall 46% contributes to the river discharge and only 1% to deeper storage. In some years there is a negative storage. The flow regime is 'flashy' indicating large surface runoff contributions. The large fraction of poorly drained soils, with drainage, present in this catchment likely indicates that annual soil water storage is small.

The geology of Ballycanew catchment consists of rhyolitic volcanic and grey/black slates of the Campile formation. A number of northwest-southwest trending foldings and faults are present in the catchment. Two main soil associations are found, the Macamore and the Clonroche. The poorly drained Macamore soils are found across most of the catchment in the lowlands. These consist of thick gravelly clay deposits and some lenses of more sandy or gravelly material closer to the surface. There are some localised zones of gravel rich material. Well drained Clonroche soils are found in the uplands, southeast of the catchment. Below these is strong rock and zones of highly to moderately weathered rock. There may also be weathering of different rock types. Typically rock/weathered rock is found close to the surface. Clay-rich zones within the rock or increased amounts of weathering products may also occur. Where the two soils meet, in the break of the slope, there is a spring line. Belowground water transport pathways are likely to be concentrated through high permeability layers (i.e. gravel or weathered rock) or along the contact between different layer types.

The transfer pathways of contaminants in the catchment are highly reflective of the distribution of the two dominant soils in the catchment. The lowland of this catchment is dominated by surface water gleys, mostly belonging to the Kilrush and Macamore soil series. These soils are derived from end-morainic and marine deposits of heavy muds giving them poor drainage characteristics. The drainage in this area has been improved somewhat by the owners through tile and mole drainage. The soils on the elevated land to the southern catchment boundary are well drained non calcarious brown earths over slate and shale geology.

Drinking water sources are under pressure by nutrients from inorganic/organic fertilisers as well as point sources (e.g. farmyards and DWWTS), pesticides and metabolites from weed control and crop production, and microbials and emerging organic contaminants from organic fertilisers and DWWTS. Based on the type of soil and subsoil in this catchment the main pathway for herbicide loss (mostly MCPA for weed control) would be through direct transport in lateral and vertical pathways (MCPA has a low sorption affinity with soil) and erosive overland flow during heavy rain

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events with a relatively short transit time. The most vulnerable time would be in spring and also autumn, after application to suppress rush (*Juncus* spp.) on grassland and during frequently occurring large rain events. Since the grasslands have been extensively improved by artificial drainage, other important quick flow pathways of MCPA to the river are via tile drains and ditches. Herbicides, and MCPA in particular, is commonly used in the area and poses a potential threat to drinking water due to its properties of being highly mobile, soluble and with a low soil sorption capacity. The soil type and structure, subsoil geology, pH of the soil, soil microbial community, soil moisture, pesticide application mode and application timing are all factors determining the fate and movement of pesticides. MCPA may also be leached to groundwater in the well-drained soils of the uplands especially where herbicide decay rates are slowed in anaerobic strata. The water recharged in the uplands that does not emerge in springs, where the well-drained soils meet the poorly drained soils, will move in the fissured rhyolite and slate under the thick confining clay layer in the lowlands. This conceptualization was strengthened by an artesian monitoring well consisting of a piezometer screening the weathered rock below the clay layer at 12 m where pesticide metabolites have been detected (McManus et al. 2017). There is also a risk of N loss through leaching on the more freely drained soils to the west and covering approximately one third of the catchment. However, by the time water has emerged along the spring-line, or below the confining clay layer, this nitrate will be largely denitrified. While both MCPA and nitrate in the lowlands may leach to the perched shallow groundwater, on top of the clay layer, the confined groundwater is effectively protected. Contaminants in this lowland perched groundwater may slowly transfer to the river via interflow pathways after rain events have elevated the hydrological gradient, or quickly via the improved drain network.

In summary, Ballycanew catchment has intensively managed grassland on mostly poorly drained soils. There are risks of nitrate and MCPA leaching to groundwater in the upland area with well drained soils which may be transferred to potable water in the confined groundwater of the lowland, or discharged via springs feeding the river. Nitrate is largely denitrified along the transfer to the river. The hydrology is “flashy” with a large component of temporal quick and erosive surface pathways connecting a large proportion of land. An extensive ditch and subsurface drainage network increases the hydrological connectivity all year round. These pathways have a large potential in quickly and temporarily transferring MCPA to the river.

Castledockerell Catchment

The Castledockerell catchment is situated between Enniscorthy and Bunclody in Co. Wexford. The catchment is 11.2 km^2 and drained by a 3rd Strahler order stream in an easterly direction and has an altitudinal range of 20 – 210 m a.s.l. Eighteen per cent of the land has slopes greater than 5% (mostly in the north-west of the catchment).

The catchment is dominated by agricultural land with 39% grassland and 54% arable land. The arable land is mostly used for spring barley production, while beef, sheep and some dairy production are the main grass-based enterprises. The average organic N and P loading was 34 and 5 kg ha^{-1} yr^{-1} respectively based on livestock numbers in 2014. The chemical N- loading is estimated

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at 155 kg ha^{-1} yr^{-1} (2010-2013 average). Pesticides including herbicides and fungicides are used during crop production.

The mean annual total rainfall within the catchment is 990 mm and the mean annual total potential evapotranspiration is 548 mm, leading to an annual net rainfall of 442 mm (2010 – 2017). Of the total annual rainfall 50% contributes to the river discharge and the storage was -5%. Discharge is mostly generated by groundwater in the thick layers of highly permeable weathered slate on top of competent slate. Here, there is a consistent small surplus in the annual water balance, indicating that regional groundwater may contribute additional flow to the catchment outlet. This catchment has a higher runoff coefficient and 11% more runoff than the Ballycanew catchment owing to its considerably higher baseflow contribution.

In the Castldockerell catchment the high ground to the north-west is typically overlain by the Black Rock Mountain soil association (loamy over gneiss and schist bedrock). The bedrock is Ordovician slate and silt stone of the Oakland formation. The soils/sub-soils consists of gravelly clay and gravel. The bedrock varies in strength from highly weathered rock to very strong rock. Water and contaminant transfer pathways are likely to be concentrated through the high permeability layers (i.e. gravel or weathered rock) or along the contact between different layer types. The water contribution from the unconfined aquifer is poor. However, the stratified zones of highly weathered and fissured rock connect groundwater to the river with relatively quick responses to rainfall.

The stream that drains the catchment is a tributary of the Slaney River which drains much of the south-east region. The majority of the land in the catchment has free draining typical brown earth soils, belonging to the Ballylanders and Clonroche Soil Series. These soils which are underlain by slate and shale geology are ideal for spring barley growing. In the low lying areas near the stream there are some poorly-drained groundwater gley soils most of which are artificially drained.

Drinking water sources in the catchment are also under pressure by nutrients from inorganic/organic fertilisers as well as point sources (e.g. farmyards and DWWTS), pesticides, herbicides and metabolites mainly from the crop production, and microbials and emerging organic contaminants from organic fertilisers and DWWTS. There is a small waste water treatment plant serving up to 75 people, with the remaining catchment population (ca. 208) using domestic wastewater treatment systems. Nitrogen is the main nutrient at risk of loss from this catchment throughout the year. This is mostly via leaching in the freely drained soils and with relatively little denitrification along the transfer pathways to the groundwater and river due to high hydrological conductivity in the dominating pathways (Mellander et al. 2012; 2014). There is also a risk of MCPA loss through leaching on the freely draining soils across the catchments. The dominant flow pathways contributing to river discharge are expected to be subsurface within the layers of permeable weathered rock with a relatively low hydrological and chemical buffering capacity. Stream water dynamics and quality are thus highly reflective of groundwater conditions. In winter there is usually a low soil moisture deficit and large rain events will produce substantial quick surface flow pathways.

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In summary, the Castledockerell catchment has intensively managed arable land underlain by well drained soils. There are risks of nitrate and MCPA leaching to potable groundwater and which may be transferred, with little attenuation, to the river. The river is mostly groundwater-driven with relatively quick belowground pathways within highly permeable layers of weathered slate bedrock. During large rain events, mostly occurring in autumn and winter, there is also a large influence of quick surface pathways connecting a large proportion of land in winter when soils are saturated.

3.2.2 Agricultural sector

In Ireland there are 128,000 farm holdings that use 56% of the total land area for agriculture. Of this land 81% is used for pasture, hay and grass silage. Farms are typically small with an average size of 32.5ha

Ballycanew catchment is dominated by grassland with the main grassland-based farm enterprises being beef production and dairying with some sheep production and sport horses. Spring barley is the main tillage crop with small areas of other cereals mainly in the uplands with well drained soils.

Castledockerell catchment is dominated by arable land with spring barley production being the main tillage enterprise with some other cereals such as winter barley, as well as some oil-seed rape and beet. Sheep production is traditional in the area and is still carried on by many farmers as well as beef production.

3.2.3 National regulations & current BMP implementation

Current management practices in Ireland concerning the protection of water against pollution caused by nutrients and pesticides from agricultural source can be grouped into one of the following three categories:

1. Mandatory / obligatory requirements
2. Financially incentivised optional measures
3. Knowledge Transfer / advisory service

1. Mandatory / obligatory requirements

Mandatory requirements are covered by the Cross Compliance system which must be complied with to receive a payment under the Basic Payment Scheme (BPS). Cross Compliance is implemented under two main areas *Statutory Management Requirements* and *Good Agricultural & Environmental Condition*.

