Transforming **U**nsustainable management of soils in key agricultural systems in EU and China

Developing an **i**ntegrated platform of alternatives to reverse soil degradation

Technical measures for soil erosion control

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Short description

The causes of erosion by water on agricultural land are numerous and complex. The most significant factors include inadequate soil cover, intense rainfall, the size and slope of the parcel, and improper tillage. The removal of vegetation, or the lack of sufficient vegetative cover, increases the susceptibility of the soil to erosion by reducing soil stability and increasing the rate of surface runoff. Slope steepness and tillage intensity (or downslope orientation) also increase the risk of erosion by facilitating surface runoff.

Technical measures help to reduce the susceptibility of land to water erosion. They can provide several functions. Slope shortening reduces runoff concentration and prevents from gullying. Stabilizing of concentrated runoff pathways reduces sediment connectivity. Slope reduction by terracing reduces runoff velocity. And finally slope interruption by retention measures promotes contour wise cultivation and supports water infiltration.

Target area

Depending on region, extremely important is keeping appropriate soil cover during intensive rain periods, since during cultivation and seeding periods the soil susceptibility to erosion is by far the highest. Technical erosion control measures are usually proposed when other forms of protection against the negative effects of water erosion cannot reach the necessary level of protection. In many cases, technical measures are combined with other types of measures (grassing, mulching, reduced tillage). The greatest effect is reached in areas highly susceptible to erosion. The determination of the susceptibility to erosion is the slope gradient, the slope length, the type of soil and the climatic conditions of the site. Technical measures are proposed to minimize damage to agricultural land, protect urban areas and infrastructure from sediment and muddy flooding.

Problem identification

The evaluation of erosion risk in the individual locality can be supported by the TUdi DST soil erosion app. The tool helps to identify, map and measure also high erosion forms (rills and gullies). Especially in places where these forms occur repetitively the technical measures should be designed.

Detailed description of protection

The basic principles of technical erosion control measures are the following:

- reduction of slope length, interruption of surface runoff, absorption of surface runoff, trapping of eroded material, and safe drainage of concentrated surface runoff (ditches, grassed waterways);
- interception of surface runoff, its retention, and safe conveyance (sedimentation and retention reservoirs, ditches);
- reducing the slope to reduce flow velocity (terraces).

Opposite to other soil erosion control measures, they should be designed using also hydraulics and runoff assessment methods. They are installed permanently, as a construction and they could provide multifunctional servicing (flood protection, ecosystem servicing, land fragmentation support, land connectivity for recreation and tourism, etc.).

Examples of technical soil protection measures can be: hedges, retention ditches, sediment traps, small dams, fish scale pits, grassed waterways and terracing.

The following types of technical erosion control measures are most commonly used for the protection of agricultural land:

- ditches;
- grassed waterways;
- terraces.

Ditches are linear structures placed at the point of a required slope interruption. They can be combined with other structures (hedges, roads). The ditch is usually orientated contour-wise. According to the purpose of the ditch, the longitudinal slope varies from zero to a slight longitudinal slope (ca 1-2%). Most often it has a trapezoidal profile with a width at the bottom of 0.3-0.6 m, a depth of between 0.6-1.2 m, and a slope gradient of 1:1.5-1:10. Also, the rainfall intensity used for ditch design varies according to ditch purpose.

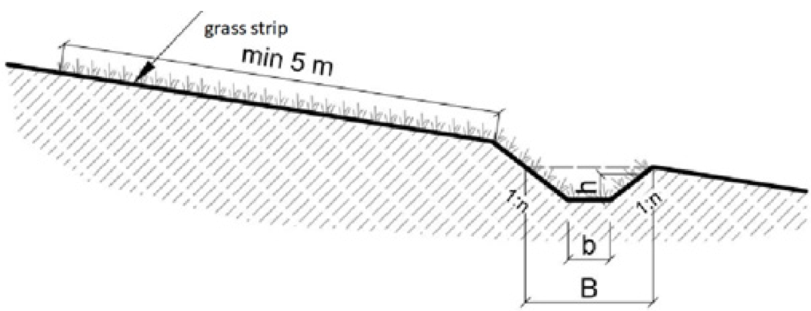

Fig. 1: Transverse profile of the retention ditch.

