

Agri-drinking water quality indicators and IT/sensor techniques



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One of FAIRWAY's objectives was to identify, select and prioritize transparent and data-driven indicators for monitoring of the impacts of agriculture activities on drinking water quality, referred as Agri-Drinking Water Indicators (ADWIs). ADWIs are intended to assist agricultural consultancy, therefore, they should be appealing and understandable for farmers. On a larger scale, ADWIs are intended to support central and local administration and policy-makers, water companies in analysing the situation of diffuse pollution and selecting measures to protect drinking water resources.

All ADWIs discussed in the report are listed in Table 1, i. e. those being subject of the survey among the case studies, those proposed by the case study leaders to be included in a further evaluation and those which, according to a literature review, are used for pesticide and nitrate monitoring/risk assessment.

From the number of indicators listed and further explained in the report, it can be deduced, that indicators which act in the agricultural sector as Driving forces and as Pressure indicators, are far more numerous than State respectively Impact indicators. The large number of agricultural Driving forces and Pressure ADWIs also explains, that from this part of the DPSLIR-model, many factors may influence water pollution. State indicators which are used for the evaluation of the water quality are on the contrary far more standardised, like the water quality standards they are supposed to monitor.

A survey on ADWIs already used in case studies was carried out to select the most promising indicators. A first weighting of indicators is listed in Table 2. On the right part of the table, three columns show the ranking of (sub)indicators in use in the FAIRWAY case studies according to their data availability in order to calculate ADWI. Answers would also indicate the resolution in space, in which data can be delivered from the case studies (at plot, farm or regional/larger scale).

In Table 2, ADWI for which data can be supplied by the case studies are marked in orange. ADWI for which data can (possibly) not be supplied by case studies are marked in blue. These data may possibly not be used in certain or all case studies to calculate those indicators.

The reason why case studies do not collect specific data, may be due to national requirements (these data are not part of the national legislation) or due to the case study -specific goals (nitrate polluted site do not spend much on pesticide analyses).

This constrains aims to calculate the same indicators in each site. Indicators, for which data are not readily available in the case studies can not be calculated except if these data are freely available from other data sources.



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Table 1: ADWIs in the DPSLIR framework

Domain	Subdomain	Indicators category
Impact	Societal and economic demands	Demands for clean drinking water*)
		Population density*)
		Cost for drinking water production*)
Driving forces	Resource management and planning	Land use (planning) <ul style="list-style-type: none"> - Land use/land cover (i.e. winter wheat surface evolution) - Land use change (grassland->arable land)
		(Water protection planning)
		Agricultural preconditions <ul style="list-style-type: none"> • Climatic conditions <ul style="list-style-type: none"> - precipitation - temperature - wind • Soil properites <ul style="list-style-type: none"> - soil type - organic carbon - clay content - top soil bulk density - field capacity • Topography <ul style="list-style-type: none"> - susceptibility to erosion and compaction
	Farm management	Farming standards <ul style="list-style-type: none"> - organic/conventional
		Farming Intensity <ul style="list-style-type: none"> - crop yield
		Farm management <ul style="list-style-type: none"> - cropping patterns - catch crop use - method of soil cultivation/tillage practice - soil cover - cropping systems
		N-fertilisation <ul style="list-style-type: none"> - Livestock density - Livestock excretion - Types of organic fertilisers - plant availability of organic bound N - Manure applied in autumn - Animals out of pasture - Organic fertilisation/ha; organic fertilisation/crop*ha - Mineral fertilisation/ha; mineral fertilisation/crop*ha - Total fertilisation/ha; total fertilisation/crop*ha - Timing of fertiliser application - Splitting/frequency of fertiliser application - Application techniques for fertilisers
		Pesticide application <ul style="list-style-type: none"> - Type of Pesticides - Chemical properties - Consumption of pesticides - Application of pesticides/ha (active substances; most frequently used pesticides; most persistent or most toxic pesticides) - Application of pesticides/ha*crop (active substances; most frequently used pesticides; most persistent or most toxic pesticides) - Timing of pesticide application - Splitting/frequency - Application techniques for pesticides
		Trends
		Intensification/Extensification
Specialisation		
Pressure	Leaching	Leaching quantity <ul style="list-style-type: none"> - Depth of water table

Domain	Subdomain	Indicators category
		<ul style="list-style-type: none"> - Drainage index (DI) - Exchange frequency (EF) Nitrogen in soil water <ul style="list-style-type: none"> - After harvest soil nitrate - Autumn soil nitrate - Spring soil nitrate - Soil water potential and nitrate content in soil solution Pesticides in soil water
	Surface water pollution	Indicators for nitrogen and pesticides in surface water
	Point sources	Point source of nitrates and pesticides
	Aerial immission	Pesticide drift Deposition of nitrogen
	N-Efficiency	Nitrogen budgets
State/ Impact	Water quality	Concentrations in water
		Concentration trends
	Regulatory compliances	Frequency of exceedance of water quality standards
Link	Catchment typology	Catchment typology
	Lag time	Recharging rate
		Water age
	Source tracer	Nitrate Isotope indicators
		Point source of pesticide
	Vulnerability	Nitrate vulnerability
Pesticide vulnerability		
	Leaching risk	Nitrogen leaching risk indicators Pesticide leaching risk indicators

*) Indicator not discussed in this report

Table 2: Ranking of ADWI according to significance and prevalence based on a survey carried in WP 3 of FAIRWAY

(Sub)indicator of ADWIs	Prevalence: evaluation of data availability in case studies (number of times mentioned)		
	Plot scale	Farm scale	Regional scale
Land use/land cover	6	2	5
Land use change			
Legislation			
Precipitation/evapotranspiration	2	2	12
Temperature			
Wind			
Soil type	5	1	4
Organic carbon			
Organic/conventional	1	7	1
(Average) crop yield	1	7	1
Cropping patterns			
Method of soil cultivation/tillage practice			
Soil cover			
Livestock density (LU/ha /yr on an area of reference)	3	7	4
Livestock excretion (kg N/ha/yr on an area of reference)	1	5	1
Organic fertilisation/ha; organic fertilisation/crop*ha	2	6	0
Mineral fertilisation/ha; mineral fertilisation/crop*ha	4	4	6
Total fertilisation/ha; total fertilisation/crop*ha	2	7	2
Type of Pesticides			
Chemical properties			
Consumption of pesticides			
Application of pesticides/ha (active substances; frequently used; most persistent/toxic)	2	6	0
Application of pesticides/ha*crop (active substances; frequently used; most persistent or toxic)			
Timing of pesticide application			
Splitting/frequency of pesticide application			
Nitrates in soil water	4	1	2
Pesticides in soil water			
Nitrogen leaching risk indicators			
Pesticide leaching risk indicators			
Surface transport of nitrogen and pesticides (with soil/fertiliser particles)			
Pesticide Drift			
Volatile N-compounds			
Nitrate: grazing animals near surface waters, farmyard, storage facilities			
Pesticides: farmyard, pesticide storage facilities			
Annual average nitrate concentration (mg NO ₃ /l)	4	1	8
Concentration trend analysis			
Frequency of exceedance quality standards (%)	2	0	8
Nitrogen maximal concentration in drinking water collection points	3	0	8
Catchment typology and dominant flowpath			
N stable isotopes			
Number of substances that exceed water quality standards at least once the year	4	0	7
Maximum concentration by substance (if >0.1 µg/l) in drinking water collection points	4	0	7
Frequency of exceedance quality standards in the drinking water (percentage of the number of samples where the 'drinking water' standard is exceeded) by substance	4	0	6
Vulnerability assessment maps of aquifer and surface water	2	0	7