Statutory Management Requirements (SMRs)

These SMRs refer to 13 legislative requirements in the field of environment, food safety, animal and plant health and animal welfare. Two of these requirements are relevant to water pollution: SMR 1 – Protection of water against pollution caused by nitrates (the Nitrates Directive) and SMR 10 – Plant Protection Products (the Sustainable Use of Pesticides Directive).

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SMR 1 – Protection of water against pollution caused by nitrates (the Nitrates Directive): BMP's covered by SMR 1 relate to farmyard and fertiliser management and include:

Farmyard Management

Divert all clean water to a clean water outfall

Prevent clean water from becoming soiled

Minimise the amount of soiled water that is produced on the holding

Collect and manage all organic fertilisers, effluents and soiled waters in a way that will prevent runoff or seepage, directly or indirectly, into ground waters or surface waters

You must have adequate storage capacity for organic fertilisers depending on the zone in which your holding resides i.e. 16, 18, 20 or 22 weeks

You must not store farmyard manure on land during the prohibited spreading period

You must not store silage bales within 20m of water where effluent collection facilities are not in place

You must not use supplementary feeding points within 20m of waters or on bare rock

You must not use or create sacrifice areas i.e. areas where livestock are kept on during the winter period to "save the rest of the land"

Managing the Spreading of Fertilisers

The total amount of livestock manure applied to your land in a calendar year must not contain more than 170 kg of nitrogen per hectare

If you farm above the 170kg limit to a maximum of 250kg limit you have to apply for a Nitrates Derogation which requires the farmer to carry out extra actions. (see link below for Derogation requirements)

You must keep within the overall maximum fertilisation rate for N & P on the holding (organic and chemical combined)

You must not spread fertilisers during the prohibited spreading period

You must not use an upward-facing splash plate for spreading organic fertiliser

You must not spread organic fertilisers or soiled water from a road or passageway

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You must not spread chemical fertilisers, livestock manure, soiled water or other organic fertilisers when: i) the land is waterlogged, ii) the land is flooded, or it is likely to flood, iii) the land is frozen, or covered with snow, or iv) heavy rain is forecast within 48 hours

You must not spread chemical fertilisers, livestock manure, soiled water or other organic fertilisers if the ground has a steep slope (> 10%)

You must not spread chemical fertiliser on land within 2 metres of surface waters

You must not spread soiled water, effluents, farmyard manures or other organic fertilisers inside different buffer zones (5 to 200m depending on the kind of water body).

Ploughing and Green Cover

Where arable land is ploughed between 1st July and 30th November, take the necessary measures to have green cover from a sown crop within 6 weeks of ploughing

Where grassland is ploughed between 1st July and 15th October, have green cover from a sown crop by 1st November

After applying a non-selective herbicide to arable land, or to grassland in the period between 1st July and 30th November, take the necessary measures to provide for the emergence within 6 weeks of the application, of green cover from a sown crop or from natural regeneration

You must not plough grassland between 16th October and 30th November

You must not remove green cover before 1st December once it is sown

You must not plough or cultivate for non-grass crops within 2m of a watercourse

SMR 10 Plant Protection Products (Pesticides): BMP's covered by SMR 10 seek to ensure that where pesticides are used, this use is necessary, and that they are used in a manner that minimises risk to the user, the environment and the food chain.

All pesticides purchased and used must be registered with the Pesticide Control Division (PCD) of Department of Agriculture Food & the Marine.

Any person who applies pesticides must be deemed to be appropriately trained.

You must ensure application equipment is fit for purpose and has been properly calibrated within the previous 12 months

A dedicated storage facilities (chemical store) must exist and: i) have a warning sign affixed at the entrance to the store, ii) be secure, lockable, and capable of containing spillages (bunded), iii) products must be stored in original containers with labels attached, and iv) facilities to clean-up spills must be available e.g. sand/peat

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Appropriate measuring equipment designated solely for weighing/measuring pesticide products must exist

You must comply with the buffer zones as specified on the product label e.g. buffer zone of 5m from a watercourse when using any MCPA product

You must not fill any sprayer directly from a watercourse.

Optimal practice in the use of each PPP requires:

Correct choice of active substance

Selecting the appropriate application rate

Number, timing and frequency of applications

Method of application

Strategies to reduce spray drift

Resistance management.

The objective is to minimise residue risk and reduce operator exposure. Safe usage takes account of occupational and public health, animal and environmental considerations.

Good Agricultural and Environmental Condition (GAEC)

This obligation of keeping land in good agricultural and environmental condition refers to a range of standards related to soil, the protection and maintenance of soil organic matter, avoiding the deterioration of habitats and water protection. While protecting water against pollution may not be the primary objective of the seven GAEC standards, they all can have a positive impact on water quality. All seven standards are outlined here:

GAEC 1 – Establishment of Buffer Strips along Watercourses (There are no additional requirements to SMR 1 described above for this GAEC)

GAEC 2 – Where the use of Water Irrigation is subject to authorisation, compliance with authorisation procedures (not applicable in Ireland)

GAEC 3 – Protection of Ground Water against Pollution, in which you must ensure that:

Agri-chemical stores are sited well away from drains, waterways and drinking water supplies

Pesticides are stored in marked secure cabinets, sufficiently bunded to contain the volume of pesticide stored in them

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Any spillages cannot escape to ground waters through drains, soak ways, wells, boreholes and watercourses

Fuel tanks are correctly located and maintained with no evidence of discharge.

Waste oils and old batteries are properly disposed of

Sheep dipping tanks are of sound construction and have no outlet pipe or valve at the base of the tank

Sheep dipping tanks are empty and securely covered when not in use

GAEC 4 – Minimum Soil Cover. You must avoid leaving land bare and without any cover on the soil for prolonged periods of time (maximum period of four months) and have sufficient green cover within 6 weeks where land has been ploughed (in accordance with SMR 1-Nitrates requirements). The aim of this GAEC standard is to protect soil from erosion.

GAEC 5 – Minimum Land Management Reflecting Site Specific Conditions to Limit Erosion. You must limit soil erosion by:

Using appropriate cropping practices and cropping structures

Managing livestock to ensure overgrazing and poaching does not occur e.g. move feeders regularly and do not have sacrifice paddocks/fields

Using suitable machinery, vehicles and trailers and avoid damaging soil structure in unfavourable weather conditions which can lead to soil erosion

GAEC 6 – Maintenance of Soil Organic Matter Levels through appropriate practices. Burning of stubble or crop residues such as straw is not permitted

GAEC 7 – Retention of Landscape Features and Designated Habitats and Controlling Invasive Species . Hedgerows, drains and / or ditches may only be removed if an equivalent length replacement is put in place in advance of the removal.

For more detailed information on cross compliance requirements please see: https://www.agriculture.gov.ie/media/migration/farmingschemesandpayments/crosscompliance/CrossComplianceHandbook130916.pdf

2. Financially incentivised optional measures

GLAS is an agri-environment scheme that first opened in Februrary 2015. It is co-funded by the EU and the Irish government and is administered by the Department of Agriculture, Food and the Marine. This scheme is focused on the rural environment, in particular on the preservation of various habitats and species, mitigating climate change and improving water quality.

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The acronym GLAS stands for Green Low-Carbon Agri-Environment Scheme and means "green" in the Irish language. Farmers that take part in the scheme must complete a number of core requirements which include:

Using a qualified agricultural advisor prepare the plan

Complete a Nutrient Management Plan with soil samples

Attend a relevant training course

Keep records of activities undertaken

In addition to the core requirements above, applicants must also choose actions that they will undertake from a menu of 24 topics. Acceptance into the scheme is not guaranteed and selection of successful applicants is determined by the actions chosen. If successful, the rate of payment received is also determined by the actions chosen. The GLAS actions listed below are those that have a beneficial impact on water quality:

Arable Grass Margins: The establishment of a 3, 4 or 6 metre arable grass margin along the full length of an existing field boundary in order to increase the diversity on the farm. Where established along a watercourse it acts as a buffer zone to intercept sediment and nutrients. Fertiliser, pesticides or lime cannot be applied to the margin.

Catch Crops: A catch crop will absorb nutrients and prevent leaching in the autumn/winter period. The primary aim for catch crops is for soil protection during fallow periods over the winter period. There is a reduction in soil erosion during heavy rainfall periods from reduced surface run-off and increased water infiltration. While protecting soil against exposure to the elements with foliage, cover crop roots break and condition the soil preventing slumping, thus ensuring easier cultivations and better soil tilth the following spring. Depending on the species, catch crops increase the absorption of residual nitrogen and reduce nitrogen leachate from soil. The catch crop must be sown annually by the 15th September, using light cultivation techniques and remain in situ until the 1st of December.