The 5-year design rainfall is used if the ditch protects arable parcel. If the objective of the ditch is to protect the urban area or other infrastructure, the level of protection is higher (to the 100 years of design rainfall can be used). The ditches should be subsequently evaluated for stability of the bottom and side slopes and, if necessary, fortified. If the ditch has steeper slopes, the culvert or other suitable infrastructure must be built for crossing by farm machinery. Ditches with slighter slopes of 1:10 can be managed and traversed without culvert, but the ditch takes up more space of the parcel. A permanent grass strip of at least 5 m wide should be established above the ditch to reduce surface runoff and to trap sediment. This strip of grass should be cut regularly to maintain maximum roughness. In terms of the spatial arrangement and function of the ditches, a distinction can be made between retention, drainage, and collection ditches.

Retention ditches capture surface runoff and allow water to infiltrate locally. It is orientated with zero/minimum slope, and often it is provided with drainage pipes in the bottom.

This type of ditch is of very important ecological importance. It supports local retention, and consequently also soil quality in the parcel. The hydraulic conductivity of the soil changes over time due to both vegetation development and sediment deposition.

On the other hand, there is a risk of overflow and runoff concentration when the capacity of the ditch is reached. Therefore, it is recommended that ditches always be designed to drain collected water by means of a slight longitudinal slope and equipped with small retention barriers, which can be overflown. Or with zero longitudinal slope but equipped with emergency spillway, which will lead excess runoff securely into recipient.

The placement of retention ditches is used on parcels with a slope less than 6%.

Fig. 2: Grassed retention ditch as designed in the Czech Republic (Dzuráková et al., 2017).

Fig. 3: A small drainage ditch as part of the drainage field system (Czech Republic)

Drainage ditches are constructed directly within protected agricultural land to reduce the length of surface runoff so that the allowed loss of soil loss is not exceeded. The longitudinal slope and the cross-sectional profile determine the capacity of the ditch and the flow velocity for which the stability of the bottom and slopes must be assessed.

Drainage ditches catch surface runoff and allow water to drain safely away from the parcel. It is usually designed with a longitudinal inclination (1-3%). The placement of drainage ditches is used in parcels with a slope above 6%. As the slope of the parcel increases, the retention capacity of the element decreases. In addition to retention ditches, drainage ditches are often accompanied by other vegetation barriers and grass strips.

Collection ditches are recipient ditches or retention ditches. These are constructed with a minimum gradient and are designed to capture and divert water away from the site. The collection ditch must then safely transport the captured water to the receiving water course. Several drainage or retention ditches may be connected to a collection ditch, so its dimension is usually larger.

Grassed waterways are surface runoff pathways where runoff water is concentrated. The waterways can concentrate and divert surface runoff from adjacent plots, or they can be the recipient of erosion control ditches. The risk point of grassy waterways is the crossing between the plot area and the grassy waterway area. If the valley is not clearly shaped, it can be modified locally to the desired cross-sectional profile. Regular maintenance is necessary for the proper functioning of the waterway.

Fig. 4: Grassed waterway in the agricultural landscape of the Czech Republic.

Terraces are the highest form of erosion protection for agricultural land and are suitable for highly sloped and sensitive land, with an approximate slope of more than 20%. In terms of stabilisation, they can be divided into terraces with a technically stabilised slope (retaining wall made of stone or concrete) or terraces made of soil, without technical slope stabilisation. In this case, the slope is stabilised only by vegetation. Terraces can be designed on deep soils and are economically feasible either in places where terraces give the landscape its special character or for production of high-income crops (vineyards, orchards, etc.). In Europe, terracing is nowadays considered only in special cases due to its extreme financial cost.

Fig. 5: Terracing in Hengshan District, Yulin, China (Google Earth).

Pros/Cons of technique, obstacles to implementation

Technical erosion control measures in agriculture are crucial to the conservation and sustainability of agricultural operations. These measures provide a range of benefits, including protecting the soil from erosion, improving water management, and promoting biodiversity. However, its implementation can be financially difficult and require time-consuming preparation. They can also limit the use of land for agricultural production. However, in the long term, they can reduce land maintenance costs and increase crop yields, bringing economic benefits. They play an important role in ensuring sustainable land management and the conservation of natural resources. Their proper use and combination with agroecological practices can lead to an overall increase in productivity.

