Interreg

EUROPEAN UNION

Danube Transnational Programme

CAMARO-D

Transnational best management practice (BMP) catalogue – ARABLE AGRICULTURE

D. T 1.2.3

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Content

1 INTRODUCTION 3
1.1 List of Best Management Practices 4

2 BEST MANAGEMENT PRACTICES - CATALOGUE 5
2.1 Conservation tillage 5
2.2 Strip tillage 8
2.3 No tillage 12
2.4 Grass buffer strips along water courses 18
2.5 Mulching 22
2.6 Fertilization with manure and compost 27
2.7 Conservation crop rotation 32
2.8 Precision Agriculture 36
2.9 Control of Nutrients application 40
2.10 Control of Pesticides application 44
2.11 Retention ditches 47
2.12 Grassed waterways 51
2.13 Sediment traps 55
2.14 Hedges 59
2.15 Infiltrating pools 64
2.16 Stabilized dung pits with retention tank 69

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1 Introduction

Catalogue of Best Management Practices was created as a result of Interreg Danube Transnational Program project CAMARO-D, dealing with flood control, water quality and related questions of land management in Danube catchment.

Catalogue is presented in the form of four issues/handbooks, according to focus area in land management. The focus areas are:

- Agriculture – arable land;
- Agriculture – grass management;
- Forestry;
- Spatial Planning.

Prior the catalogue creation the BMP transnational synthesis had been worked out by CAMARO-D project in close cooperation of all project partners. The synthesis was the first catalogue input offering comparison of BMP use in Danube countries.

Then four international expert teams in above listed focus areas worked out final selection and qualified description of measures to be included in the BMP catalogue.

The catalogue therefore neither collects and assesses all practices, applied within water and landscape management in partner´s countries, nor lists practices most often recently applied within individual Danube countries.

It summarizes most effective practices applied and practices rarely (or even not yet) applied, but which application is highly desirable in several Camaro-D countries. The authors are aware that there exists number of other practices that can be effectively applied within individual countries.

The list will never be complete, but catalogue tries to collect the most effective and most often implemented practices to share knowledge and experiences within Danube countries.

All four issues of BMP catalogue have standardized structure for better orientation and includes indicative criteria as frequency of recent implementation within individual countries, effectiveness and cost demand of general support from state, EU or other legislation.

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According to the title the catalogue deals with Management Practices, but it describes also Technical Measures. Practice or Measure are understood generally as any activity, leading to improvement of water management within target area of Danube catchment.

Hopefully our target group consists of decision makers, land managers, stakeholders, and local authorities interested in Danube region landscape improvement.

1.1 List of Best Management Practices

- Conservation tillage
- Strip tillage
- No tillage
- Grass buffer strips along water courses
- Mulching
- Fertilization with manure and compost
- Conservation crop rotation
- Precision agriculture
- Control of Nutrients application
- Control of pesticides application
- Retention ditches
- Grassed waterways
- Sediment traps
- Hedges
- Infiltrating and sediment trapping pits
- Stabilized dung pits with retention tank

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2 Best Management Practices - catalogue

2.1 Conservation tillage

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Conservation tillage is agricultural practice applied on arable land. Basic principle consists in replacement of conventional tillage based on regular plough (turning of top soil layer of ca 15 – 30 cm) by soil surface loosening by cultivator. Top soil layer of ca 5 - 10 cm is loosened by various technologies, but is not turned upside down.

Intended goals of practice/measure
The top soil layer is not turned, but only loosened. This provides good condition for germination of seeds and mechanically damages weeds.

Characteristics of practice/measure
The measure is suitable for any types of field, soil and crop.

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Effectiveness in operation	
Positive effects includes mainly following: soil is only disturbed by cultivator, but nut turned by plough. It allows to soil organisms continuous activity, not interrupted by ploughing and following period. Soil structure is not that much affected by mechanical processing of soil. This technology allows to let mulch (crop residues) within topsoil, what provides good protection against soil erosion. Last but not least – the operation is less energy and time demanding than conventional tillage, based on ploughing. The movement of machinery is easier (less energy needed) and faster than conventional ploughing. The measure (technology) enhances soil properties – mainly soil structure, organic carbon content, hydraulic conductivity and provides good soil protection.	
On soil conservation	***
On flood control	**
On water quality conservation	*

Cost	
The technology needs special machinery, which is not cheap, but on the other hand, it usually combines cultivator together with seeding machine. In such a case it needs only one field operation instead of 3 – 4 in case of conventional tillage based on plough. Operational costs therefore are lower, than in case of conventional tillage due to fuel and time savings. Economically, the technology is usually profitable for farmers, due to savings in time and energy. Yield increases for ca 5 % within several years after application due to increased soil quality and fertility.	
Investment costs	**
Operational costs	*

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Economic losses of farmer	Not relevant for this measure

Potential problems/conflicts	
Necessity of exchange of machinery from set of machines for conventional tillage to combined machine for conservation tillage. Can be reduced by purchasing simple cultivator and keeping conventional seeding machine.	
Rate	*

Required or supported by CAP?
Common agricultural policy should lead to comparable conditions for farmers, but also to comparable standards in soil conservation and water protection. On the other hand, CAP is implemented with high variability in different countries, due to different power of agricultural industries in negotiation conditions for every country. This type of measure is generally supported and is recognized as positive measure in terms of soil and water quality conservation.

Required or supported by national implementation of Common Agricultural Policy?

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

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Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**					

Photos – if relevant

Only sample photo

2.2 Strip tillage

Type of practice/measure		
Technical	Management	Other - specify

Project co-funded by European Union funds (ERDF, IPA)

	X	

Description of practice/measure
Strip-tillage is a conservation system that uses a minimum tillage. It combines the soil drying and warming benefits of conventional tillage with the soil-protecting advantages of no-till by disturbing only the portion of the soil that is to contain the seed row.

Intended goals of practice/measure
The main advantages include soil processing by deep loosening in a strip up to the depth of 35 cm with the option to apply fertilizer into the root zone. Plant residues are placed in the inter-row which not only eliminates erosion processes, but also unproductive evaporating. Strip-tillage, which creates a soil environment that enhances seed germination, is an alternative to no-till in areas where poorly drained soils are dominant. Where soil moisture conditions are suitable, strip-tillage — traditionally in the fall — creates narrow-width tilled strips to increase early spring soil evaporation and soil temperature in the top 5 cm. Strip-tillage is defined as less than full-width tillage of varying intensity that is conducted parallel to the row direction. Generally no more than one-fourth of the plow layer is disturbed by this practice. The goal of strip-tillage is to create a seedbed condition in the row that is similar to that achieved by moldboard plowing, while leaving a relatively high amount of crop residue on the inter-row soil surface to reduce erosion.

Characteristics of practice/measure
The principle characteristics are based on following: Strip-tillage leads to warm up of soil temperature and improvement of plant emergence. Strip-tillage has a yield advantage over no-till in wet, poorly drained soils.

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Strip-tillage minimizes soil disturbance and keeps 75 percent of residue on soil surface.

Effectiveness in operation	
Often, fertilizer is injected into the tilled area during the strip-tilling operation. The tilled strips correspond to planter row widths of the next crop, and seeds are planted directly into the tilled strips. Strip tilling normally is done in the fall after harvest, but it also can be done in the spring before planting. Evaluating the economics of tillage systems is very complex. Consideration must be given to the initial and maintenance costs of equipment, the size of tractor needed to pull the tool, equipment depreciation, labor costs, conservation program incentives, and increaseed management costs related to fertilizer and pest management. Producers will have to determine if it is cost effective to strip-till all row crops, as opposed to striptilling the corn, but using a drill to plant soybean.	
On soil conservation	**
On flood control	**
On water quality conservation	*

Cost
The traditional strip-till system comes from America. Investment costs vary depending on the type of equipment, size and accessories purchased. Based on American data, total investment will run between $3,000 and $4,000 per row. Ownership costs are heavily influenced by the amount of use per year and the number of years the equipment can be used. Operating costs include fuel, lubrication, repairs and labor. There may also be an economic incentive for strip-tillage because of the time and equipment cost savings compared to full-width tillage. Strip-tillage can be a one-pass tillage and planting operation

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depending on the type of system that is selected. A producer can plant more acres when time is limited early in the growing season. Furthermore, the producer may be able to maintain a smaller equipment inventory.	
Investment costs	*
Operational costs	*
Economic losses of farmer	Not relevant for this measure

Potential problems/conflicts	
Cost of preplant operation. Strips may dry too much, crust, or erode without residue. Not suited for drilled crops. Timeliness in wet falls. Possible RTK guidance costs.	
Rate	*

Required or supported by CAP?
In the EU the strip till is intensively tested but not heavily implemented.

Required or supported by national implementation of Common Agricultural Policy?