Environmental Management of Fallow Land: While the main objective of this action is to provide food and habitat for ground nesting birds, other fauna and insects throughout the nesting season, it also benefits water quality as fertiliser and pesticides are not permitted and livestock must be excluded. When located adjacent to water bodies, this measure provides a buffer area. Strategic location of this action can have a very beneficial impact on water.

Farmland Habitat (Private Natura): Farmers must avoid farming practices that cause environmental damage and protect vulnerable designated habitats such as wetlands, which in turn helps to safeguard animals and plants which occupy them. The practices required vary depending on the type of habitat.

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Low Emission Slurry Spreading: While the main objective of this action is to improve the recycling of organic fertiliser and to contribute to reduced nitrous oxide emissions, ammonia emissions and odours, low emission slurry spreading equipment facilitates the application of slurry on grazing pastures. This allows farmers to apply slurry during the grazing season, which generally takes place when ground conditions are good (higher soil moisture deficit). This significantly reduces the risk of phosphorous run off.

Low Input Permanent Pasture: The main objective of this action is to promote a grassland management system that, through appropriate grazing levels and restriction on fertiliser and pesticide use, results in a more diverse sward with an increase in flora and fauna. The restriction on fertiliser and pesticide use will also benefit water quality.

Minimum Tillage: Minimum tillage means sowing a crop without inverting the soil i.e. the soil cannot be ploughed. It reduces damage done to soil by rain, the breakdown of soil structure and reduces the formation of a hard pan in the soil. The resulting improvement in soil structure will benefit water quality.

Protection of Watercourses from Bovines: Livestock grazing along a watercourse can lead to direct pollution of water with urine and faeces which could mean pathogens entering the water. Excluding bovines from watercourses will prevent the breakdown of vegetation on the banks of the watercourse, resulting in less sediment. It will also prevent pollution of the watercourse from bovines. Participants must fence off all watercourse(s) a minimum of 1.5 metres from the top of the bank to exclude all bovines.

Riparian Margins: This action is very similar to the "Protection of Watercourses from Bovines" action described immediately above. The main difference is that the riparian margin should be 3, 6, 10 or 30 metres wide. Riparian margins will stabilise riverbanks and intercept nutrients transported in overland flow.

Traditional Hay Meadow: The main objective of this action is to promote the maintenance of traditional methods of forage conservation that is beneficial to grassland flora and fauna. The restriction on fertiliser and pesticide use will also benefit water quality.

Wild Bird Cover: While the main objective of this action is to provide a food source and winter cover for farmland birds and other fauna, the restriction on fertiliser and pesticide use will also benefit water quality. As the crop is not harvested and must remain in situ until the 15th of March, this action will protect soil against exposure to the elements with foliage during the winter months.

3. Knowledge Transfer / advisory service

An agricultural advisor is available to farmers with land in the two catchment areas of the project outlined above. This advisor is funded by the Department of Agriculture, Food and the Marine through the *Agricultural Catchment Programme* (ACP) and is available free of charge to the 80 farmers involved with the two catchments. While the advisor provides a general agricultural

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advisory service, he would have an expertise in nutrient management planning and water pollution as a result of working in the Agricultural Catchments Programme. The ACP advisors work closely with researchers within the programme. The researchers investigate nutrients using the "nutrient transfer continuum" as a conceptual framework, i.e. in soil sources, via mobilization and transfer pathways, and to delivery in water. This provides a greater level of understanding of water pollution than a typical agricultural advisor would have. The availability of this advisory service over the past ten years has had a significant impact on nutrient management planning and farmyard management. It has been considered successful in mitigating against water pollution and has partly supported the establishment of the *Agricultural Sustainability Support and Advisory Programme* (ASSAP).

The ASSAP is a new government/industry collaborative initiative running from 2018 to 2021. The programme offers a free support and advisory service from 20 Teagasc and 10 Dairy Co-op advisors. The aim is to improve water quality through working with farmers and participation is voluntary. The ASSAP advisors are available in 190 catchments or 'areas for action' where the water status is considered at risk of reaching WFD objectives. These are located throughout Ireland covering all soil types and farming enterprise. These can be viewed on www.catchments.ie

Under the Water Framework Directive Ireland has been set a target of achieving 'good status' for all waters in Ireland. Water quality has remained static in the last number of years despite the huge investment made by the state and by private industry including farmers. This initiative is part of a new national approach which encompasses the whole community and aims to work with all sections of society to improve water quality in Ireland for all our benefit.

The ASSAP is designed to work closely with the farming community in each catchment. Scientists from the Local Authority Catchment Assessment Teams assess the streams and the ASSAP advisors follow up by working closely with farmers providing them with a free and confidential advisory service. Farmers can avail of this service within the 'areas for action' on a voluntary basis.

The ASSAP will provide three main services on farms: i) Improved nutrient management with more targeted use of slurry and fertilizer, ii) New approaches to land management to reduce nutrient losses in critical source areas, and iii) Better farmyard management and practices.

At the end of a visit the advisor and farmer will agree on where the farmer should focus improvements or actions, if any are required, on his farm. The practical advice will be designed to 'break the pathway' and prevent nutrients from entering water. All interactions between farmer and advisor are completely confidential and non-regulatory. The role of the advisor is to provide support and advice to the farmer.

The ASSAP is a collaborative programme with funding and support received from the DAFM, DHPLG and Dairy Sustainability Ireland. Support from all the farming organisations for the programme has been very strong and this is vital when communicating and informing farmers about the ASSAP programme and its key messages.

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3.2.4 Recommendations

Drinking water sources in both catchments are vulnerable to contamination from microorganisms, nutrients (from inorganic/organic fertilisers as well as point sources such as farmyards and domestic wastewater treatment systems), pesticides and metabolites from crop production and emerging organic contaminants. However, the distinct hydrogeological settings have not only greatly influence contaminant transfer pathways but have also led to different farming practices in each location. As a result of these different transfer pathways and farming enterprises there is a significant contrast in which BMP's are most effective in each catchment.

Ballycanew Catchment

In this catchment there are risks of nitrate and pesticide leaching to groundwater in this upland area which may be transferred to potable water in the lowland, or discharged to the river. Nitrate is, however, largely denitrified along pathway. Due to the poorly permeable nature of the lowland areas the hydrology is "flashy" with a large component of quick and erosive surface runoff. An extensive artificial drainage network further increases the hydrological connectivity. Acid herbicides, and MCPA in particular, are of concern due to its use in controlling rushes, which are typical of the poorly drained soils, and secondly due to its highly mobile and soluble nature. It is likely that the weed controlling herbicide MCPA will have episodic loss to water via quick surface pathways during rain events. However, MCPA has a long half-life in anaerobic conditions giving rise to a potential for legacy stores in susceptible catchments. With this in mind, the timing and location of fertilizer and weed control applications would be of greater significance than curtailing the quantity applied over the year.

Advice on the timing, choice and location of the BMP is very important and best provided by someone that understands the pathway's transporting pollutants in this catchment. For this reason an advisory service collaborating with scientists is most important to maximise the effectiveness of the BMP's. Effective BMP's include:

- BMP 6: Avoiding spreading during high risk times and on high risk areas. The use of GPS would be useful.
- BMP 1/ BMP 64: Nutrient management plan/soil analysis
- BMP 57: Professional support in selection and practice of appropriate pesticides (demonstrations of best management when handling pesticides)
- BMP 23: Only use approved PPP and comply with all their conditions of use
- BMP 15: Adequate covered storage of organic manures
- BMP 22: Do not spread fertilisers/pesticides when heavy rain is forecasted
- BMP 11: Buffer zones on targeted delivery points along watercourses
- BMP 10: Winter cover crops
- BMP 12: Water ponds and wetlands
- BMP 78: Fallow land

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Castledockerell Catchment

In this catchment nitrogen is the main nutrient at risk of loss from the catchment. This is mostly via leaching in the freely drained soils and with relatively little denitrification along the transfer pathways to the groundwater and river due to highly permeable geology in the dominating belowground pathways. There is also a risk of pesticide loss through leaching across the catchment. Buffer strips would not be effective in this scenario. Any action that would improve the efficiency of Nitrogen fertiliser should be considered.

Effective BMP's include:

- BMP 1/ BMP 64: Nutrient management plan/soil analysis
- BMP 3: Soil liming for optimal pH
- BMP 10: Plant cover in autumn and winter
- BMP 11: Buffer zones on targeted surface delivery points along watercourses
- BMP 6: Avoiding spreading of chemical fertilisers and manure during high risk times and on high risk areas. The use of GPS would be useful.
- BMP 57: Professional support in selection and practice of appropriate pesticides (demonstrations of best management when handling pesticides)
- BMP 23: Only use approved PPP and comply with all their conditions of use

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3.3 Italy - the Val Tidone catchment

3.3.1 Conceptual understanding of the catchment

The Italian Action Lab is in the Tidone Valley and covers part of Tidone Torrent catchment and the catchments of the two streams Lora-Garogna and Carona- Boriacco for an area of 206.72 km^2. Tidone Valley is located 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 zone characterized by an elevation level between 100 and 350 above sea level. The soil lithology is given by the geological surface map (geo250. shape) and is formed by: 57.67% marls, shales and limestone, 17.95 % gravel, sand, silt and clayey silt- unselected alluvial deposits, 9.40 % sandstone and shales, 4.74 % silt and clayey silt- fan and terrace deposits, 4.28 % clay, shale and clayey breccia, marl, sandstone and ophiolite, 3.60 % gravel and sand- fan and terrace deposits, 2,35 % clay and marl.

