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EFFICIENCY OF SOIL AND FLOOD CONTROL MEASURES IN LAND CONSOLIDATIONS

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Abstract

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Land consolidations are an important instrument for implementation of erosion and flood control measures. Thanks to their poly-functional character, they also contribute to increase of ecological stability and aesthetic of landscape. Although the land consolidation process does not advance as quickly as requisite, it brings unquestionably positive results. One or more erosion and flood control measures are built in 17% of cadastres with finished complex land consolidation. Land consolidation designs are supported by the state and the EU funds are used for the realization of protective and ecological measures. With the aim to evaluate real efficiency of implemented measures, research project QI92A012 has been started. This paper presents its method principles and particular results for one of the model cadastres – Lejčkov. Realized elements in Lejčkov were confronted with the plan of common facilities and critical analysis of the size, parameters, type and localization of elements was made with regard to their efficiency to keep the soil from surface erosion away in the long run, to decrease discharges and sediment transport in extreme precipitation events. We can state that erosion control measures in Lejčkov were designed and built well and they are suitable for the highland type of countryside.

soil and water conservation, land consolidation, conservation measures, efficiency

Soil degradation, lowering of landscape water retention and quality of surface water belongs among the hottest problems of the mankind. A large effort has been given to research on soil erosion and extreme rain storm – runoff events, its principles, patterns and effects. Simultaneously strategies and measures for the control of their harmful effects have been searched. Although most governments have some forms of soil protection policies (including erosion control), few are translated into effective action. Farmers do not consider the erosion and flood control measures as economic and so there is a very weak political will to enforce them (Morgan, 2008).

A possible way how to implement soil and water conservation measures is land consolidation. It is defined as planned reallocation and rearrangement of land parcels and their ownership. The land consolidation can be used to improve the rural infrastructure and to implement the developmental and environmental policy. Its goals and tools vary mainly in dependence on the needs and advancement of a country. The creation of conditions for intensive farming to obtain higher basic food production is the main aspect of land consolidation in Asia and Africa (e.g. Asadi, Mohammadi, Fami, 2009). European countries profitably use the land consolidation like a tool to establish public subservient buildings (Dijk, 2007) and other projects for a long time (e.g. motorways, dams, canals, etc.). Lisec and Pintar (2005) like other authors paid attention to ecological structures such as hedges, small patches of shrubs, trees and water holes in areas of intensive agricultural production, which should be preserved. E.g. Herweg and Ludi (1999) confirmed the high efficiency of such measures in decreasing the soil loss and extreme discharges.

To support new private agricultural business and farming in the Czech Republic after the year 1989 it was necessary to make the land ownership transparent, consolidate fragmented and narrow

parcels, and to make blocks of fields accessible (Sklenička, 2006). For this purpose the process of land consolidation started. It is defined by law that the soil, water and environment conservation is an important and publicly needful aspect of any complex land consolidation. Hence land consolidation creates a space for the designing and implementation of soil-conservation measures (e.g. grassing, balks, diversion terraces, shelterbelts, …).