In the Czech Republic, the technology is GAEC supported for slopes over 4° and erodible soils under specific conditions.

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes			yes		

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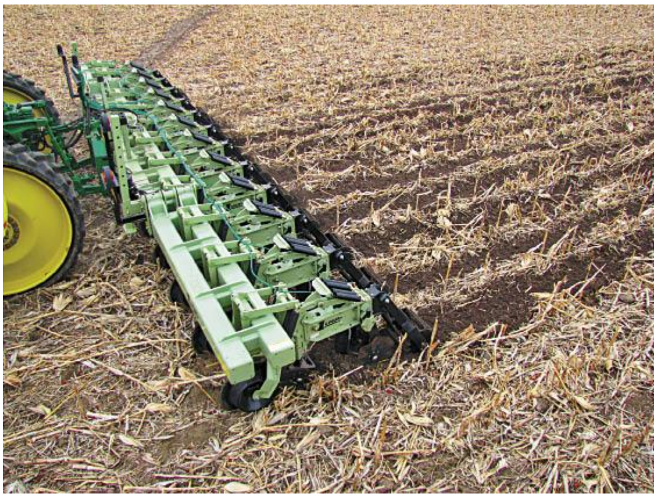
Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				*			*		

Photos – if relevant



Only sample photo

2.3 No tillage

Type of practice/measure

Technical	Management	Other - specify
	X	

Description of practice/measure
In agricultural crop production one term – no-till – is leading to increased polemic and polarization of the parties. No-till or no-tillage describes a form of cropping which does not use any mechanical tillage of the soil for crop establishment. Mechanical tillage, a standard operation in agriculture since ancient times, is mostly symbolized by the use of the plough.

Intended goals of practice/measure

- *Less Soil Erosion*: In no till farming, the soil is more resistant to erosion caused by wind and water. This is especially true when an abundance of mulch cover (stalks, straw, leaves, pods, chaff) is maintained on the soil surface.
- *Less Soil Compaction*: Ground that is not tilled is less compacted than soil that is tilled. Tillage busts up the natural soil structure. Loss of structure makes the soil less able to support heavy loads, such as the wheel traffic from tillage operations.
- *Lower Fuel Costs*: Fewer passes across the field in no till farming will dramatically reduce fuel costs.
- *Less Soil Moisture Loss*: No till seeding leaves plant residues on the ground, which can help keep the soil moist and protect against evaporation caused by sun and wind.

The possible solution to address the threat of unsustainability of the agricultural soil resource base would include the avoidance of mechanical soil disturbance, or no-till.

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Characteristics of practice/measure
The measure is suitable for any types of field, soil and crop, when respecting specific conditions of complex agricultural approach.

Effectiveness in operation
The aim is to move as little soil as possible in order not to bring weed seeds to the surface and not stimulating them to germinate. No other soil tillage operation is done. The residues from the previous crops will remain largely undisturbed at the soil surface as mulch. Natural environments produce significant amounts of biomass and in most cases this is very sustainable. If we accept the initial statement that tillage in most cases leads to unavoidable soil erosion and degradation, a sustainable agricultural production system should be based on no-tillage. Yet, agricultural production is an unnatural system that must find ways to learn from nature in order to make most use of natural control mechanisms, for example against insect pests, pathogens and weeds, to reduce the need of further artificial interventions. Soil tillage causes a major disruption of natural systems and therefore no-tillage systems should provide much better opportunities to reduce the need of inputs than do tillage-based systems. To mimic natural systems no-tillage needs to be complemented with additional elements: First of all, no-tillage needs to be a permanent feature, to allow soil life to establish in the soil profile to its full potential and diversity and to avoid damaging the soil structuring processes facilitated by the different forms of soil life. Secondly, the soil needs to be covered permanently with organic material, which provides shelter and protection from sun, rain, heat, cold and wind and which also provides the substrate for the soil organisms to feed on and to perform a variety of ecosystem services such as carbon sequestration, water infiltration and erosion control. Thirdly the crops grown need to be as diverse as possible under given market conditions. Natural systems in very few cases are pure stands of one species; the more stable and resilient systems show a high degree of diversity. In agriculture, this can be achieved either by diverse crop rotations, or by crop associations, inter-, under- or relay cropping.

On soil conservation	**
On flood control	**
On water quality conservation	*

Cost	
By passing over a field just once (rather than three or more times) no till farming saves in labor costs and fuel. On the other hand the investment in machinery is relatively high, and successful seeding is site, time, and soil specific.	
Investment costs	*
Operational costs	*
Economic losses of farmer	Not relevant for this measure

Potential problems/conflicts
The initial statement that no-tillage systems require more chemicals can be considered a misconception. The problem with systems that use higher levels of inputs is not no-till, but other unsustainable practices, such as monocropping and exposed soil surface. In fact, no-till is a necessary, but not a completely sufficient condition to arrive at truly sustainable agriculture eventually. No-till as a practice has to be complemented with other practices to arrive at such true sustainability of a farming system in which the environmental footprint, be it from soil management or the use of agrochemical inputs, is smaller than the recovery capacity of the natural ecosystem. This can only be achieved in the absence of soil tillage, but it also requires a very careful and moderate use of agrochemicals, which will lead to a reduction in their use. While both systems, tillage-based as well as no-till systems can be

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operated at high as well as at low external input levels, the well managed no-till systems provide in the long term better chances to reduce the use of external inputs to levels even below the ones of well managed tillage based systems, without sacrificing production.	
Rate	*

Required or supported by CAP?
The concern in the EU on agricultural production, global food security, and the environment are high priority topics for the CAP reform (Basch et al., 2012). Other, related issues include sustainable management of natural resources, mitigation of climate change, and improvement of competitiveness. The European Commission, the European Parliament, the European Economic and Social Committee, and the Committee of the Regions have developed three general objectives for the future CAP: 1) viable food production; 2) sustainable management of natural resources and climate action; and 3) territorial development. The concept of "Smart Growth" is also included in the EU 2020 Strategy, referring to better resource efficiency and competitiveness. Basch et al. (2012) set out a detailed list on the advantages of CA corresponding to the goals of the CAP revision.

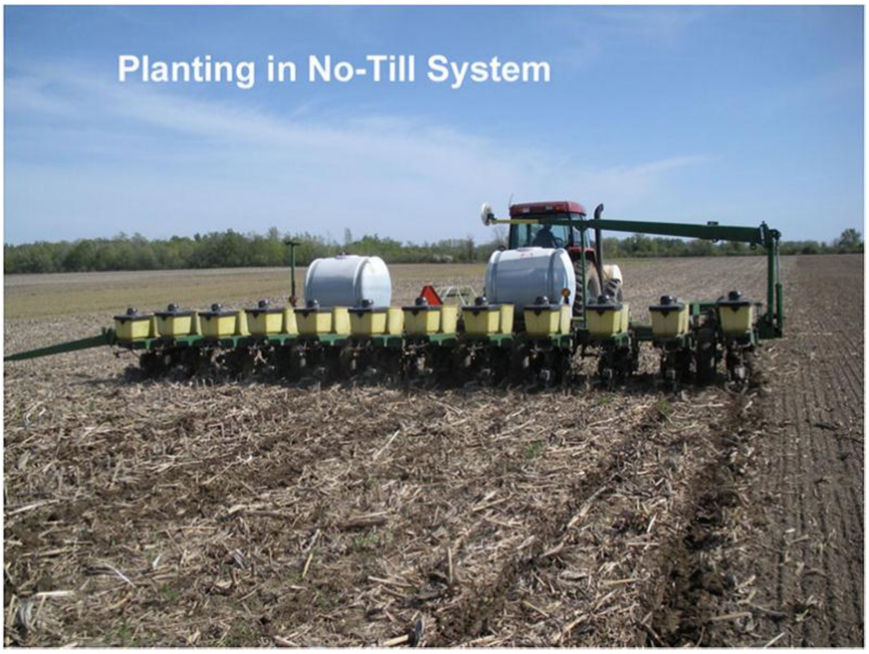
Required or supported by national implementation of Common Agricultural Policy?

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes			yes		

Applied in the country?

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							**		

Photos – if relevant



Only sample photo

2.4 Grass buffer strips along water courses

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Buffers and filter strips are areas of permanent vegetation located within and between agricultural fields and the water courses to which they drain to interrupt sediment fluxes and allow infiltration and sedimentation of eroded material. The strips must be designed with proper dimensions (width) according the field topography and have to be maintained (mowed). Simpler variant is formed by strips of protective crops on arable land (supported by GAEC in several countries), but this variant is much less effective then permanent filter strips.