The surface and ground water are used for drinking water, agricultural, zootechnical and industrial sectors.

The direction of the groundwater flow is from SW to NE, following the direction of all tributaries of the right hydrographic bank of Po River. The entire area of the Italian Action Lab is considered with a low level of intrinsic vulnerability. However, at regional level, the area under investigation is partially under the zone sensitive to nitrates. Concerning the sensitivity to pesticides, the regional map is under development. Therefore, no information for our zone is available.

The inhabitants of the rural villages are mainly involved in grape and wine production, organised as private farms or as social wineries.

3.3.2 Agricultural sector

The main culture is the vineyard, with 2941 ha in 2016.

The grape and wine production in the Tidone Valley is of a high quality, with several DOC, DOP and IGP certifications for the products and with a positive economic remuneration for all population categories. Furthermore, the high wine and grape quality production determinate an increase of the quality of the infrastructure management and the protection of the surrounding environment.

Two types of farm structure are present:

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

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

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There are 455 farms in the catchment with an average surface area of 6.5 ha.

175 farmers (38% of the total) 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.

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 ancestral 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.

3.3.3 National regulations & current BMP implementation

Regulations:

- DLGS 150/2012 – receipt of Directive 2009/128/EC to achieve the sustainable use of Pesticides with National Action Plan established with the national decree of 22/01/2014
- DLGS 30/2009 – receipt of Directive 2006/118/CE to prevent and control groundwater pollution
- Directive 2000/60/EC, Part III of Legislative Decree No 152 of 3 April 2006 as amended and supplemented

Obligatory requremenets:

Training and certificate of competence is compulsory for pesticide users/distributors and consultant (BMP 20) and only approved PPPs could be use (BMP23).

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 (BMP25 and 26).

Transport can be made directly by the supplier (preferred option) or by the farmer. In both cases it is important to take all necessary precautions in compliance with current regulations. In addition to the provisions of the Highway Code, the transport of hazardous substances is further regulated by the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR, Geneva September 30, 1957) and subsequent updates and relevant national laws (BMP27).

Storage of pesticides in appropriate places within lockable rooms/containers or cupboards and proper disposal of containers and obsolete product (BMPs 28 29 and 35) are compulsory. By 1st January 2015 all professional users were asked to comply with provisions of Annex VI of the Italian National Action Plan.

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A buffer strip is compulsory in Italy if indicated on the label (BMP 44).

Failure to comply with the aforementioned BMPs could result in the revocation or suspension of the certificate of competence and therefore the authorization to the use, and sanctions.

Other proposed BMPs, included in the project and aimed to limit the point sources contamination, are specific subjects of the compulsory training of professional users, distributors and consultants set out in Annex I of the Italian National Action Plan.

In detail the most relevant are: BMP 21 - Always plan and organize your spray activities; BMP 24 - Do store sprayers safely; BMP 30 - Choose a safe filling and cleaning place for the spraying equipment; BMP 31 - Be prepared for and manage spills safely; BMP 32 - Prevent overflow and foam escape during filling; BMP 33 - Rectify/Adjust any equipment problem immediately; BMP 34 - Adequate cleaning of sprayers to minimize the amount of spray remnants.

These measures are partially respected but their control is difficult as their compliance depends on behavioral factors.

To protect the aquatic environment and drinking water, according to the Italian National Action Plan the Regions and the Autonomous Provinces shall put in place specific measures.

Possible measures may include: a set of mitigation measures aimed to reduce pesticide drift and run off, replacement / use limitation / elimination of pesticides, and information and training initiatives. The choice shall be made by the Regions and Autonomous Provinces having due regard to the characteristics of the area and its fragility, the type of pressures present and expected type of response, and to the ecosystems to be protected. An inventory of the risk mitigation tools for pesticides being implemented is reported in the recent work (2017) of Commissione Consultiva Fitofarmaci on the basis of the work done by Allix et al in the framework of MagPie project.

As for point sources pollution, BMPs aimed to limits the diffuse contamination proposed in the project (from 38 to 48) are set as specific subject of the training programs. Are not compulsory but suggested as good management practice.

The following BMPs that are compulsory by low are implemented in our pilot area:

- A buffer strip of size (width) not less than 5 meters and not more than 15 meters is applied. (BMP 44). In addition, the Vegetated filter strip (VFS) at edge-of-field (BMP 65) is applied in 52% of farms, to reduce or control diffuse run off also if in some cases it is used for passage of vehicles (inaccurate knowledge) or it was already present as hydraulic arrangements.
- Vegetated ditches are present in 78% of farms and are considered effective in containing runoff (BMP 55).
- In general, technical devices for drift reduction and special equipment to reduce spray drift are considered effective in reducing drift exposure (BMP 38 and 40).

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- Inter-row processing and weeding on the row, and permanent grassing in the inter row and weeding on the row (BMP 67,68) are applied to control weed.
- Nutrient soils analysis for pH, macro elements, organic matters and C/N, correlates to the fertilization planning (BMP 64) are performed.

Subsidies and financial incentives:

Depending on regional Rural Development Plans (RDP) some BMPs could be supported or partially financed. Several measure of the 2014-2020 RDP programme (as Measure 10-11 and 4) can contribute achieving the objectives of the NAP through the involvement of beneficiary farmers for the sustainable use of plant protection products.

Implementation:

Proper Pesticide storage (BMP 28) and handling and 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 (BMPs 35-36-37). The use of Biopurification systems to treat the pesticides containing water coming from sprayers internal and external washes is of great interest but in Italy is limited as a specific environmental impact authorization is required.

Dedicated area for mixing and filling the sprayers (BMPs 30 and 34) are not so common in our lab. Actions supporting farms to upgrade or create equipped product mixing areas and for filling the sprayer could be of interest.

The adoption of vertical barriers to intercept the drift (hedges, trees, artificial windbreak), in addition to buffer zones, to manage spray drift generated by sprayers (BMP 47) is of interest. Indeed 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.

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….) (BMPs 22-38-39-41-42-43-45-81).

Soil analysis can be implemented without generation of any/excessive costs (BMP64) as optimization of irrigation timing and rate (BMP 56).

3.3.4 Recommendations

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

The BMPs identified as most effectiveness are BMP 30, 34 and 35. Indeed, after the examination of territorial characteristics, agricultural techniques and farmer's behavior, and the preliminary result

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of water monitoring, we identify **the management of pesticides in farms as a critical issue**, with high contribution to groundwater contamination in the area.

In details we identify as **the most critical steps the management of contaminated water coming from sprayers internal and external washes and cleaning of empty containers/packages**.

Furthermore, actions supporting upgrade farmer's knowledge and behaviors could be of interest.

Considering the results of pesticides presence in groundwater, from the first three sampling campaigns, and the highest density of vineyards in the municipality of Ziano Piacentino, the best location in the action lab for the implementation of new BMPs is the Vicobarone Social Cellar. Here the farmers will have a mobile platform to wash the spaying machine and to recover the waste waters. Furthermore the waters will be treated following the Italian legislation for special waste.

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3.4 Poland - the Gowienica river catchment

3.4.1 Conceptual understanding of the catchment

The Polish Action Lab, the Gowienica river catchment is located in the North-West Poland and has the surface of 63.65 km^2. In this area arable land occupies 85.72% of the catchment, 5.43% - meadows, rural areas - 2.3%, forests - 1.2%, the area of the former air base - 3.5%, garden plots - 1.16 %, others - 0.69%.

The average catchment height is 34 m, altitude - 40 m, and the average slope is 5.01 m/km. The area is characterized by a slight decline in the river basin and small denivelations in the catchment. The elevation of the catchment area decreases gently from the watershed to the river valley, which runs its waters on ordinates from 25 to 14 m above sea level at the mouth to Lake Miedwie.

The Gowienica river is a small river of some 15 km length. It constitutes one of the inflows to Lake Miedwie, which is a water source for the city of Szczecin – the capital of the Westpomeranian region.

The Gowienica River is a shallow lowland river with small flows. It has very few tributaries, all of which are drainage ditches that collect water mainly from agricultural areas. The best-known drainage system is located in the south-western part of the catchment, near Reńsko. The source area in Kłęby is also drained.

To assess the migration of pollutants in the catchment, it is necessary to know the connection of groundwater with the surface waters of the Gowienica River and the Miedwie Lake. As part of the Quaternary aquifer, two water-bearing horizons can be separated: the upper intermoraine and the lower intermoraine aquifer, whereby its vulnerability to pollution is highly limited and can be regarded as non-vulnerable. Only the upper intermoraine aquifer is used for the purpose of drinking water production. This water bearing zone is characterized by an unconfined or poorly confined (locally) water table. The permeability coefficients (k) are in the range of 2 to 20 m/d. They correspond to well permeable and permeable sands. In the most part of the catchment area water table is located 1 to 10 m below surface. These hydrogeological conditions cause the aquifer to be vulnerable to nitrate pollution from agricultural sources.