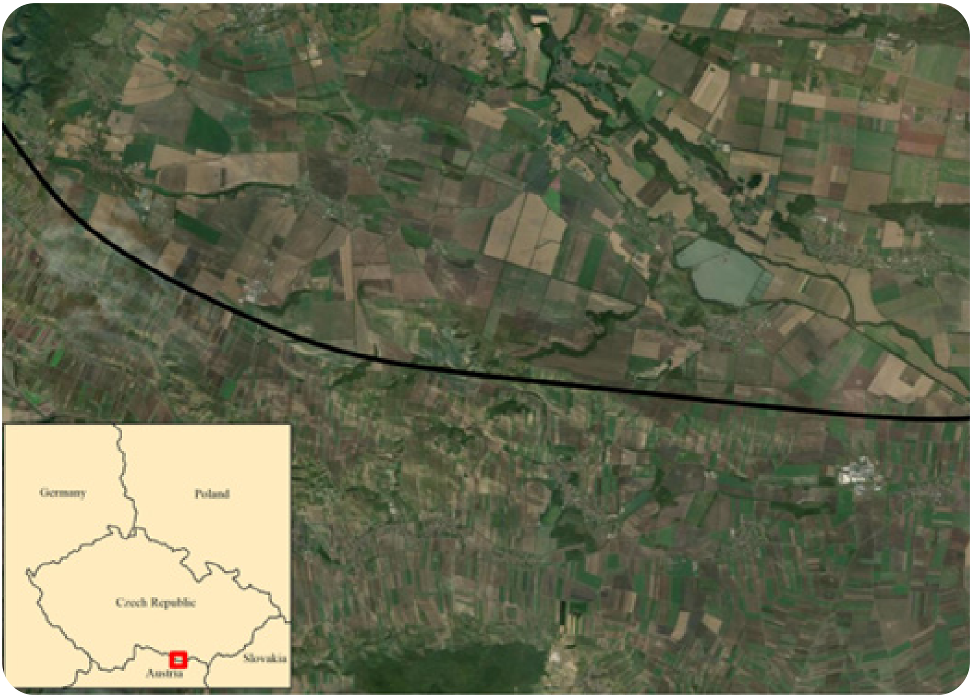

Fig. 6: Differences in plots sizes between the Czech republic and Austria (Noreika et al., 2021).

Effects/results/case studies

Each type of erosion control measure has its own specific characteristics and dimensioning requirements that must be taken into account in its design and implementation. The main objective is to protect the soil from erosion and to maintain the sustainability of agricultural operations, but also to protect downslope regions and reduce off-site effects.

For example, landscape of the Czech Republic suffers from collectivization of agriculture during 20th century. On average it resulted in largest field blocs in Europe in rolling landscapes. Here the technical measures can serve not only to reduce on-site soil erosion, but also to bring back desired landscape diversity promoting many other ecosystem services, including biodiversity and land attractiveness for tourism and sustainable living. Many technical measures can be inspired by land history (originally grassed waterways, old pathways and removed hedges).