Intended goals of practice/measure
These buffers are intended to intercept and slow runoff thereby providing water quality benefits. In addition, in many settings they are intended to intercept shallow groundwater moving through the root zone below the buffer. If properly designed they reduce the surface runoff and sediment connectivity to desired level. Additional benefit is reduction of nutrient fluxes caused by both surface and hypodermic flows. The grass strips can provide soil surface protection for steeper slopes, help to stabilize river and stream banks. They can help to provide necessary landscape fragmentation in areas with improper field sizes.

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They allow easier stream accessibility for machinery used for stream maintenance.

Characteristics of practice/measure
In rolling and hilly topography, the grass buffer strips are suitable for any types of field, soil and crop, especially in areas of prevailing row crops.

Effectiveness in operation	
The only limiting factor is field shape combined with complex topography. For intensive heavy machinery use limitation is caused by machinery width and possibilities of field traffic effectiveness. With typical 20 – 30 meters row accessibility the minimal effective field width is about 80 m. On the other hand, rise of precision agriculture allows to propose effective algorithms for the machinery to follow if the grass strips are reasonably designed. Another issue may be reduced area of arable land, when it is dedicated to grassland and necessary agricultural company production structure optimization. On the other hand the areas of the stripes remain low compare to full grass conversion and the landscape protection lead to the long term benefits.	
On soil conservation	**
On flood control	*
On water quality conservation	**

Cost

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An easy method for eventually consider these potential benefits is thence to provide a financial support to farmers for changing land use pattern and dedicate part of their fields to buffer zones. The amount of the compensation is usually quantified in relation to the losses accruing to the farmer for not cultivating that portion of land any longer (or at least for the time the buffer zone is in place). Farmers can then remain on income levels comparable to the previous situation without internalising external costs (Hediger and Lehmann, 2007). The costs associated with buffer practices are from land being taken out of production and costs associated with planting, establishing, and maintaining the buffers. The costs will vary with location since land values would vary.	
Investment costs	*
Operational costs	depend on grass maintanence
Economic losses of farmer	depend on area to be converted

Potential problems/conflicts	
If not combined with technical measures (grassed waterways and shallow diches) the stripes should not raise any issues with land owners and another stakeholders. The main problem is the difficulty in determining benefits and costs associated with buffer zones. Consistent with most analyses of the costs and benefits of natural resources management alternatives, the social marginal costs of setting a buffer strip (i.e. income foregone, costs of management), might appear easier to quantify than social marginal benefits due to the fact that the latter are seen as non-market values – e.g. water quality , species diversity and valuable fish species – and thence more difficult to evaluate (Anbumozhi et al., 2005).	
Rate	**

Required or supported by CAP?
Water pollution, caused by the intensification in the use of fertilisers and pesticides, is a current policy issue in many countries. In the recent European environmental policy discussions around the reorientation of the Common Agricultural Policy (CAP), water associations are demanding as well as the implementation of riparian buffer strips, which are considered as a potentially refundable non-market service (Sieber et al., 2010).

Required or supported by national implementation of Common Agricultural Policy?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes			yes		

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**			***		

Photos – if relevant

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Only sample photo

2.5 Mulching

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Mulch is any material that is spread or laid over the surface of the soil as a covering. It is used to retain moisture in the soil, suppress weeds, keep the soil cool, and make the garden bed look more attractive. Organic mulches also help improve the soil's fertility, as they decompose. Mulching is the process of covering the topsoil with plant material such as leaves, grass, twigs, crop residues, straw etc. Mulching plays a crucial role in preventing soil erosion.

Intended goals of practice/measure
A mulch cover enhances the activity of soil organisms such as earthworms. They help to create

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a soil structure with plenty of smaller and larger pores through which rainwater can easily infiltrate into the soil, thus reducing surface runoff. As the mulch material decomposes, it increases the content of organic matter in the soil. Soil organic matter helps to create a good soil with stable crumb structure.

Mulching are useful for following reasons:

- Protecting the soil from wind and water erosion: soil particles cannot be washed or blown away.

- Improving the infiltration of rain and irrigation water by maintaining a good soil structure: no crust is formed, the pores are kept open

- Keeping the soil moist by reducing evaporation: plants need less irrigation or can use the available rain more efficiently in dry areas or seasons

- Feeding and protecting soil organisms: organic mulch material is an excellent food for soil organisms and provides suitable conditions for their growth

- Suppressing weed growth: with a sufficient mulch layer, weeds will find it difficult to grow through it

- Preventing the soil from heating up too much: mulch provides shade to the soil and the retained moisture keeps it cool

- Providing nutrients to the crops: while decomposing, organic mulch material continuously releases its nutrients, thus fertilizing the soil

- Increasing the content of soil organic matter: part of the mulch material will be trans-formed to humus.

Characteristics of practice/measure

The measure is suitable for any types of field, soil and crop, but needs proper technology and machinery to be successfully applied. It has to be incorporated in crop rotation scheme.

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Effectiveness in operation
Mulching is one way to improve the water use. Research has shown that a 5 cm layer of wheat straw mulch decreased water evaporation by 40% compared to bare ground control test plots. Doubling the depth of mulch increased the efficiency by another 10%. In addition to improving water use efficiency, mulching reduces soil temperature. This is especially important when the hot summer temperatures can quickly exceed a plants upper critical temperature. By keeping the soil and plant roots cooler, it can continue to maintain its vigor and growth. The kind of material used for mulching will greatly influence its effect. Material which easily decomposes will protect the soil only for a rather short time but will provide nutrients to the crops while decomposing. Hardy materials will decompose more slowly and therefore cover the soil for a longer time. If the decomposition of the mulch material should be accelerated, organic manures such as animal dung may be spread on top of the mulch, thus increasing the nitrogen content. If possible, the mulch should be applied before or at the onset of the rainy season, as then the soil is most vulnerable. If the layer of mulch is not too thick, seeds or seedlings can be directly sown or planted in between the mulching material. On vegetable plots it is best to apply mulch only after the young plants have become somewhat hardier, as they may be harmed by the products of decomposition from fresh mulch material.

On soil conservation	**
On flood control	*
On water quality conservation	*

Cost

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Investment costs vary depending on the type of equipment, size and accessories purchased. On the other hand most modern farms are equipped for mulch use, so only proper mulch use technology education is required.	
Investment costs	*
Operational costs	*
Economic losses of farmer	Not relevant for this measure

Potential problems/conflicts	
Some organisms can proliferate too much in the moist and protected conditions of the mulch layer. Slugs and snails can multiply very quickly under a mulch layer. Ants which may cause damage to the crops also may find ideal conditions for living. When crop residues are used for mulching, in some cases there is an increased risk of sustaining pests and diseases. Damaging organisms such as stem borers may survive in the stalks of crops like cotton, corn or sugar cane. Plant material infected with viral or fungal diseases should not be used if there is a risk that the disease might spread to the next crop. Crop rotation is very important to overcome these risks. When carbon rich materials such as straw or stalks are used for mulching, nitrogen from the soil may be used by microorganisms for decomposing the material. Thus, nitrogen may be temporary not available for plant growth. The major constraint for mulching usually is the availability of organic material. Its production or collection usually involves labour and may compete with the production of crops.	
Rate	**