Gowienica Miedwiańska is recognized as a poorly draining river. In the northern part of the catchment, Gowienica flows almost without draining or groundwater recharging. This means that there is no connection of groundwater with surface waters. However, to the south of Dębica, the river has a clearly draining nature, the range of groundwater runoff to the river is extended especially in the right-bank part of the catchment.

The problem of high nitrate concentrations occurs in the catchment. Subsequently, the Gowienica river brings high loads of nutrients into the lake Miedwie, on which a surface water supply for the city of Szczecin is located. The SWAT model results show that the main river load of nitrogen and phosphorus comes from diffuse pollution associated with agriculture.

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3.4.2 Agricultural sector

The catchment area is intensively utilized in agriculture, nearly 96% of the area is agricultural land. Plant production dominates - 86% of agricultural land is arable land, while meadows and pastures occupy- 10%. Forests occupy an area of less than 2.5% of the catchment.

Intensive agriculture in this area is favoured by good quality soil and climatic conditions. The glacilacustrine deposits gave rise to the creation of very fertile soils classified as chernozems and brown soils.

82 % of farms declare to have only a pland production, mainly cereals such as barley and wheat, as well as industrial plants, including sugar beetroots and rape. Nonetheless, 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.

Farm structure includes small-scale, individual farm, as well as large-scale agricultural industries. Large part of land is reclaimed, and drainage water flow to melioration ditches or directly to the river.

Since recent years large area farmers use monocultures and grow industrial plants (e.g. corn and rape) 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 (e.g. biogas plant waste) used as natural fertilizers. Gowienica catchment was included to the first Nitrate Vulnerable Zone delineation in 2004.

3.4.3 National regulations & current BMP implementation

Regulations:

In Poland general legislation and regulatory framework for water management is the Act of 20 July 2017 - Water law. 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". This act establishes that overall area of Poland is in a nitrate vulnerable zone (NVZ). 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 Water law. 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.

Obligatory requirements:

- 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

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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 LU according to the average annual level.

The Chief Inspectorate for Environmental Protection and the voivodeship inspectorates are responsible for monitoring the implementation of the Programmes of Measures (POMs). For non-compliance with regulations, inspectors may give instructions or impose penalties specified in the Water Law Act. In addition to the imposition of a penalty, farmers are obliged to correct the deficiencies.

The first inspections took place on farms located in the area where the quality standard for nitrates was significantly exceeded in groundwater bodies. Large scale farms with an area of at least 50-100 ha as well as farms with large stocking density, over 60 LU were also controlled.

During these inspections, such requirements as proper manure storage, implementation of fertilizer plans and keeping records of agrotechnical procedures (e.g. application of fertilizers) were checked. The least irregularities were found in areas where NVZ requirements were already in force before the implementation of the POM across the country.

In this case, it can be concluded that the failure to comply with new requirements is largely due to the lack of knowledge about the existing regulations, as well as the lack of time needed to implement new procedures. Existing regulations are sufficient, but their implementation is unsatisfactory. Introduction of new regulations should be preceded by a public awareness campaign to increase farmers' level of knowledge. Financial support and trainings for farmers should also be provided. In this case, the cooperation between framers and supervising institutions in a key factor.

Subsidies and financial incentives:

After Poland's accession to the EU in May 2004, about 1.35 million Polish farmers were included in the agricultural income support schemes under the CAP. The direct payment scheme provides the Polish rural residents with a stable source of income and reduces the cost of operating farms.

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Farmers applying for direct payments are required to meet standards for maintaining the land included in the farm in accordance with the Good Agricultural and Environmental Condition (GAEC) and the basic requirements for management of the Statutory Management Requirements (SMR 1 Nitrate Vulnerable Zones), set out in Annex II to Regulation (EU) No 1306/2013 of the European Parliament and of the Council. The above standards and requirements make up one mechanism bearing the common name of cross-compliance. The principle of cross-compliance means linking the amounts of direct payments received by farmers, as well as area payments under the RDP for 2014-2020, with the fulfillment of specific requirements.

In the framework of RDP 2014-2020, Polish farmers can receive subsidies as following:

- Measure 4 - Investments in physical assets: Investments aimed at protection of waters against pollution caused by nitrates from agricultural sources, e.g. costs of building, rebuilding or purchasing **tanks for storage of natural liquid fertilizers, manure pad for collecting natural solid fertilizers, costs of purchasing new machines and devices for applying natural fertilizers**.

- Measure 10 – Agri-environment-climate payments: Promotion of a sustainable management system, prevention of soil organic matter loss. The beneficiary is obliged to perform the **soil analysis** twice (at the beginning and end of the commitment period that allows to assess the effects of implementation), carry out an annual **fertilizer plan**, crop diversification (minimum 4 in each year), appropriate **crop rotation**, at least two uses on each plot during the commitment period, one of the three practices increasing organic matter content in the soil: catch crop, plowing straw or plowing manure, but at least once it should be a catch crop.

The employees of Agency for Restructuring and Modernisation of Agriculture (ARMA) carry out inspections to check the adherence to cross-compliance rules, which is a condition for paying all area payments. Compliance with the requirements of the nitrate program is part of the cross-compliance (so-called SMR1, GAEC1 and 2). Failure to comply with them results in deduction of area payments.

Implementation:

Practices regarding animal production are less popular in the Gowienica Catchment. In recent years, there has been a noticeable drop in the profitability of animal production, as a result of which many farmers quit breeding and production of milk for plant production. Currently, 82% of investigated farms in the catchment are concentrated on crop production, while only 18% declared to have a mixed production.

BMPs connected with plant production and soil management are more popular. Several practices and measures, such as liming (BMP3) and soil analysis (BMP 64), have been already implemented in the Polish Action Lab. Farmers admit that implementation of these measures brings various

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benefits such as improvement of the quality and quantity of yields and reduction of fertilizer expenditure, due to the assimilation of nutrients by plants increases. In addition, in some cases, the reduction in the amount of fertilizer has a positive effect on yields, for example, the amount of sugar in beets is increased. Soil sampling can be used to minimize the amount of nitrogen applied while maximizing the amount of sugar recovered from each hectare. Farmers also use a fertilizer program (BMP 2). Although, they admit that due to extreme weather events (droughts, floods), it is difficult to plan the appropriate fertilization in advance.

BMP 10- plant cover in autumn and winter is frequently used in the Gowienica Catchment. Farmers notice that the implementation of this measure has a positive effect on soil properties and nutrients content. An additional benefit may be the harvesting of the crop that can be used for green fodder. There are subsidies for plant cover, so the seed cost is refunded.

Introduction of crop rotation (BMP 9) is also a popular solution. The additional benefit is elimination of pests, if phacelia or mustard are planted before beetroot.

In the catchment area there are very high quality soils, which allow farmers to achieve high quality yields. Implementations 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. Subsidies for implementation buffer zone are five to six times lower than profits obtained from the yields.

Farmers claim that there is a tendency to liquidate wetlands, due to the increase in cultivated area and difficulties with agrotechnical operations. Moreover, the area of the wetland is deducted from the basic payment area.

3.4.4 Recommendations

The Polish action lab focuses on nutrients in surface waters and groundwaters in the Gowienica river catchment. Based on the SWAT model results, it was found that the main river load of nitrogen and phosphorus comes from diffuse pollution associated with agriculture. Therefore, it is necessary to work further to prevent this main source of water pollution.

The implementation of appropriate BMPs should be adapted to local conditions. The cooperation with farmers interested in applying new solutions is necessary and should be strengthened. According to this approach, it is recommended that the following practices should be implemented:

- Adjust the application strategy to the environmental circumstances:
  - especially **BMP 6** - Avoiding the application of chemical fertilizers and manure during high-risk periods.
- Optimization of application practices:
  - **BMP 4** - Incorporating organic manures immediately after application;
  - **BMP 5** - Injection, trailing shoe or band spreader used for slurry.

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- Optimization of production methods:
  - **BMP 12** - Constructed wetlands;
  - **BMP 14** - Controlled drainage.
- Optimization of layout of the fields:
  - **BMP9 -**Crop rotation and its role in rebuilding and preservation soil organic matter;
  - **BMP11** - Grass buffer zones.
- Optimizing of environmental production conditions:
  - **BMP 2** - Fertilizer program **;**
  - **BMP 3 –** Liming**;**
  - **BMP 64-** Soil analysis**;**
  - **BMP10 -** Plant cover in autumn and winter**.**

BMP 2 and BMP 6 are included into POM and should be implemented in whole catchment without any exception. However, often as a result of unfavourable weather conditions, the problem of non-adherence to the requirements is observed. In this case, the increasing knowledge and awareness among farmers is a key factor. The basic activity in this matter should be information about improper practices, education and effective control process during appointed institutions (municipal guard, Inspection of Environmental Protection, ARMA).

BMP 4 and BMP 5 are practices related to the application of liquid manures. Despite the fact that plant production dominates in the catchment, animal husbandry is also carried out in this area. There is a large farm for cattle breeding with fields located close to Reńsko village. In this case, optimizing liquid manure applications is a key factor to prevent nitrates pollution from area sources. Moreover, a large part of this land is reclaimed, and drainage water flow to melioration ditches and to the river.

