AGRICULTURAL SOIL AND FRESHWATER ECOSYSTEM SERVICES IN SLOVAKIA – OPPORTUNITIES AND CHALLENGES FOR THEIR PRACTICAL APPLICATION

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Abstract
Water and soil belong to natural resources which are essential for the existence and development of human civilization. Ecosystem services (ESS) which provide bring different benefits to people. In Slovakia, mapping and valuation of ecosystem services of agricultural soil and freshwater, driven by development in soil functions concept and later by nature and biodiversity protection, have been focused especially on provisioning and regulation & maintenance sections. The integration of ESS concept into decision making remains challenging issue both in area of soil and water policy as well as creation of new and useful information on the total and sustainable capacity of individual ecosystem services in space and time.
Concerning the quality of the existing ESS-related information, the immediate use of ESS concept in the land area can be seen at spatial planning to decrease the irreversible soil loses which occur during urban sprawl, industry and infrastructure development. In the area of freshwater, the valuation of related ESS can be considered at the selection of cost-effective measures provided that the assessment of the ESS will be specified for the conditions of a particular water body and/or related watershed. To achieve unambiguous and lasting improvement of environment and related ecosystem services, which clearly includes the sustainable use of agricultural soils and freshwaters, it is necessary to address deeper causes, closely related to human thinking and activities which are not punishable/solvable solely by the ESS concept.

Key words
Ecosystem services, Soil functions, Agricultural soil, Freshwater.

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INTRODUCTION AND OBJECTIVES

Deterioration of natural resources recorded in several documents (e.g. MEA, 2005; EEA, 2019; Ekins et al., 2019) is a great challenge for the maintenance or improvement the welfare of human civilization on Earth in the future, the reassessing priorities and restructuring of the global economy, for more efficient use of natural resources and environment protection.

Soil and water belong to natural resources which are essential for the existence and development of human civilization. These resources create essential part of natural capital and provide many ecosystem services (ESS) (Leach et al., 2019; Fairbrass et al., 2020). Ecosystem services are defined as the outputs of natural systems of which people benefit (e.g. NRC, 2004; Boyd and Banzhaf, 2007). According to the typology of ecosystems (Maes et al., 2013), agricultural soil/land is linked to terrestrial ecosystems (cropland, grasslands) and freshwater corresponds with freshwater ecosystems (rivers, lakes) as well as groundwater.

Employing the ecosystem service concept is not an end in itself. It should to serve as frame at development of policies and instruments for ecosystem management (Birkhofer et al., 2015; Bouwma et al., 2018) as well as at integrating of ESS natural capital into mainstream economic policy and review the existing expression of the gross domestic product (Constanza et al., 2017).

This paper is focused on significant agricultural soil and freshwater ecosystem services relevant to Slovakia in accordance to current knowledge and the Common International Classification of Ecosystem Services (CICES) v. 5.1 (Haines-Young and Potschin, 2018). Actual state of valuation of ecosystem services and practical utilisation of existing information in Slovakia are analysed and discussed.

ECOSYSTEM SERVICES RELATED TO AGRICULTURAL SOIL

Until now, the evaluation of the benefits of soil for human and their use was based on soil functions. The aim to define these functions was to highlight their importance to society and the necessity to protect this natural resource (e.g. Blum, 1990; European Commission, 2006). While some authors make difference between functions and ecosystem services (e.g. NRC, 2004; Potschin and Haines-Young, 2011), some do not. In fact, many of the soil ecosystem services and soil functions overlap in content (e.g. Dominati et al., 2014; Coyle et al., 2016) and as stated by Baveye et al. (2016), it is possible to use both "function" and "ecosystem service" if they are articulated correctly.

The most common ecosystem services relevant to agricultural soil in Slovakia are introduced in Table 1. Naturally, the most important agricultural soil related ecosystem service is biomass production followed by water accumulation, filtration and decomposition of pollutants as confirmed by Coyle et al. (2016). These functions closely correspond with production and regulation ESS.

The following functions (marked in Table 1 with an asterisk) have been valuated both bio-physically and economically, and spatially delineated in Slovakia so far (Vilček, Koco, 2018): biomass production, rainwater accumulation, filtration of inorganic pollutants, filtration of organic pollutants and transformation/detoxification of organic pollutants.

Table 1 Most common Ecosystems services relevant to agricultural soil

Division	Group
Provision services	
Biomass	Cultivated terrestrial plants for nutrition, materials or energy*
Non-aqueous natural abiotic ecosystem outputs	Mineral and non-mineral substances used for nutrition, materials or energy (peat, sand, gravel, clays)
Regulation and maintenance services	
Transformation of biochemical or physical inputs to ecosystems	Mediation of wastes or toxic substances of anthropogenic origin by living and non-living processes (substances filtration*, accumulation, sequestration, remediation*)
Regulation of physical, chemical, biological conditions	Regulation of baseline flows and extreme events (water infiltration and accumulation*, soil erosion and flood control)
	Regulation of soil quality (decomposition of organic matter, nutrients turnover, buffering pH changes)
	Lifecycle maintenance, habitat and gene pool protection
Cultural services	
Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment (e.g. recreation or agritourism)
	Intellectual and representative interactions with natural environment (scientific, education, heritage, cultural, aesthetic issues)

* so far valuated soil functions or ESS

Principles of bio-physical valuation of several regulation functions/ecosystem services in the Slovak Republic are based on key soil parameters, relief and in the case of biomass production also on climate which primarily affect the biomass production. Regarding the valuation of biomass production, the expert approach is applied. It is based on pricing of production and cost parameters obtained from economic valuation of homogenous fields within typical set of land evaluated unit. In the case of regulation functions, the existing economic valuation is based on the use of cost methods – namely on saved or avoided costs, and replacement costs (Vilček et al., 2020; Bujnovský et al., 2009; Vilček and Bujnovský, 2014).