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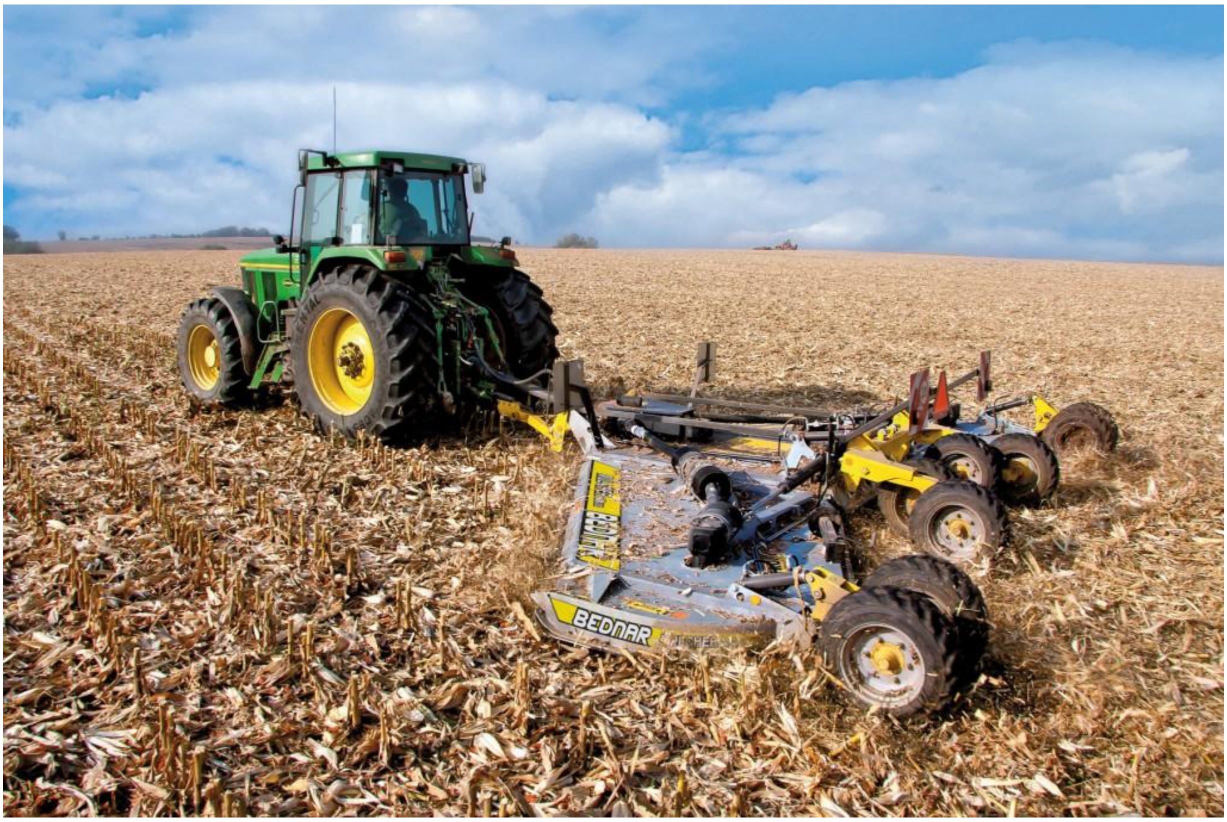
Required or supported by CAP?
Defined percentage of field surface cover by residues (typically 30 %) is required for some periods and crops by several countries within GAEC. No general common policy is being implemented, more protective mulching strategies are not supported.

Required or supported by national implementation of Common Agricultural Policy?									
In the Czech Republic required percentage of field surface cover by residues is 30% for high erosion risk fields and 20% for moderate erosion risk fields in combination with other measures.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes			yes		

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**			**		

Photos – if relevant



Only sample photo, http://mechanizaceweb.cz/vyssi-vynosy-reste-poskliznove-zbytky/

2.6 Fertilization with manure and compost

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Compost and manure are excellent fertilizers containing nitrogen, phosphorus, potassium and other nutrients. It also adds organic matter to the soil which may improve soil structure,

aeration, soil moisture-holding capacity, and water infiltration.

Applying compost and manure requires proper period, volumes, and a mixture of the fertilizers to be applied.

Intended goals of practice/measure

Composting biodegrades organic waste. i.e. food waste, manure, leaves, grass trimmings, paper, wood, feathers, crop residue etc., and turns it into a valuable organic fertilizer.

Compost reduces greenhouse gases. When food waste goes to landfills, it cannot decay efficiently and produces methane. Composting these organic materials that have been diverted from landfills reduces the emission of methane into the environment.

Composting is known to regenerate poor soil by encouraging the production of beneficial micro-organisms (mainly bacteria and fungi), which then break down organic matter to create humus. Humus helps retain moisture and naturally increases the nutrient content in soil.

Compost helps clean up contaminated soil. According to the EPA, the composting process has been shown to absorb odors and treat volatile organic compounds (VOCs) like heating fuels and explosives. In some cases, wood preservatives, pesticides, and both chlorinated and nonchlorinated hydrocarbons in contaminated soils were eradicated by the compost process.

Compost reduces the amount of water consumed by plants. Composting can also reduce plant diseases and pests, lessening the need for expensive chemicals and fertilizers. A higher yield of agricultural crops grown in composted soil can be reached.

Characteristics of practice/measure

The measure is suitable for any types of field, soil and crop. Accessibility or preparation of the compost is the key of the process.

To determine how much manure is needed for a specific application, the nutrient content and the rate nitrogen becomes available for plant uptake needs to be estimated. Nutrient content

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of manure varies depending on source, moisture content, storage, and handling methods.

Effectiveness in operation	
The effectiveness of the composting process is dependent upon the environmental conditions present within the composting system i.e. oxygen, temperature, moisture, material disturbance, organic matter and the size and activity of microbial populations. Composting is not a mysterious or complicated process. Natural recycling (composting) occurs on a continuous basis in the natural environment. Organic matter is metabolized by microorganisms and consumed by invertebrates. The resulting nutrients are returned to the soil to support plant growth. Nitrogen content in manure varies with the type of animal and feed ration, amount of litter, bedding or soil included, and amount of urine concentrated with the manure. Moisture content is also a major consideration. For example: The moisture content of fresh manure is around 70% to 85%. The moisture content of air-dried manure is around 9% to 15%. As manure dries, the nutrients not only concentrate on a weight basis, but also on a volume basis due to structural changes (settling) of the manure. Volatilization of urine nitrogen can result in considerable loss of nitrogen, up to 50% or more of the total nitrogen. Generally, dry manure contains 1.5 to 2.2 cubic meters per ton. Dry poultry and steer manure contain around 1.9 cubic meters per ton.	
On soil conservation	***
On flood control	*
On water quality conservation	*

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Cost	
Costs vary according to the region where the compost is purchased as determined by the cost of living and market trends. Pricing compost through multiple vendors may prove useful to save on overall expenses. For large quantities, it may also be necessary to factor in additional costs such as delivery.	
Investment costs	*
Operational costs	*
Economic losses of farmer	Not relevant for this measure

Potential problems/conflicts	
A healthy compost pile should not have a strong odor. If the pile does have a bad smell, it's most likely too wet or has too much nitrogen. Applying manure requires proper weather conditions and application has to be done according plant and field conditions.	
Rate	*

Required or supported by CAP?
Generally manure application is limited or regulated by GAEC standards based on field and weather conditions and is also a part of Nitrate Directive fulfilling strategy.

Required or supported by national implementation of Common Agricultural

Policy?									
In the Czech Republic manure application is limited or regulated by GAEC standards based on field and weather conditions.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no							yes		

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							*		

Photos – if relevant

Only sample photo

Project co-funded by European Union funds (ERDF, IPA)

2.7 Conservation crop rotation

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Crop rotation is an integral part of a sound soil conservation and crop management program. It involves growing different crops in sequence or at different times in a field. Through the selection of the proper sequence of crops in the rotation program, different goals can be achieved such as: increase soil organic, matter, improve soil structure, increase or decrease the content of some soil nutrients, and break disease and other pest cycles. Crops grown in the rotation system are chosen based on a number of factors such as: main commodity(ies) produced on the farm, location and climatic conditions, land base and soil type, cost of establishing the rotation crop and its potential return, production practices, and goals to be achieved.

Intended goals of practice/measure
The potential benefits of crop rotation should be an inspiration to evaluate crop rotation plans. The principle key points are based on the following aspects. Rotating crops with different types of root systems can improve soil structure, water holding capacity, and crop yield potential. Crop rotation offers benefits in disease, insect, and weed management. Introducing surface protecting crops in the crop rotation scheme reduces risk of soil erosion

by water and helps the soil protection. These are also intercrops and winter cover crops in relevant Danube regions.

Introducing proper fertilizing crops reduces inputs of synthetic fertilizers. E. g. numerous studies have shown yield increases when corn and soybean are rotated.

Characteristics of practice/measure

The measure is suitable for any types of field, soil and crop.

Effectiveness in operation

Soil organic matter and clay particles hold large stores of plant nutrients. These reservoirs, however, are not all available to the crop. In an organic crop rotation, the grower manages soil organic matter and nutrient availability by incorporating different crop residues, cycling among crops with different nutrient needs, using cover crops, and adding organic soil amendments. Most crops deplete soil nutrients during their growth cycle. Some of these nutrients leave the farm as harvested products, and the rest return to the soil as crop residues. The nutrients in residues may or may not be available to the next crop. Crop roots and residues improve soil fertility by stimulating soil microbial communities and improving soil aggregation. This improved soil physical environment facilitates water infiltration, water holding, aeration, and, ultimately, root growth and plant nutrient foraging. This section will review different ways that crop rotations affect soil fertility.