The drainage scale on the west bank of the river is small, but an extensive drainage system located close to Reńsko village can contribute significant pollutant loadings to the Gowienica river. The implementation of BMP 14 can contribute to reduction of water pollution in an effective way at the local level. Suitable areas for controlled drainage are:

- ✓ Flat (slope less than 0.5 %);
- ✓ Systematically drained with subsurface tile drains;
- ✓ Medium to high level of N in the drainage water.

According to the above conditions, controlled drainage could be also an effective measure to reduce load of nutrients in the upper course of the river. Currently, existing drainage system collects water from agricultural land from the south-eastern part of the catchment close to Kłęby village.

In conjunction with controlled drainage, the integrated buffer zone (IBZ) should be implemented, before the drain pipes discharge into the watercourse (Figure 3). IBZs consist of two segments, a

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water collecting ditch and an infiltration bank, composed of grass or natural herbaceous vegetation (BMP 11). Combinations of BMPs that control the same pollutant are more effective than individual BMPs. These combinations of BMPs can be specifically tailored for particular agricultural and environmental conditions.

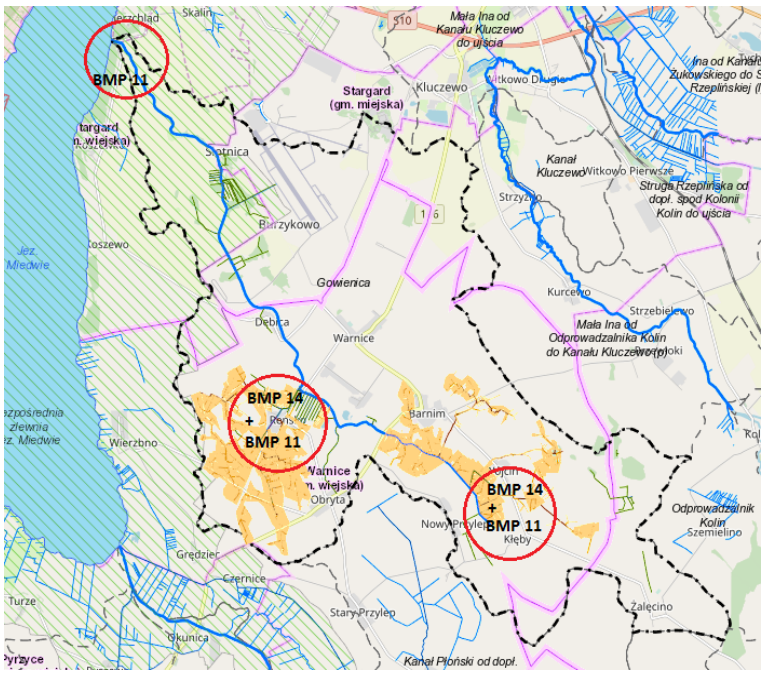

Figure 3: Drainage system in the Gowienica river catchment. Possible location for implementation controlled drainage system and IBZ.

In the northern part of the catchment, where a large area without upper intermoraine aquifer occurs, Gowienica flow almost without draining or groundwater recharging. In this area there is no connection of groundwater with surface waters, the river flows directly into the Miedwie lake, discharging pollutants. The establishment of IBZ in the river estuary can play a meaningful role in reducing impacts to aquatic resources (Figure 3).

The Gowienica river has a clearly draining nature to the south of Dębica, the range of groundwater runoff to the river is extended especially in the right-bank part of the catchment. Shallow occurrence of groundwater (in the most part of the catchment area from 2 to 3 m depth) and a large share of well permeable sands on the surface significantly affect the groundwater quality. Therefore, it is a key importance to implement BMPs aimed at minimizing the loss of nutrients from agricultural soils in this area (Figure 4).

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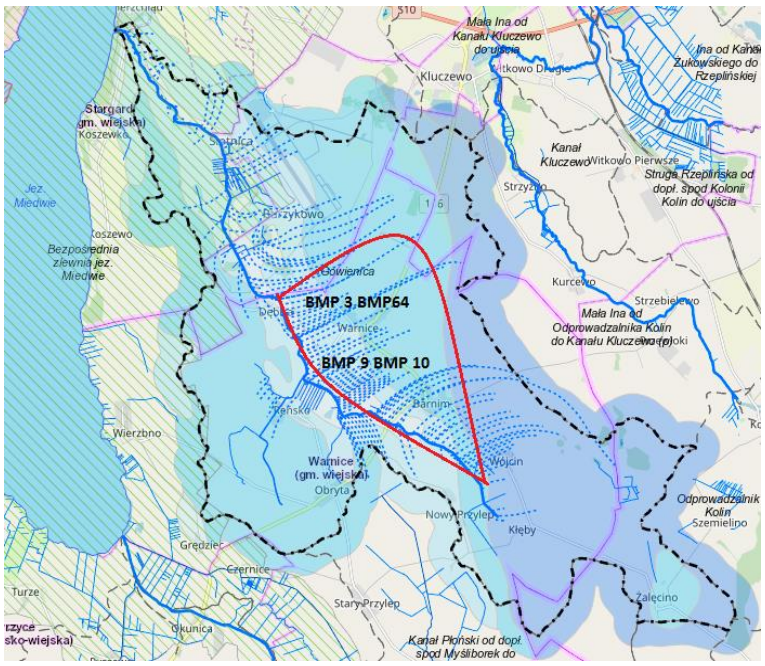

Figure 4: Depth to the water table and groundwater runoff in the Gowienica river catchment. Possible location for implementation BMPs

BMP 3 and BMP 64, as well as BMP 9 and BMP 10 are well implemented within the catchment. This means that farmers note the positive effects of these practices. Therefore, a special effort should be made to improve the uptake of these measures in the whole area. Applaying these practices in a large scale can significaly contribute to improvement of groundwater quality in the Gowienica catchment. It is crucial to strengthen the cooperation with farmers and increase their level of knowledge. Farmers must be aware that the activities will not have immediate effects, but they will certainly bring results in the future.

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3.5 Romania - the Maramures catchment

3.5.1 Conceptual understanding of the catchment

Maramures action lab is a rural region from North Western Romania, including a typical cultural landscape shaped by traditional practices, representative for small scale/ subsistence farming systems in the Carpathian Mountains – cattle and sheep breeding. The core area of the action lab is Breb village located at the basis of Northern part of Gutai Mountains. The area is economically dependent mainly on agriculture and emerging ecotourism.

Most of the agricultural land in Mara Catchment consists of meadows and pastures. In and around Breb Village arable land and orchards (consisting of mostly plum trees) occupy the largest areas.

Leptosols and andosols characterize the mountainous areas typical for the Romanian case lab. Fluvisols are found in the lower parts of the Breboaia River. Dystric cambisols dominate the hilly areas from the catchment, while haplic podzols are found in a small area in the north-west.

The territory of Breb village is crossed by a rich hydrographic network. The depth to phreatic water table ranges from a few centimetres to a few meters and it is used for drinking water from dug wells.

The climate in RO action lab is typical for temperate continental climate.

The geological structure of the Gutâi Mountains, where volcanism was predominant, determines the present aspect of the morphology.

The quality of the water is considered good, according to official data. Destination of the water courses has a concentration of nitrates due to crossing of the village where farmers use manure as fertilizer. 90% of the population is using the current public drinking water system, managed by Ocna Sugatag Mayor House as for the rest there are some wells and individual water systems in use. As part of Maramures depression, Breb village has some mineral springs, but they are not used anymore.

Problems only occur due to household waste, due to the use and storage of manure, due to their defective management. Monitoring from official authorities is performed on larger scale and thus not includes study area of Breb.

Potential pressures on the water resource in the area could only be generated by the non-conforming use and storage of manure. As a result, the main objective of the research is to monitor the nutrients in the surface waters that drain the Breb area and to assess the riverside nitrofile vegetation. Seasonal water samplings were carried out during the vegetation period from 5 stations, for which the acidity regime, the oxygen regime and the nutrients were analyzed during the period from 2017 to 2018. Quantitative and qualitative samples of macrozoobenthos were taken from the same stations too.

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3.5.2 Agricultural sector

Typical farm structure include small, semi-subsitance farms of approx. 1 to 5 ha; fragmented agricultural landscape, mosaic patches of semi natural grasslands created and maintained by traditional livestock grazing systems: sheep, cattle, small plots of cultivated land with rather low intensity/extensive management. Dimension of farms in these areas is mostly included in the category of small/semi-subsistence farms, having about 1-5 ha. Farmers usually have 2-4 cattle (left grazing on the fields in summer time during day), some sheep, 2-3 pigs and poultry, horses. Agricultural production include crop as well as animal production (e.g. cows, sheep, poultry, pigs, horses, rabbits).

Most important crops relate to cereals (maize), vegetables, potatoes, fodder plants, fruit trees (apples, pears), lucerne, honey.

Most of the agricultural land in Mara (Breboaia) Catchment consists of meadows and pastures. In and around Breb Village arable land and orchards (consisting of mostly plum trees) occupy the largest areas.