MATERIAL AND METHODS

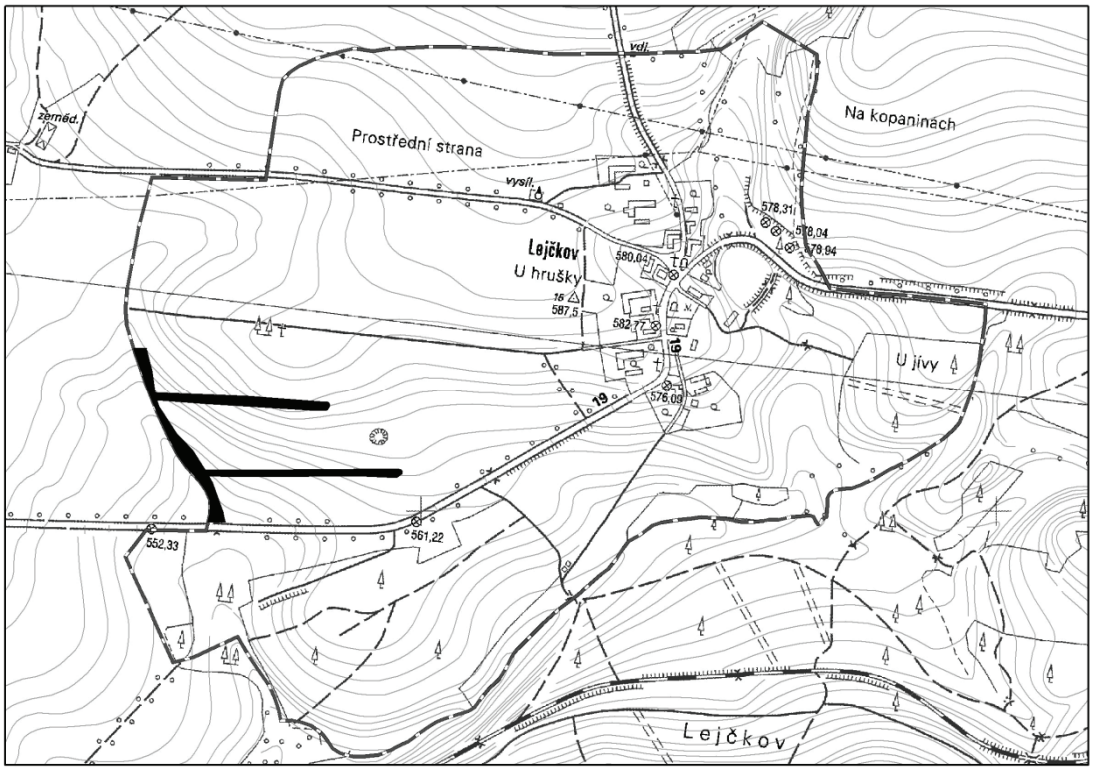
Twenty-five cadastral areas with at least one realized soil-conservation or hydrological facility were selected in order to evaluate the real effectiveness of land consolidation. Model cadastres are evenly distributed across the whole CR and represent its heterogeneous natural and anthropic conditions. To evaluate common measures in all cadastres methods and criteria based on uniform principles are used. Realized elements are confronted with plans of common measures and critical analysis of the size, parameters, type and localization of elements follows with regard to their efficiency to keep the soil from surface soil loss in the long run, to decrease discharges and sediment transport in extreme precipitation events. The method steps of evaluating the efficiency of soil-conservation and hydrological measures are:

1. calculation of the average long-term loss of soil using the USLE equation and GIS tools,
2. comparison of the long-term soil loss before and after realization using the planar histogram method,
3. evaluation of parameters of hydrological measures with their required capacity for considered N-year floods.

As the first step of evaluating the efficiency of soil-conservation measures it is necessary to determine the average limit of long-term soil loss for a given territory. It is calculated as the planar average of limits for shallow, medium deep and deep soil (Janeček *et al*., 2007) according to the representation of these soils in the territory concerned. Using the histogram method in the GIS environment it is computed what percentage area of agricultural land has lower erosion vulnerability than the computed limit. The efficiency of realization of soil-conservation measures is considered as convenient if the resultant long-term sheet erosion on 85% of agricultural land is below the defined limit. The exclusive use of planar average may be misleading if there are several small patches with a high rate of erosion in a territory weakly vulnerable to erosion. In case that the territory in question complies with the defined limit already before the realization of land consolidation, attention should be paid to localities that are more vulnerable to erosion and they should be evaluated in greater detail. It means that the efficiency of soil-conservation measures should be evaluated within the respective given catchment area. The general influence of the realization of soil-conservation measures on a reduction in the extreme long-term soil loss above 20 t/ha/year (= high vulnerability of deep soils to erosion) can be used as a complementary aspect.

The primary aspect of the convenient efficiency of flood-control measures is the protection of built-up areas of municipalities. A technical solution should meet the requirements of respective standards. Their capacity is usually designed for the safe transformation of maximum discharges from 50-year or 100-year rainfall events.