Understanding the basics of how nutrients are added to and released from soil organic matter will help the farmer in choosing crop sequences and amendments to optimize organic crop fertility. Certain fractions of soil organic matter contribute to plant nutrition more than other fractions. To effectively plan organic crop rotations to meet crop nutrient needs, several factors should be considered. Legume crops, which capture atmospheric nitrogen and “fix” it into forms available to plants, can be used strategically in rotations to meet the needs of nitrogen-demanding crops. Cover crops used after a cash crop capture surplus

Project co-funded by European Union funds (ERDF, IPA)

plant-available nutrients and conserve these for following crops. Cash crops themselves vary in their nutrient demands; considering their needs helps make the most efficient use of the available soil nutrients in a rotation. Finally, other types of organic amendments, such as compost and manures or approved mineral fertilizers, can supplement nutrients at targeted times during a rotation.	
On soil conservation	***
On flood control	*
On water quality conservation	***

Cost	
Proper crop rotation requires no additional costs, the economic balance is depended on farm planning in long enough term.	
Investment costs	*
Operational costs	*
Economic losses of farmer	Not relevant

Potential problems/conflicts	
Crop rotation breaks the cycle of disease between susceptible, closely related crops. Growing disease-resistant varieties and practicing excellent sanitation can be just as effective. Soil tests can confirm if nutrients need replenished in areas with heavy feeders.	
Rate	*

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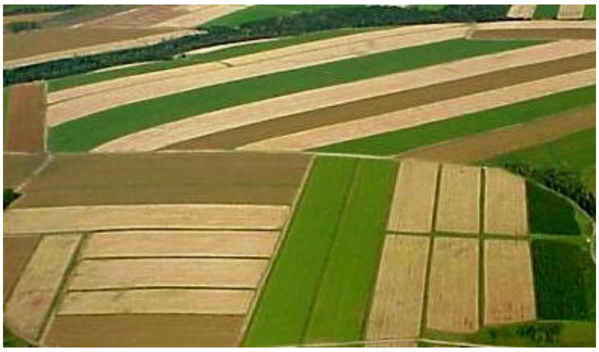
Required or supported by CAP?
Common agricultural policy should lead to comparable conditions for farmers, but also to comparable standards in soil conservation and water protection. On the other hand, CAP is implemented with high variability in different countries, due to different power of agricultural industries in negotiation conditions for every country. This type of measure is generally supported and is recognized as positive measure in terms of soil and water quality conservation.

Required or supported by national implementation of Common Agricultural Policy?									
In the Czech Republic winter cover crops and intercrops or other conservation crop rotation schemes are required by GAEC when using row crops in erodible areas.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no							yes		

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							*		

Project co-funded by European Union funds (ERDF, IPA)

Photos – if relevant



Only sample photo

2.8 Precision Agriculture

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
Precision agriculture (PA) or site-specific crop management (SSCM) is a farming management concept based on observing, measuring and responding to inter and intra-field variability in crops. The goal of precision agriculture research is to define a decision support system (DSS) for whole farm management with the goal of optimizing returns on inputs while preserving resources. Precision Agriculture (PA) is a whole-farm management approach using information technology, satellite positioning (GNSS) data, remote sensing and proximal data gathering. These technologies have the goal of optimizing returns on inputs whilst potentially reducing environmental impacts.

Intended goals of practice/measure
One example of a precision agriculture practice is to evaluate the natural soil variability of a field. If the soil in one area holds water better, crops can be planted more densely and irrigation can be sparing. Or, if the plot is used for grazing, more cattle can graze than a similar area of poorer quality soil. By studying these factors and using precision agriculture, farmers are able to produce more food at a fraction of the cost. Farmers also conserve soil for sustainable food production. Precision agriculture results in a stable food supply, which results in a strong community.

Characteristics of practice/measure
Precision agriculture can be implemented in all environments, on the other hand satellite driven machinery it is much more effective in large parcel systems and in flat topography.

Effectiveness in operation
Precision agriculture relies upon specialized equipment, software and IT services. The approach includes accessing real-time data about the conditions of the crops, soil and ambient air, along with other relevant information such as hyper-local weather predictions, labor costs and equipment availability. Predictive analytics software uses the data to provide farmers with guidance about crop rotation, optimal planting times, harvesting times and soil management. Sensors in fields measure the moisture content and temperature of the soil and surrounding air. Satellites and robotic drones provide farmers with real-time images of individual plants. Information from those images can be processed and integrated with sensor and other data to yield guidance for immediate and future decisions, such as precisely what fields to water and when or where to plant a particular crop. Agricultural control centers integrate sensor data and imaging input with other data,

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providing farmers with the ability to identify fields that require treatment and determine the optimum amount of water, fertilizers and pesticides to apply. This helps the farmer avoid wasting resources and prevent run-off, ensuring that the soil has just the right amount of additives for optimum health, while also reducing costs and controlling the farm's environmental impact.

On soil conservation	***
On flood control	*
On water quality conservation	**

Cost
Part of proper cost effective planning is keeping flexible and reducing capital expenditures in the early years of adopting precision agriculture. It is important to gather a few years of historical data and learn from the fields . The science behind the technology is currently changing rapidly and now might not be the best time to buy expensive equipment. New features, lower costs, and better functionality usually occur a few years after a big technology revolution.

Investment costs	***
Operational costs	***
Economic losses of farmer	

Potential problems/conflicts
The issue isn't with the technologies that make up precision agriculture, but the business model behind them. When it works, it is spectacular, but it only works in a few places—

where farmers can pay for them. Precision agriculture is sophisticated but it doesn't come cheap. The companies that sell it recover development costs from farmers with deep pockets, who make the investment because they work on a scale that makes it economically viable. Neither is it simple to operate or to service precision technologies. Farmers need to be well-educated, or depend on an extensive network of third party providers. None of this applies to where precision agriculture is actually often most desperately needed—where resources and inputs are scarce, farmers are poor, and lives are on the line. How to get the benefits of precision agriculture spread more broadly around the world is probably the most important question right now because, just maybe, the future of the world food system could depend on it.	
Rate	*

Required or supported by CAP?
The state-of-the-art of PA on arable land, permanent crops and within dairy farming are reviewed, mainly in the European context, together with some economic aspects of the adoption of PA. Options to address PA adoption are discussed, including measures within the CAP 2014-2020 legislation and the important contribution of advisory services across Europe. The goal of PA is to ensure profitability, sustainability and protection of the environment.

Required or supported by national implementation of Common Agricultural Policy?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**

Project co-funded by European Union funds (ERDF, IPA)

yes/no							yes		

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							*		

Photos – if relevant

Only sample photo

2.9 Control of Nutrients application

Type of practice/measure		
Technical	Management	Other - specify
	X	

Project co-funded by European Union funds (ERDF, IPA)

Description of practice/measure
In modern agriculture, use of essential plant nutrients in adequate amounts and proper balance is one of the key components in increasing crop yields. Further, in developing crop production technologies, research work under field and controlled conditions is necessary to generate basic and applied information. In addition, research is very dynamic and complex due to variation in climatic, soil, and plant factors and their interactions. Control over nutrient application should reduce the nutrient use and their fluxes to the environment, mainly to water sources to prevent excessive eutrophication.

Intended goals of practice/measure
The nutrients added to the system have to be controlled to • maximize productivity, • minimize nutrient losses, • maintain soil properties (organic carbon storage leading to better soil structure).

Characteristics of practice/measure
Generally, nutrients are essential part of soil fertility and their management is a key to the success of agricultural production of arable lands. Nevertheless, control over nutrient application is very complex task, depending on crop rotation, soil properties, type of fertilizers used (natural versus synthetic), machinery, and technology level of the farm. Precision agriculture in optimal conditions allows sophisticated nutrient management, on the other hand small scale family farms allow knowledge transfer from generation to generation. Soil and land are dynamic systems with long term variations concerning eg. phosphorus storage, and planning in years (better decades) is necessary to get sustainable nutrient management.

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Effectiveness in operation	
In most arable soils the nitrate availability depends mainly on the quantity of nitrate present in the rooting zone at the beginning of the growing season. Easily mineralizable organic N and the release of non-exchangeable NH4 from clay minerals may in addition control the nitrogen availability during a season. In flooded soils, ammonium is the major form of nitrogen absorbed by plants. Ammonium dynamics in these soils is similar to that of potassium. The availability of both is controlled mainly by the intensity and buffering power for ammonium or potassium, respectively. Basically, intensity of the supply and buffering power for phosphate are the main factors determining the phosphate availability. The determination of the phosphate buffer power, especially in the root zone, however, remains to be difficult. Soil test methods should take into consideration the major factors and processes relevant to the availability of a particular plant nutrient.	
On soil conservation	***
On flood control	*
On water quality conservation	***

Cost	
Proper control over nutrient management is money saving, no other costs are necessary. In combination with precision agriculture, costs are defined by investments in technology and education.	
Investment costs	For large farms – precision agriculture equipment

Operational costs	only connected to technology changes
Economic losses of farmer	-

Potential problems/conflicts	
Sophisticated systems, ideally precision agriculture, are required to minimize nutrient losses. To enhance the nutrient management over typical level needs only education and in young agronomist-driven farms it becomes to be a standard.	
Rate	*

Required or supported by CAP?
Required by GAEC in the water protection section and in Nitrate Directive implementation. Defined by no fertilizing distances to streams and water sources and to weather conditions.