3.5.3 National regulations & current BMP implementation

Regulations:

In Romania the general legislation and regulatory framework for water management is the Environmental Protection Law no. 137 of 1995 and the Water Law no 107 of 1996, with subsequent amendments. Additional rules and regulations are included in secondary legislation in the field, including rules on the protection of water sources, obtaining water-related permits or complying with notification obligations, investigating the pollution of groundwater and remediation thereof.

Agricultural lands are monitored with regard to the level of nutrients in soil and the amount of fertilizer applied, but the network between the stakeholders performing monitoring and control is deficient; in addition laboratory equipment and sample collection are too old and insufficient.

There are various materials issued by Ministry of Agriculture in Romania (e.g. farmers guide on Eco conditionality, 2018) as well as some leaflets related to standards. The leaflets are also sent to each county in Romania to Agriculture Directorates where experts do have some meetings in the field with farmers to disseminate information.

Many BMPs are included within Romanian Code of Good Agricultural Practices for Pollution Prevention with nitrates in waters from agricultural sources for the use of the farmer, which is part of the Action Plan for the Protection of Waters against Pollution with nitrates from agricultural sources.

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Obligatory requirements:

The following BMPs 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 is respected.
- BMP 74: Use of impermeable folia where the location of manure is possible to lead to water pollution (proximity of water courses) -– BMP is not respected all the time due to financial costs involved; but there are very few farmers in the catchment area having fields in proximity of water.
- BMP 72: Temporary depositing on the field, taking into consideration proximity of waters – BMP is respected.
- BMP 11: Grass buffer zones (strips of land covered with permanent vegetation located between agricultural land and watercourses and reservoirs) -– BMP is not relevant, it is not a traditional practice in the area; moreover farmers do not have fields in the proximity of water.
- BMP 4: Incorporate organic manures immediately after application on cultivated land – BMP is respected.
- BMP 71: Directing manure towards special ponds (for sedimentation of organic substances for extraction of nutrients), for bigger agricultural exploitations not relevant in the Breb village.
- 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 – BMP is respected.

There are some good practices and measures used by farmers in the Romanian case lab area, measures 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 72 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).

Subsidies and financial incentives:

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 comply with eco-conditionality (cross-compliance) norms. These norms include verifiable standards which are derived from the Code of

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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. In order to get the subsidies the farmers must also apply the obligatory BMPs listed above.

In the National Rural Developmrnt Proramme Romania (NRDP) 2014-2020, there are some financing schemes (4.1, 6.1, 6.3) in which alongside with increasing farm productivity the farmer also needs to build manure storage platforms, and via these financing schemes they may have funding for implementation of manure storage platforms.

3.5.4 Recommendations

The most effective BMP for Romanian action lab relates to encouraging the construction of simple**, improved facilities for storing animal manure** (e.g. 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**.

The challenge relates to identifying financial means to facilitate implementation of manure platforms, as farmers need some subsidies in order to implement this BMP.

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).

As a rule residues and manure generated by livestock are stored directly on the soil. Under the influence of environmental factors and the activity of microorganisms, organic matter resulting from fermentation generates bad odorous substances. The livestock manure in individual households in the Breb area is stored under improper conditions, without measures against leakage and infiltration of liquid fractions (urine and rainwater) with a major risk to the environment and health. **It is recommended to apply a sustainable manure management system for each household having livestock.**

Project team identified some potential locations for the implementation of manure storage platforms. The locations relate to the existence of the most important anthropogenic threats, which are along the Valea Sunatoarei, where a large proportion of the Breb households. For example, monitoring station for surface water “Breboaia River, after the confluence with Sunătoarea River” (April 2018 monitoring campaign), indicated 0.76 mg/l NO_2, when maximum admitted limit is 0.5 mg/l. The high NO_2 concentration is due to location of monitoring station in a

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place where there are many households with livestock and no manure management systems in place and there was reduced rain in the season. In the coming period exact locations of farms (indicator 4) will be identified for demonstration/potential testing implementation of manures storage platforms.

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3.6 Spain - the lower Llobregat River catchment

3.6.1 Conceptual understanding of the catchment

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 Hm^3/year for human consumption, and industrial and agricultural uses. Groundwater quality is affected by the industrial and urban activity. Waters historically has presented a medium-high level of mineralization, and high content of chloride ions

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(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).

3.6.2 Agricultural sector

The Agrarian Park of the Llobregat lower basin extends over an area of 3,489.83 ha (1,954.30 ha of effective agrarian space) distributed in 14 different municipalities. Agriculture has been always a relevant activity in the region (with its golden era in the middle of the 20th century). However, the surface devoted to this use has been reduced due to urban pressures. Nowadays, irrigation farming is carried out in this area, with 60% of the land devoted to orchards, and in particular to grow artichoke, tomato, *Brassica* species, different lettuce plants, pumpkin, cucumber and squash, beans, onions, celery, etc, and with the remaining land (40%) devoted to fruit trees (peach tree, cherry tree, plum tree, apple tree and pear tree) and cereals.

As for the type of operation, and according to the Special Plan for Protecting and Improving the Agrarian Park of the Llobregat lower basin.

- Most of the activity in the Agrarian Park is carried out in family-run agricultural farms. They include 200 and 250 professional farmers that own farmland between 3 and 10 ha
- There are only 5 big agricultural companies that develop their activity in areas between 30 and 50 ha.
- About 300 farms with an extension between 0.5-1 ha are run by retired people and part-time farmers
- There are also 1000 small (80-100 m^2) vegetable gardens for recreational purposes

It is important to highlight the intense subdivision of the farming land, which makes that different units of the same farm are separated long distances.

The water used for irrigation has different sources, depending on the location of the farmland. Thus, there are farms irrigated with Llobregat River water, farms irrigated with a mixture of the Anoia River water (tributary of the Llobregat River water) and reclaimed water, farms irrigated with a mixture of groundwater and reclaimed water, farms irrigated with groundwater, and farms (at the Delta area) irrigated with a mixture of reclaimed water, groundwater, and field, urban, and forest areas run-off.

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Most farms take water from the irrigation channels and use gravity-fed irrigation systems. Greenhouses use mainly groundwater for irrigation, and in consequence, pressure-based irrigation systems. In those farmlands close to the sea, where the groundwater table is 50 cm deep, irrigation is carried out by capillarity.

Livestock farming is limited to few chicken farms for chicken meat production with a geographical indication (Catalana del Prat breed). These animals are kept in fenced yards with less than 8 individuals per m^2 and they are fed without animal fats. There are also few sheep farms for meat production, where animals are breed by extensive grazing

3.6.3 National regulations & current BMP implementation

There are some regulations concerning the protection of water against pollution caused by nutrients and pesticides from agricultural sources.

The most important regulations are:

Royal Decree 1416/2001, on packaging of PPP's.

Order 2809/2012 which approves the Plan of National Action to achieve a sustainable use of the phytosanitary products foreseen by the Royal Decree 1311/2012.

Royal Decree 1311/2012 which establishes the framework for action to achieve sustainable use of PPP's to adopt the necessary measures to promote integrated pest management (GIP) and the techniques of alternative fight. From January 2014, all professional farmers must apply the general principles of integrated pest management in their holdings (it is the transposition of Directive 2009/128 / EC).

Royal Decree 1702/2011 about periodic inspections of the equipment of application of PPP's.

Law 42/2002 on plant health.

Royal Decree 1416/2001 on packaging of plant protection products.

Decree 61/2015 about the producers and operators of means of phytosanitary defense of Catalonia and the Plant Protection Association.

All these regulations are already implemented at national, regional and local level.

At present all the BMP's which are mandatory have a high level of application, due to control mechanism and activity of Farmer Advisers (ADVs). If there is no application of any mandatory BMP some financial consequences could be applied.

The Agricultural National Department in application of the PAC in the territory has a line of subsidies called the Global Farming Contract. This Contract encompasses various subsidies aimed at agrarian entities. There are subsides to improve sustainability. Within these, there are subsides for

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different agri-environmental practices such as the management of fertilization, cultivated diversity, the promotion of integrated agriculture and organic farming.

Often, farmers have no information about the support of the Department of Agriculture due to the lack of dissemination and explanations regarding subsidies. The subsides are proportional to the implementation area.

The most relevant BMP's implemented in the Lower Llobregat pilot area are the ones promoted by integrated pest management scheme (GIP). In these cases the figure of Farmers advisers (ADV's) is very relevant for their implementation. This implementation is mandatory from January 2014, and, nowadays all farmers are used to its application.

Associated with the application of GIP principles, we find several measures to promote the reasoned and controlled use of plant protection products:

- The obligation to fill the Farmer's Holding register that is a record of all the phytosanitary applications that are carried out and a follow-up in the farm.
- From November2015, it is mandatory to have the phytosanitary applicator card to buy any product.
- From November 2016, it is mandatory that all the machinery for the application of PPP's is inspected.

Both the European and the national regulations establish the obligation to carry a record of data for farmers. These obligations include the description of the characteristics of the exploitation and the means of production used, the registration of phytosanitary treatments, the registration of sales of the products of the exploitation and, in the cases established by the regulations, the registration of PPP's application.