More literature

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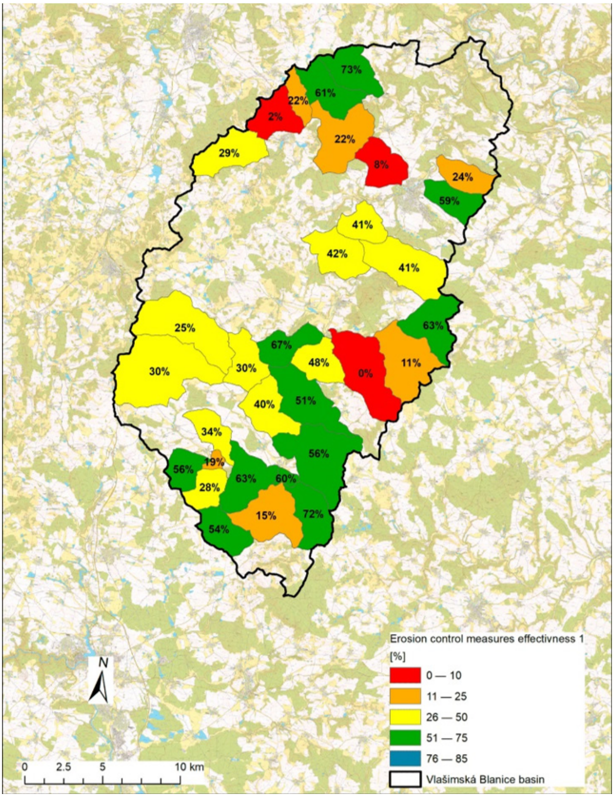
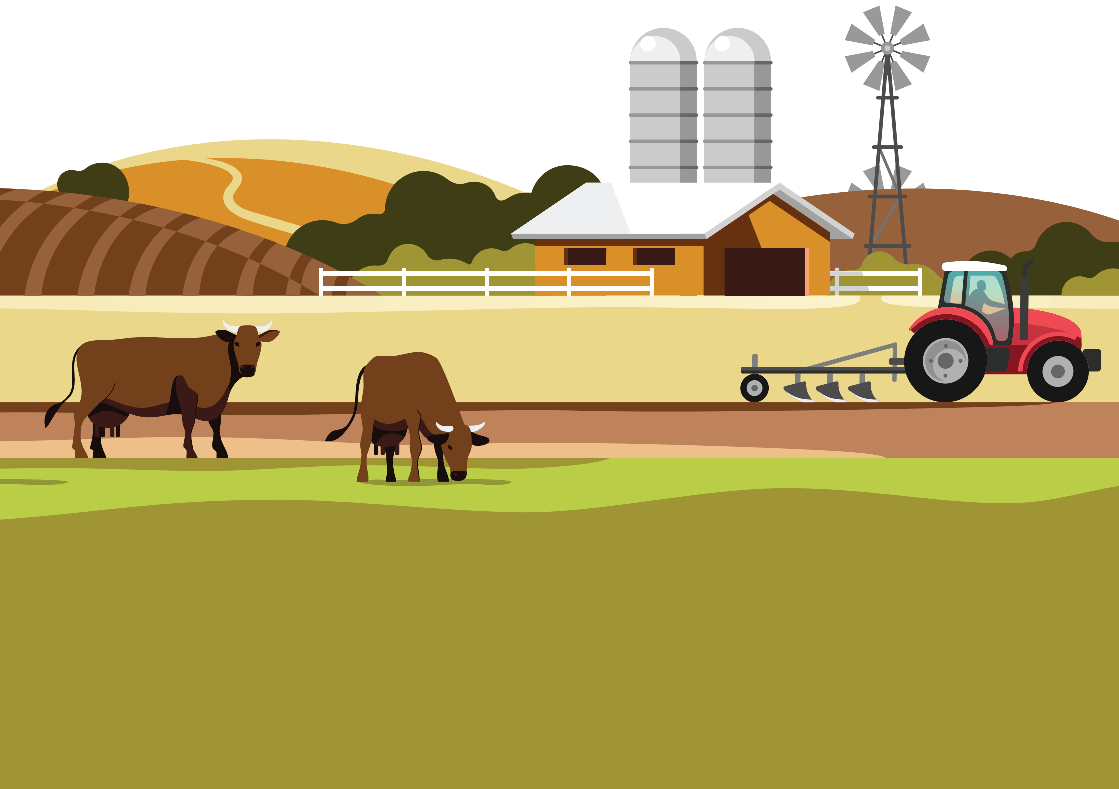


Fig. 7: Evaluated sediment transport in Blanice basin in Czech republic

Summary

Technical erosion control measures are often proposed as a last option where other soil erosion protection methods reach their limits. Their main principle is to interrupt the length of the slope, to capture and slow down the surface runoff, and to reduce the slope of the land. Examples include ditches, grassed waterways, and terraces. These measures are designed to take into account factors such as slope gradient, slope length, soil type, and climatic conditions to minimise damage to agricultural lands and protect intra-village, linear structures, and neighbouring lands from erosion. The positive effect is also seen in sediment transport, which is significantly reduced by technical measures and contributes to the preservation and quality of soil and water.



Summary table

	Rating	Comments
Soil health overall	**	
Water budget	*	
Soil structure		
Erosivity	***	
Nutrient balance	*	
Soil life	**	
Practicability		
Economy		

Consortium

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