Required or supported by national implementation of Common Agricultural Policy?

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

Project co-funded by European Union funds (ERDF, IPA)

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**			*		

Photos – if relevant

Only sample photo

2.10 Control of Pesticides application

Type of practice/measure		
Technical	Management	Other - specify
	X	

Description of practice/measure
The term pesticide can refer to insecticides, herbicides, fungicides, rodenticides, and various other substances used to control pests. Pesticides are used in agriculture to control weeds, insect infestation and diseases. A pesticide is any substance or mixture of substances used to: prevent; destroy; repel; reduce pests and the damage caused by pests. Control over pesticide application should reduce the pesticide use and their fluxes to the environment, mainly to water sources.

Project co-funded by European Union funds (ERDF, IPA)

Intended goals of practice/measure
The biggest advantage of pesticides is they are readily available and very easy to use unlike alternative methods, such as biological control and other similar methods which can take a long while to plan and often don't have an immediate effect on pests. When pests must be controlled over large areas of land, pesticides prove to be very cost effective, including when less human labour is needed to maintain the pesticide process. The general effectiveness of the program and its economic benefits are increased greatly still when pesticides are used in a way that reduces the likelihood of the pests becoming resistant to the chemicals used to fight them. If all the correct precautions are used, including using no more than the recommended level, then chemical control of pests can be used effectively.

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Characteristics of practice/measure
Pesticides are widely used on agricultural crops, in the home and yard, and in public places. Pesticides come in a variety of states. They can be solid, such as dusts, granules, pellets, wettable powder, etc. Liquids can be ready-to-use or concentrated.

Effectiveness in operation	
On soil conservation	*
On flood control	*
On water quality conservation	*

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Cost	
Farmers maintain unnecessarily high levels of pesticide use because pesticides are weakly regulated, because farmers pay none of the costs to remedy the pollution caused by pesticides, and because pesticides account for a relatively small percentage of overall production costs and per-acre crop value.	
Investment costs	***
Operational costs	**
Economic losses of farmer	***

Potential problems/conflicts	
However, when the disadvantages of pesticides outweigh the advantages, farmers look to alternative methods of pest control, the most common being biological pest control. Unlike chemical pesticides, biocontrol uses natural methods to fight pests; i.e., the pests' natural predators. The most obvious advantage to this method over pesticides is that the natural balance in the ecosystem remains fairly undisturbed. When pesticides are put into use it isn't only the pests that can be affected, but also their natural predators; eventually the pests might even come back in more force, as their natural predators aren't around to deter them anymore.	
Rate	**

Required or supported by CAP?
Pesticides are limited by general legislation, but the protection of environment is week. GAEC is generally not limiting the pesticide use.

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Required or supported by national implementation of Common Agricultural Policy?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no									

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							**		

Photos – if relevant

Only sample photo

2.11 Retention ditches

Type of practice/measure		
Technical	Management	Other - specify

X		

Description of practice/measure
Retention ditches are usually connected to a system of other retention features, including, where appropriate, hedges, ponds, ditches trees in line, and others. Opposite to typical ditch, to achieve retention capacity, they have to be contour oriented, usually constructed as a grassed, shallow profiles accessible with conventional agricultural machinery.

Intended goals of practice/measure
They are used to collect surface runoff and to improve the quality of water by natural processes such as sedimentation, decomposition, solar disinfection and soil filtration. The main advantages are following: • Simple, if space is available • Collection and improvement of water quality at the same time • Natural processes, no energy or high-tech appliances required • Improved storm water management and flood control • New habitat can be created in a complex of enhanced landscape fragmentation

Characteristics of practice/measure
The design of a retention ditches needs to be well fitted to its surroundings. When choosing a suitable site, the main factors to consider are the cost effectiveness of the area as well as its ability to support the retention ditch environment. The retention ditches should be constructed on mild slopes (up to 6°) and on permeable soils

Project co-funded by European Union funds (ERDF, IPA)

to infiltrate fast enough prior another rainstorm episode. They have to be designed to hold the total flow volume (not only peak discharge) of the design flood. Otherwise, being overflooded, they loose their anti-erosion and flood protection function.

Effectiveness in operation	
One main prerequisite for the construction of retention features generally is space. Retention ditches are usually wider than other technical measures, depending on soil texture and soil profile composition (infiltration capacity).	
On soil conservation	*
On flood control	***
On water quality conservation	**

Cost	
Primary implementation costs of retention ditches are high and constant maintenance is inevitable, as otherwise pollutant export and erosion can occur.	
Investment costs	**
Operational costs	*
Economic losses of farmer	

Potential problems/conflicts
The main problems refer to the following:

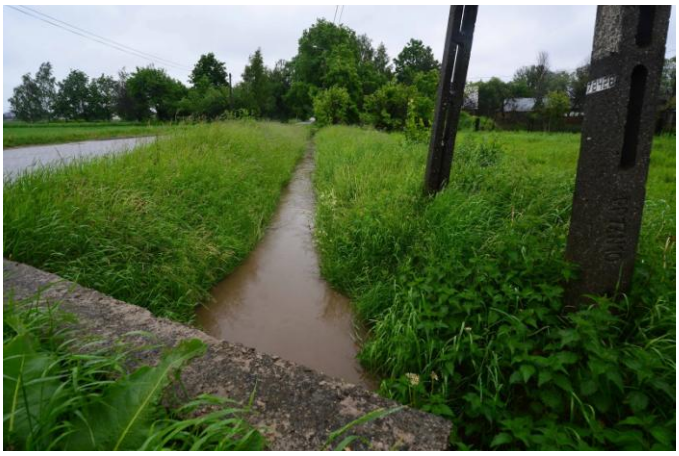
• large land areas are needed; • if not designed correctly, negative impacts on water quality can occur. • Implementation is best with a complex system of other prevention systems, and the ditches are limiting field sizes and complicating field management for heavy machinery use. • As a technical measure, the large area for structures usually have to be bought or rented, the land consolidation process have to be started for implementation, slowing and complicating the process.	
Rate	*

Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?									
In several countries the measure is one of the possible choices of protection of highly erodible parcels within GAEC. In the Czech Republic Rural Development Plans support land consolidation on cadaster level, that is slow, but the most effective tool for implementation of technical measures.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no									

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				*			*		

Photos – if relevant



Only sample photo

2.12 Grassed waterways

Type of practice/measure		
Technical	Management	Other - specify

X		

Description of practice/measure
Grassed waterways are broad, shallow and typically saucer-shaped channels designed to move surface water across farmland without causing soil erosion. The vegetative cover in the waterway slows the water flow and protects the channel surface from the eroding forces of runoff water. Left alone, runoff and snowmelt water will drain toward a field's natural draws or drainage ways. It is in these areas that grassed waterways are often established. If properly sized and constructed, grassed waterways safely transport water down natural draws through fields. Waterways also provide outlet channels for constructed terrace systems, contour cropping layouts and diversion channels. Grassed waterways are a good solution to the erosion caused by concentrated water flows when the watershed area generating the runoff water is relatively large.

Intended goals of practice/measure
The main advantages of a grassed waterway are as follows: • the waterway will carry large flows, making it suited to safely carry runoff from large upstream watersheds • Grassed waterways likely improve the quality of the water that enters the channel, and they can also prevent further water-quality degradation by reducing ephemeral gully erosion. • Farm machinery can cross it. • Once vegetation is established, maintenance is low.

Characteristics of practice/measure
The waterway reduces soil erosion and captures most nutrients and pesticides that would

normally wash out into major waters. It helps to carry surface water at a non-erosive velocity. Outlets must be adequate enough to allow water to drain without ponding or flooding the area being protected, while also preventing erosion of the water into the outlet which can be accomplished through the use of riprap. A limitation is during large runoff events, when soil is saturated, grassed waterways will have a very concentrated flow of water making them not as effective during high rainfalls. Grassed waterways require very little maintenance once they are introduced with major upkeep being mowing of the grass and reseeding. Farm machinery and cattle can usually cross it during normal climatic conditions.

Effectiveness in operation	
Well designed and maintained grassed waterways can be an important tool for maintaining soil quality and productivity.	
On soil conservation	***
On flood control	*
On water quality conservation	*

Cost	
Primary implementation costs of technically structured waterways are high depending on the design parameters and project complexity. In rural open areas the design may be much simpler just by proper grassing of typical ephemeral gully areas reducing the investment costs to minimum.	
Investment costs	**

Project co-funded by European Union funds (ERDF, IPA)

Operational costs	**
Economic losses of farmer	*

Potential problems/conflicts
The disadvantages may be: • working around the waterway with farm equipment can be difficult • the waterway lacks the depth necessary to serve as a tile drainage outlet • establishing vegetation may be difficult. • As a technical measure, the large area for structures usually have to be bought or rented, the land consolidation process have to be started for implementation, slowing and complicating the process.