3.6.4 Recommendations

Considering identification of the problem and the characteristics of the catchment, the most effective BMPs to be implemented in Baix Llobregat area are:

BMP 26 - Calibrate the sprayer for an appropriate and optimum application of PPP
BMP 29 - Dispose obsolete PPP by an authorized waste collection company
BMP 30 - Choose a safe filling and cleaning places for the spraying equipment
BMP 37 - Safe disposal of spraying liquid residues
BMP 76 - Alternatives systems to chemical fights for pest control

The most important factor in choosing the above BMPs is good relation of cost to effectiveness. The project partners have already undertaken actions aiming at enhancing the potential of their effective implementation. In the following lines we explain different actions that CPABL undertakes jointly with other local entities in that area.

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BMP 26 - *Calibrate the sprayer for an appropriate and optimum application of PPP*

- Hold training sessions (TOPPS project) with UMA-UPC (Universities in the zone).
- Edit one flyer of recommendations already made by TOPPS to distribute them among the farmers.
- Organize training days for the use and calibration of manual machinery / backpacks (action proposed in coordination with the National Government).
- Develop application for farmers done by UMA-UPC (Universitys in the zone) (action proposed by Farmers advisers- ADV Fruita).
- Edit the calibration disk of the TOOPS project and distribute it among the farmers.

BMP 29 - *Dispose obsolete PPP by an authorized waste collection company*

- Design the circuit of the solution for the removal and treatment of full PPP'scontainers (Farmers Advisors are working on it):

    - Establish a common collection point;
    - Make contacts with the waste management company;
    - Organise common transport to the plant treatment to reduce costs.
    - CPABL is studying e some possible economic help for farmers.

BMP 30 - *Choose a safe filling and cleaning places for the spraying equipment*

- Update an inventory of water points (potable) for tanks loading, distributed in the territory of the Agricultural Park.
- Evaluate the state of these water points.
- Recover them and build a new point if it is considered necessary.
- Make a flyer for the dissemination of points between farmers.

BMP 37 - *Safe disposal of spraying liquid residue*

- UMA-UPC has an installation example in Agropolis for the collection of leftovers and the remains of cleaning equipment.
- Evaluate the distribution of strategic points in the territory to establish common points of cleaning and clearance of surpluses. It is necessary to study the investment for this installation.

BMP 76 - *Alternatives systems to chemical fights for pest control*

- Organize Training days about auxiliary fauna
- Edit an informative brochure for dissemination and organize a training session at the same time.
- Support for Farmers Advisers ADV's with agreements to carry out more experiences.
- Encourage the use of calendula and globular margins (application of the conclusions of the Study in the zone done by Farmers Advisers)

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- Campaign for the installation of nest insectivorous and rat-nest boxes, distributed throughout the territory.
- Organize Training days about mechanical weeding

The best location in the catchment to implement new BMPs is the Agrarian Park.

With the collaborative Management Tool, the results of all the water analyses done in the zone could be collected and all users can know the quality of the water in the different points.

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3.7 Denmark – Vester Hjerk

3.7.1 Conceptual understanding of the catchment

The extraction area for the Vester Hjerk water work is briefly described below. Note that the description differs from the description in previous deliverables due to a change in the delineation of the area.

Vester Hjerk waterworks is located on the Salling Peninsula in the north-western part of Denmark in the municipality of Skive. The land surface of the extraction area covers 696 ha. The dominating land use is agriculture. The agricultural fields cover 86% of the extraction area. The dominating soil in the extraction area is loamy sand (71%) followed by sandy clay (23%) and organic soils (6%). As the area is completely dominated by agriculture very little natural vegetation is present.

The climate on the Salling Peninsula is typical for the North-Western part of Denmark. The mean precipitation at Vester Hjerk in the period 1990 to 2016 was 962 mm, which is around 20% higher than the national average of 792 mm.

The Salling Peninsula is characterized by relatively irregular, moderately hilly terrain from 0 and up to 50 m.a.s.l.. Throughout time the landscape has been dominated by erosion and seabed formations. Since the last ice age, the landscape has been broken up into a number of smaller areas by late and postglacial erosion that has led to the formation of many and relatively large erosion valleys and ravines. These valleys and gorges often provide a sharp border to low-lying and flat areas, which is the case around Vester Hjerk.

Vester Hjerk waterworks abstracts water from a sandy aquifer which is partly located in a buried valley, and found only 10-15 m below terrain. In the buried valley the thickness of the aquifer is relatively thick (20-30 m) but with limited horizontal extent. The drinking water supplied from Vester Hjerk is solely groundwater. The water work has an abstraction license of 35,000 m3/year. At Vester Hjerk, where rising nitrate concentrations have been found during the last decades and with a few measurements above the drinking water standards of 50 mg/l and since 2007 the concentration have generally been above 37.5 mg/l.

3.7.2 Agricultural sector

The Vester Hjerk area is dominated by intensive agriculture. Note that the description differs from the description in previous deliverables due to a change in the delineation of the area.

The agricultural land inside the extraction area is managed by 19 farms managing a total of 4 864 hectares including the land outside the extraction area. This gives an average farm size of 256 ha, ranging from 17 to 1 107 ha. 6 farms are smaller than 100 ha and 10 is larger than 200 ha.

The farms cover all major types of production. Husbandry systems are 4 pig farmers, 3 dairy farmers and 1 beef cattle farmer. The rest of the farms are dominated by plant production, with one very large farm specializing in seed potatoes and grass seeds.

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The dominating crops are (2018): Winter wheat (26% of agricultural area), winter barley (14%), winter rape (14%), maize (10%) and seed potatoes (8%).

The agricultural land is almost entirely arable, with only 5.5% of the area in permanent grassland.

3.7.3 National regulations & current BMP implementation

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

The reasons that some BMPs are irrelevant in the Danish case are:

- Some BMPs 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).
- Some are 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).
- Finally, one BMP is likely to be illegal: BMP 16 (Slurry bags).

BMP 10 (Plant cover in autumn and winter) is as mentioned also included in obligatory regulation in Denmark. The standard choice is 'ordinary' cover crops sown in August and possible plowed late October. The alternative choices are interim crops, sown late July – harvested late September, early sowing of winter crops early September, and voluntary reduction of the N-quota or energy crops.

Compliance with regulation in Denmark is generally quite high. Non-compliance with the BMPs mentioned above as obligatory according to Danish regulation are either fined or leads to reduced Pillar one support through the cross-compliance measure. Support schemes are also available for constructed wetlands, energy crops, set aside and afforestation.

Cover crops are the only one of the obligatory BMPs that are supported in a support scheme. Part of the cover crops demands are obligatory, but if the farmers plants additional cover crops a premium is available.

3.7.4 Recommendations

The process of working with the farmers in the Vester Hjerk has been disrupted by a significant change in the localization of the extraction area for the supply of ground water to the water work. This means that only a limited number of the farmers in the new extraction areas was involved in the previous work on BMPs (D4.2). In the new extraction area we have had one workshop with the farmers (12 of 20 farmers participating) and we have been visiting the 9 largest of the farmers on

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their farms. This has created a new situation where the focus is not on BMPs, but on an optimal localization of crops and farm management at field, farm and above farm level. This change of scope is also a consequence of the relatively high implementation of existing suitable BMPs in the area and the fact that the enlargement of the extraction area. The approach of course also depends on some pre-conditions:

- The problem to solve must not be too severe. In Vester Hjerk the required reduction in leaching for the root-zone could be in the range of 10-20 mg. Nitrate per liter.
- There must be a natural differentiation in robust and vulnerable areas. In Vester Hjerk we are mapping the retention and the split on run-off to surface and groundwater to provide justification for in-field variation in farm management.
- The farms must be relatively large compared to the extraction area providing flexibility for the farmers to move crops and farm management around. In Vester Hjerk all farmers have land both inside and outside the extraction area and the majority of the land is outside.

In the next steps we will follow up with further farm visits and a joint workshop where we use our collaborative tool – The Landscape Tool – to find optimal solutions together with the farmers. The main 'BMPs' to be included are:

- Crops with high risk of leaching versus crops with low risk of leaching (linked to BMP1)
- Reduced application on vulnerable areas/increased application on robust areas (Linked to BMP 1 and 76)
- Plant cover in autumn and Winter (BMP 10)

The 'BMPs' selected above requires no or only small changes for the farmers, but our hypothesis is that an optimal spatial allocation of the crops and the farm management is sufficient to reach an acceptable level of leaching for the agricultural area within the extraction area. If this assumption turns out to be false we will explore the interest among the farmers in more severe changes like set aside (BMP 78) or permanent grassland (linked to BMP 11).

The best location to implement 'BMPs' are inside the extraction area, that is not on the agricultural land still belonging to the farms in question, but outside the extraction area. Inside the extraction area the best location of the 'BMPs' are on agricultural land with a low retention and a high run-off to the groundwater. As an additional layer the best location can also be evaluated above farm level by allowing allocation of 'BMPs' in between farms.

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Annex 1

Table 1: Best Management Practices selected for 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
Soil management	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

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		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
		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

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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
	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

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	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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