1: *Lejčkov – location*



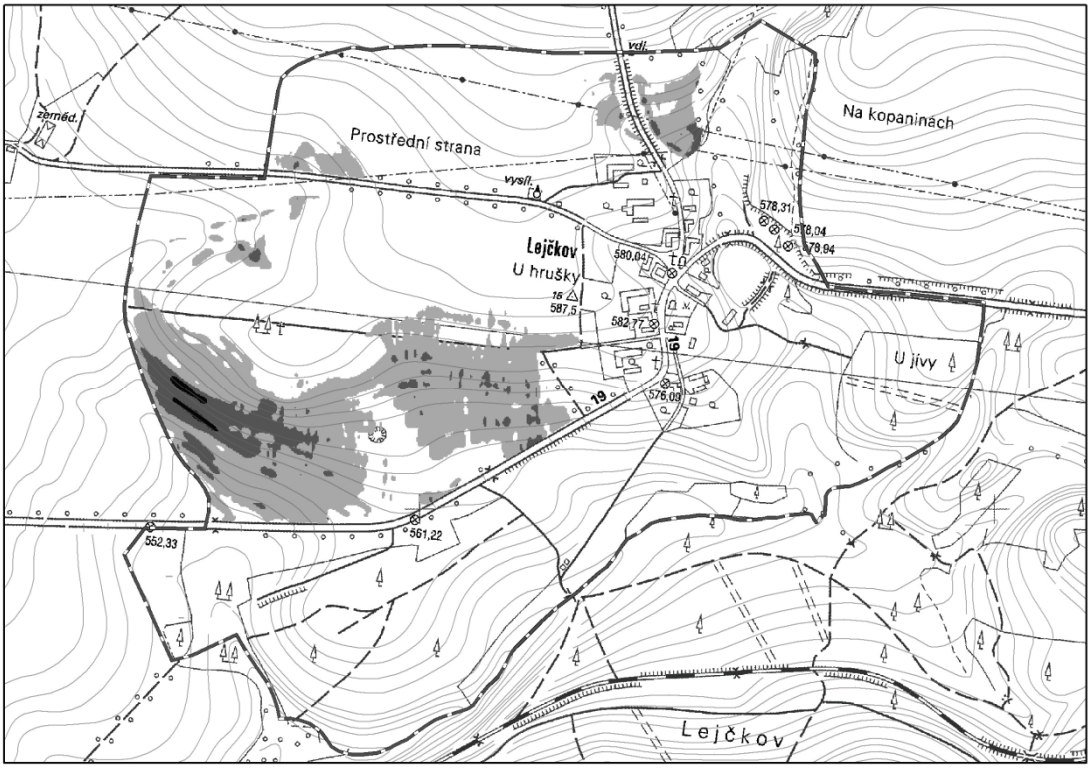
Legend – Fig. 2

Cadaster boundary

Erosion control measures

2: *Map of measures implemented in Lejčkov*

3: *Lejčkov – a view from the hillside ditch onto the grass waterway*



Legend – Fig. 4 and 5

Cadaster boundary

Average annual soil loss (t/ha/year)

0 – 4.1

4.11 – 10

10.1 – 20

> 20

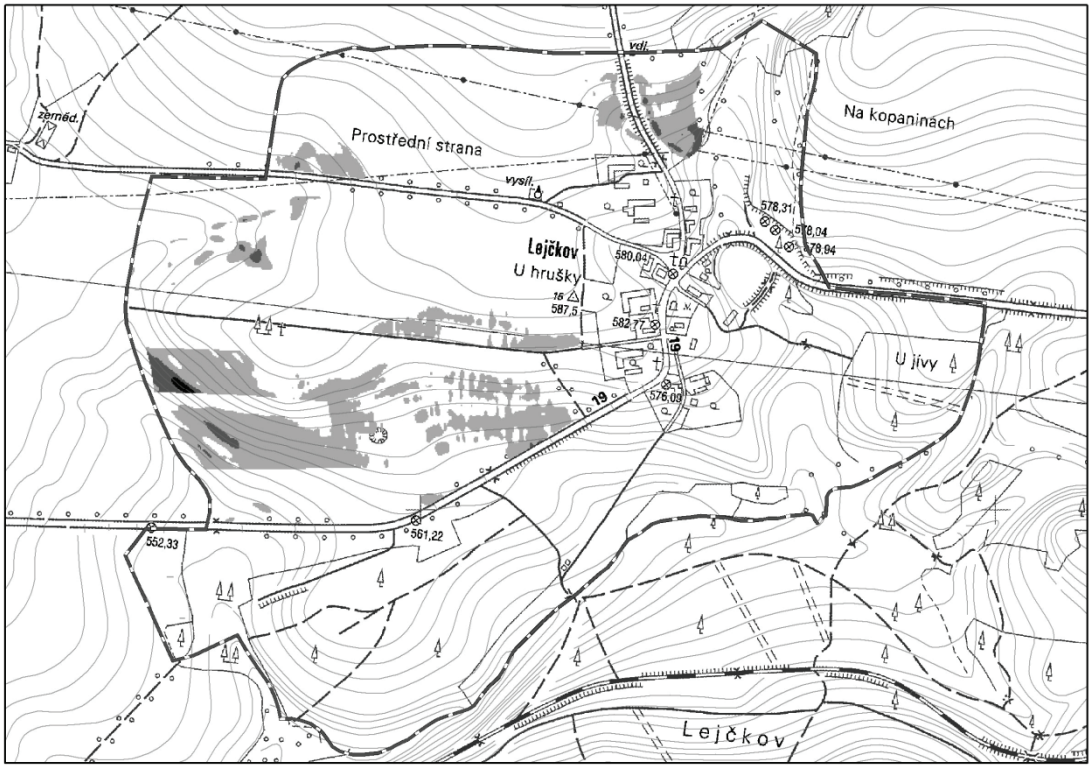
4: *Erosion threat before land consolidation*