Rate	**

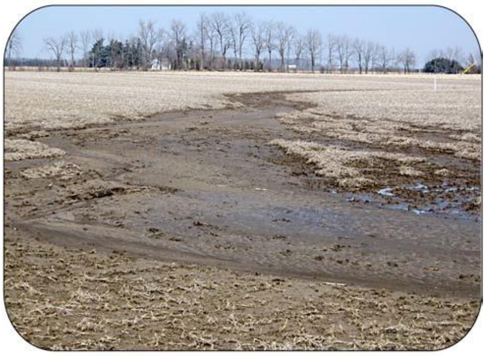
Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?
In several countries the measure is one of the possible choices of protection of highly erodible parcels within GAEC. In the Czech Republic Rural Development Plans support land consolidation on cadaster level, that is slow, but the most effective tool for implementation of

technical measures.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				*			*		

Photos – if relevant



Only sample photo

2.13 Sediment traps

Type of practice/measure

Project co-funded by European Union funds (ERDF, IPA)

Technical	Management	Other - specify
X		

Description of practice/measure
A sediment trap is generally a constructed 'basin' or depression or a dam at the field outlet, where sediment settles out and accumulates, allowing for its removal. Regular maintenance of sediment traps (removal of accumulated sediment) is a necessity to ensure their proper function.

Intended goals of practice/measure
Sediment traps and bunds can reduce pollution risk by intercepting run-off and allowing the soil carried in the run-off to fall out. They can also be useful in emergency situations to intercept and capture any small slurry or chemical spills on the steading. They are most appropriate where run-off polluted with sediment is the main concern and are not appropriate for accepting more polluted types of run-off such as slurry. Having a sediment trap upstream of a pond or wetland will help provide the opportunity for heavier particles within the run-off such as soil and sediment to settle out. Sediment traps or bunds can also be used in-field to help reduce soil erosion. For example sediment traps can be a useful method of collecting run-off from a particular area at higher risk of soil erosion, such as a gateway. Bunds are particularly useful on sloping fields where the run-off tends to exit the field at a particular point, such as a valley bottom, where slopes converge or the low corner of the field.

Project co-funded by European Union funds (ERDF, IPA)

Characteristics of practice/measure
Sediment traps can be designed as dry ponds at the field or small watershed outlets prior the sediment entrance to ditches or permanent streams. The other variant is digging small sinks with overflow for smaller contributing areas. Finally, impervious, but recyclable dams are being tested worldwide, built from straw piles, bushes or wooden residues.

Effectiveness in operation	
Sediment traps are intended to treat run-off which currently discharges directly to a watercourse, to minimise the volume or level of polluted run-off that the feature must deal with. Within an arable field other measures have to be introduced together with a sediment trap to reduce the risk of soil erosion and enhance the effectiveness of the trap. To be effective it is important that the traps are regularly maintained.	
On soil conservation	*
On flood control	**
On water quality conservation	**

Cost	
Investment costs	**
Operational costs	***

Project co-funded by European Union funds (ERDF, IPA)

Economic losses of farmer	*

Potential problems/conflicts	
The sediment trap is a technical structure affecting runoff conditions. Therefore the official process of construction permission and land allocation can be necessary, needing a permission of river management authorities and relevant stakeholders.	
Rate	**

Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?

In several countries the measure is one of the possible choices of protection of highly erodible parcels within GAEC. In the Czech Republic Rural Development Plans support land consolidation on cadaster level, that is slow, but the most effective tool for implementation of technical measures.

Country	AT	BG	HR	CZ	D	HU	RO	RS	SLO
yes/no									

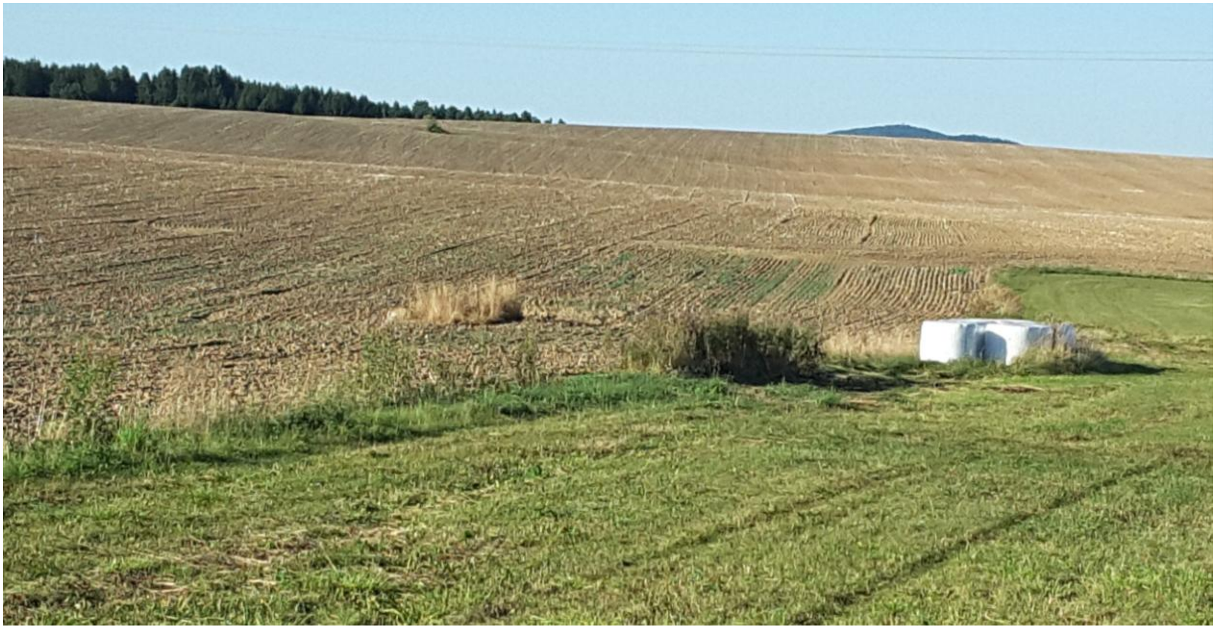
Applied in the country?

Project co-funded by European Union funds (ERDF, IPA)

Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***							*		

Photos – if relevant

Only sample photo (JK)



2.14 Hedges

Type of practice/measure		
Technical	Management	Other - specify

Project co-funded by European Union funds (ERDF, IPA)

X		

Description of practice/measure
A hedge is a permanent cover stripe together with a row of bushes or small trees separating two parcels, often accompanied by a path, small road, or a ditch. Hedging agricultural crops can be a very useful risk management tool if used correctly, promoting also other ecosystem functions.

Intended goals of practice/measure
Besides the basic erosion function (permanent obstacle to the surface runoff), there are of great importance in terms of landscape aesthetics and nesting and migration zones for small game, insects, plants and all living organisms, while increasing the permeability of the landscape for living (because of disproportionately large field units created earlier, the agricultural landscape became a human being impenetrable). It can function in the landscape as an indispensable part of local bio-corridors. Advantages of hedges: • Shelter for lambing/calving and crops • Livestock retention • May help prevent water run off • Potential yield increases due to change in microclimate • Increase resistance to soil erosion • Reservoir of predators of pests • Breeding site for birds • Natural habitat corridor

Project co-funded by European Union funds (ERDF, IPA)

Characteristics of practice/measure
The hedges, often designed with infiltration stripes or ditches are permanent obstacles to the concentrated surface runoff. They are basically composed of the three parts: - infiltration grass stripe - a custom body with trees and bushes - drainage elements (ditch, waterway, road)

Effectiveness in operation	
Well designed and maintained hedge can be an important tool for maintaining soil quality and productivity, but also rises the overall quality of the landscape.	
On soil conservation	**
On flood control	*
On water quality conservation	*

Cost	
The costs may vary depending on local conditions and design complexity. Generally the hedges were a natural result of a landscape maintenance (with a limited force) over centuries. Re-introducing main original structures is an investment to the future sustainable open landscape in Europe.	
Investment costs	**

Operational costs	*
Economic losses of farmer	*

Potential problems/conflicts	
Pesticide & fertilizer drift. This can be a particular problem on intensively managed arable land. Herbicides were often applied to 'hedge bottoms' to eliminate arable weeds such as Cleavers (Galium aparine) or Baron Brome (Anisantha sterilis). This proved to be a very damaging practice for the flora and fauna of hedgerows, and there is research evidence to show that it is an ineffective strategy for weed control as herbicides may not kill all of the plants they come into contact with. Accidental spray drift into hedge bottoms is very common, particularly in arable fields that are cultivated right up to the field boundary. The removal of hedge base flora has been shown to reduce insect numbers, having an indirect effect on predatory invertebrates, bird, mammal and where relevant, reptile and amphibian populations. The same factors apply to the use of insecticides, many of which are 'broad spectrum' and consequently lethal to a diverse range of invertebrates. Small mammals such as shrews and bird species such as tits and partridges depend on field margin insects to rear their young. In some studies, fewer bird species have been recorded in hedgerows adjacent to arable fields compared to those bordering grassland, this has often been attributed to insecticide drift, but could be attributed, to some extent, to the larger field sizes, and greater frequency of management operations on arable land. **Close cultivation.** Cultivating land right up to the hedge base can be detrimental to the flora and fauna. It: • Reduces the width of, or totally removes the 'grassy strip' between the hedge bottom and the crop, therefore restricting habitat by plant removal • Increases the likelihood of pesticides and fertilizers entering the hedge itself • Can also directly damage roots of hedgerow shrubs and trees.	
Rate	

Project co-funded by European Union funds (ERDF, IPA)

Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?									
In several countries the measure is one of the possible choices of protection of highly erodible parcels within GAEC. In the Czech Republic Rural Development Plans support land consolidation on cadaster level, that is slow, but the most effective tool for implementation of technical measures.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**					

Photos – if relevant

Only sample photo

2.15 Infiltrating pools

Type of practice/measure		
Technical	Management	Other - specify
X		

Description of practice/measure
An infiltration basin is a type of best management practice (BMP) that is used to manage stormwater runoff, prevent flooding and downstream erosion, and improve water quality in an adjacent river, stream, lake or bay. It is essentially a shallow artificial pond that is designed to infiltrate stormwater through permeable soils into the groundwater aquifer. Infiltration basins do not release water except by infiltration, evaporation or emergency overflow during flood conditions..

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Intended goals of practice/measure
Infiltration basins are vegetated depressions designed to hold runoff from impervious surfaces, allow the settling of sediments and associated pollutants, and allow water to infiltrate into underlying soils and groundwater. Infiltration basins are dry except in periods of heavy rainfall, and may serve other functions (e.g. recreation). They provide runoff storage and flow control. Storage is provided through landscaped areas that allow temporary ponding on the land surface, with the stored water allowed to infiltrate into the soil. The measure enhances the natural ability of the soil to drain water by providing a large surface area in contact with the surrounding soil, through which water can pass. Infiltration basins may also act as "bioretention areas" of shallow landscaped depressions, typically under-drained and relying on engineered soils, vegetation and filtration to reduce runoff and remove pollution. They provide water quality benefits through physical filtration to remove solids/trap sediment, adsorption to the surrounding soil or biochemical degradation of pollutants. Infiltration basins have the potential to provide ancillary amenity benefits. They are idea for use as playing fields, recreational areas or public open space. They can be planted with trees, shrubs and other plants, improving their visual appearance and providing habitats for wildlife. They increase soil moisture content and help to recharge groundwater, thereby mitigating the problems of low river flows.

Characteristics of practice/measure
In general, infiltration basins are designed to treat small drainage areas, typically covering a number of properties. They are typically used to serve drainage areas up to 20 hectares. Infiltration basins should be designed to treat runoff from a small drainage area (small number of properties), since use for larger drainage areas may result in increased risks of high sediment loadings that will reduce the effectiveness of the basin. Water quality has to

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be investigated first as this has a considerable influence on the design, especially of the pre-treatment part to avoid spreading of polluting substances that may afterwards be difficult or costly to treat and keep the quantity of sludge to treat as low as possible. Although designed to infiltrate stored water, an outflow control structure should also be included in the design, along with an emergency spillway where required to deal with exceedance events in a controlled manner. The basin floor should be made as level as possible to maximize storage and infiltration potential and minimize the risk of erosion. This will also reduce flow velocities within the basin and maximize pollution removal potential for detention basins.

Effectiveness in operation	
Infiltration basins are typically designed to infiltrate 50% of their storage volume within 24 hours of filling. Infiltration basins are generally designed to capture and infiltrate runoff volumes for events up to the 1 in 30 year storm for the drainage area, but sometimes even for events up to 1 in 100 year storm. The effectiveness of the basin at providing this storage will depend on the condition of the underlying soil and the characteristics of the drainage area. If designed correctly with an appropriate outfall, infiltration basins are also effective at slowing runoff for events that exceed the storage/infiltration capacity of the basin. Additional storage should be allowed above the outlet to allow for some slowing of runoff rates during larger events. Infiltration basins are effective at storing runoff from small drainage areas and route this, via infiltration, to soil and groundwater storage. Through this impact, they enhance the potential of the landscape to store water during floods and, through preventing rapid runoff, make this water available for other purposes (e.g. recharge to groundwater, offering soil moisture to support terrestrial ecology).	
On soil conservation	*

On flood control	***
On water quality conservation	*

Cost	
Infiltration basins are high land - take measures. The primary cost is therefore the cost of land acquisition. Due to the higher costs of land, it is usually more expensive to retrofit these basins to already developed areas as compared to constructing one in an undeveloped region. Geotechnical investigations are required to confirm the land stability and underlying soil/geology conditions prior to construction. These may need to be intrusive and require analysis of land contamination to determine suitability of infiltration techniques.	
Investment costs	***
Operational costs	*
Economic losses of farmer	

Potential problems/conflicts	
Infiltration basins should not be used as solutions for larger drainage areas due to the increased risk of sediment loading to the basin, reducing its effectiveness as an infiltration feature and increasing the risks of pollutant loading that may be transferred to groundwater through infiltration. Even for small drainage areas, effective pre-treatment to capture sediment inflows is required to maintain the effectiveness of the basin.	
Rate	

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Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?									
In several countries the measure is one of the possible choices of protection of highly erodible parcels within GAEC. In the Czech Republic Rural Development Plans support land consolidation on cadaster level, that is slow, but the most effective tool for implementation of technical measures.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***				**					

Photos – if relevant

Only sample photo

2.16 Stabilized dung pits with retention tank

Type of practice/measure		
Technical	Management	Other - specify
X		

Description of practice/measure
The construction of a manure storage facility involves some risks with regards to the negative effects on the environment. Therefore, it is impetuous to establish rules and conditions for setting up and organizing livestock manure storage structures that have a negative impact on the environment.

Intended goals of practice/measure
To operate the important and fertile, yet dangerous nutrient source, manure, safely, with benefits for agricultural production and minimal risks for environment.

Characteristics of practice/measure
The farmer must be trained and aware of all considerations regarding the geological, technical and most important aspects of soil, water, and atmosphere protection. In most cases, however, farm advisory services are virtually non-existent, storage facilities for unsuitable livestock are arranged, which are inconsistent with the soil's capacity to take over the loads from the accumulation of enormous quantities of residual organic materials, which, as is known, contain besides the nutrients necessary for the development of crop plants and organic

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elements and components with potentially toxic effects on the main environmental resources such as soil, water, atmosphere. This is a general framework for the conditions to be met when a manure storage facility is planned for large-scale agrozootechnical farms with high yields of animal waste and low-capacity farms, the so-called households. Also, the conditions that need to be met when designing a communal manure storage platform are presented.

Effectiveness in operation	
In many cases, the incorporation of livestock manure into natural soils can cause sealing, ie, clogging of porous space. Some salts present in animal manure have negative effects on the soil, causing particle dispersion, reducing water permeability. The structural state of the soil can be altered as a result of the biological processes that are intensified by the accumulation of organic matter from the livestock manure. Although the quantities of animal manure embedded in the soil can cause compact layers due to the occurrence of porous space clogging processes, reducing its permeability, it is almost certain that these effects do not lead to the creation of a "waterproof barrier" for deep migration and accumulation in the groundwater of potentially toxic elements and substances. It is therefore mandatory to set a maximum allowed limit for the soil infiltration rate on which the manure storage basin is built; it is admitted a maximum permissible soil infiltration rate of 10^{-7} cm / s.	
On soil conservation	*
On flood control	
On water quality conservation	*

Cost

Investment costs and manipulation costs depending on a farm size and proportion of animal production.

Investment costs	*
Operational costs	**
Economic losses of farmer	

Potential problems/conflicts	
The measure should be mandatory, not raising actual conflicts.	
Rate	

Required or supported by CAP?
The measure is supported generally mainly by EU documents, dealing with nature and water quality conservation – i.e. nitrate directive (91/676/EHS).

Required or supported by national implementation of Common Agricultural Policy?									
Covered by Nitrate directive implementation in GAEC requirements within the Czech Republic.									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
yes/no				yes					

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Applied in the country?									
Country	**AT**	**BG**	**HR**	**CZ**	**D**	**HU**	**RO**	**RS**	**SLO**
Select level: *, **, ***									

Photos – if relevant

Only sample photo

Project co-funded by European Union funds (ERDF, IPA)