Example of the Lejčkov cadastre evaluation

Lejčkov (Fig. 1) is a small cadaster (120 ha) on the Křemešnická vrchovina highland (av. 556 m a.s.l.). It belongs to the climatic region MT4 (moderately warm, wet). Loamy Cambisols and Stagnosols on gneiss predominate in the soil cover of the cadaster. Land consolidation in 1994–1997 was among the first carried out in the CR. Planned common measures were built in 2004–2005.

Intensive water erosion and surface runoff from sloping large blocks of agricultural land situated east of the municipality repeatedly caused damage to the state road. The area of the catchment at high risk of soil erosion partly stretches to the neighbouring cadastre Dolní Hořice. In accordance with methodological rules the project engineer did not solve only the land consolidation perimeter but the local catchment was solved as a whole. A grass waterway (40 m in width) with the consolidated stream bed in the middle was realized in the Lejčkov area. The stream bed consolidation was necessary because during surveys an erosion rill and damage to amelioration drainage were identified in the level line. Two collecting hillside ditches with balks (Fig. 2 and 3) open into the waterway, their width of 7.5 m being in accordance with implementation documentation. Their capacity is sufficient to safely conduct runoff from a 100-year rainfall event. The mirror continuation of hillside ditches on the opposite slope in the Dolní Hořice cadastral area is designed in the plan of common measures (PCF) for land consolidation that is underway there. Before the realization of land consolidation 20% of the territory was vulnerable to erosion (Fig. 4). After the implementation of the PCF the limit of the long-term erosion soil loss (4.1 t/ha/year) has not been exceeded on 89% of agricultural land (Fig. 5). Hence the efficiency of soil-conservation measures is excellent.

Somewhat problematic is the inlet of the waterway into a pipe culvert (30 cm in diameter) under the road of category I. Discharges in this profile ($P_{watershed}$ = 39.6 ha) may reach 2.74 m³/s in a 100-year rainfall event. The culvert capacity is maximally 0.16 m3/s. There is a sufficient accumulation space above the road embankment but as a result of



5: *Erosion threat after implementation of erosion control measures*

repeated impacts of water the road embankment could be destroyed over time. The waterlogging and deposition of fine soil particles in the construction layers of the road pavement decrease its carrying capacity. A bridge e.g. with the rigid frame culvert would be a suitable solution.

SUMMARY

After 1990 greater fragmentation of the consolidated blocks of land was expected while it was assumed that the land owners would take possession of their lands and would farm on their property. But these assumptions failed even after the transformation of state and cooperative organizations and farmers continue to work in the original consolidated fields. Since the mid-nineties diversification elements have gradually been introduced into landscape, particularly thanks to various programmes and subsidies from national resources and also from the EU funds since 2002. Land consolidation is an important tool for the realization of these elements.

According to the report of Ministry of Agriculture of the CR as to the 31st December 2011 there were 1 334 cadastres that finished the project of complex land consolidation (i.e. 8 % of the CR area). At least one erosion or flood control measure was implemented in 17 % of them. Nowadays the projects are running in 779 cadastres (5 % of the CR area). Although the land consolidation process does not advance as quickly as required, it brings marked positive results. Erosion control measures implemented in the Lejčkov cadaster are an illustration of potential and possibilities of land consolidations in the soil and water protection. The balks along the hillside ditches were planted with row of local trees so the landscape aesthetic and ecological stability improved.

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