While the current valuation of specified ESS is satisfactory in terms of spatial variability (done at the scale of 1: 10000), the development changes in the capacity of soils to provide individual functions over time is currently lacking. Elimination of stated deficit presupposes taking into account the impact of management practices which significantly affect the evolution of relevant soil parameters and eventually the capacity of relevant ESS. For example, the increase of soil organic matter content via carbon sequestration belongs to climate change mitigation goals. The rate of carbon sequestration depends on both the soil texture and soil/land use. While soil texture primarily determines the general carbon sequestration capacity, exploitation the potential of this ecosystem service requires the application of minimum or no-tillage systems. Of course, the conversion of arable land to permanent grassland, or forest, is the best solution in this regard, provided that it remains enough land to grow field crops. Forestry and Agroforestry systems provide a number of ecosystem services. Numerous research works clearly indicates that forestry and agroforestry, as part of a multifunctional working landscape, can be a viable land-use option that, in addition to alleviating poverty, offers a number of ecosystem services and environmental benefits e. g.: carbon sequestration, biodiversity conservation, soil enrichment and air and water quality (Fleischer et al 2017; Gomoryová et al. 2013; Mindaš et al. 2018; Bartík et al. 2016).

Some soil functions or ecosystem services, especially those which belong to cultural ones (as space for recreational purposes and agri-tourism). These are not tied to soil parameters and if yes so rather in inverse way because for these activities are usually attractive pre-hilly and hilly areas where usually occur less productive soils with often less capacity to provide regulation ESS. Presumably, until now this ecosystem service has marginal importance even from the economic point of view. Space for human activities as urban sprawl and industry development was originally assumed as one of soil functions (Blum, 1990), however, is not on the ESS list (Haines-Young and Potschin, 2018). It is fully understandable, because in this case the initial capacity of the soil to provide ESS is destroyed.

ECOSYSTEM SERVICES RELATED TO FRESHWATER

The most common freshwater ecosystem services in Slovakia are introduced in Table 2. Valuation of water-related ecosystem services in Slovakia has been so far focused on those where the highest benefit was expected and sufficient information was available to estimate their use at the level of 10 sub-basins without GIS-based delineation. Some of above introduced ecosystem services, marked in Table 2 with an asterisk, were subject to valuation (Bujnovský, 2018) with a focus on the demand side or actual use.

Until now, the amount of abstracted water or extracted mineral substances (sand, gravel) serves as base for biophysical valuation of many ESS. In other cases, the amount of transported cargo (waterways transport), amount of caught fishes (angling) or the number of visitors (bathing) served as a starting point (Bujnovský, 2018). Economic valuation of freshwater ecosystem services was mostly based on the non-preferential methods (in particular the methods of market valuation and cost methods) applicable in the case of valuation of production and regulatory services as reported by several authors (e.g. COWI, 2014; Grizzetti et al., 2016).

The results from corresponding assessment show that the greatest benefit from the use of water related ESS is identified at provisioning ESS, especially at electricity generation, raw material and cooling medium in industry, waterways transport, water for drinking purposes and for crop irrigation. These ESS are often related to the amount of water consumed. As for inland waterway transport, it should be noted that this ecosystem service is not explicitly listed in the current ESS categorization (Haines-Young and Potschin, 2018) but has its importance in terms of reducing of greenhouse gas emissions in the transport sector.

Table 2 Most common freshwater ecosystem services

Division	Group
Provision services	
Biomass	Reared aquatic animals for nutrition, materials or energy
Water	Surface water and groundwater used for nutrition – drinking water*, materials (crop irrigation*) or energy*
	Other aqueous ecosystem outputs (waterways transport*)
Aqueous natural abiotic ecosystem outputs	Mineral and non-mineral substances used for material (e.g. river bed sediments, sand and gravel*)
Regulation and maintenance services	
Regulation of physical, chemical, biological conditions	Water conditions (decomposition/removal of pollutants, dilution of pollutants)
Cultural services	
Direct, in-situ and outdoor interactions with living systems that depend on presence in the environmental setting	Physical and experiential interactions with natural environment (e.g. swimming*, boating, angling*)
	Intellectual and representative interactions with natural environment (scientific, education, heritage, cultural, aesthetic issues)

* so far valuated freshwater ESS

It can be noted that the overuse of ESS, in particular provisioning and some regulating services, put pressure on the water bodies. Excessive use of water (water abstraction) and dilution of pollutants due to wastewater discharge, may create considerable pressure on the water bodies and increase the risk of not achieving WFD objectives.

The ecological status of waters is often considered as a quality indicator of the structure and functions (and consequently services) related to aquatic ecosystems linked to surface water (e.g. Giakoumis and Voulvoulis, 2018). This assumption, however, does not apply to ESS which are not linked to the achievement of the good ecological status of surface waters (electricity generation, waterways transport or aqueous natural abiotic ecosystem outputs).

Naturally, an freshwater ecosystem with improved ecological status (as a result of implementation of measures and restoration) will often be able to provide a higher variety of ecosystem services, however, in view of that many of water uses (ecosystem services) have fixed locations (e.g. water abstraction for drinking purposes, natural bathing waters), final effect of improved water state on value of used ESS will be lower.

UTILISATION OF ECOSYSTEM SERVICES MAPPING AND ASSESSMENT

The concept of ecosystem services was originally developed to illustrate the benefits of natural ecosystems for society and to raise awareness of biodiversity and ecosystem conservation while managed systems were not the primary aim (Birkhofer et al., 2015). Later it was extended into a platform for management of specific environmental issues and corresponding policy interventions (Karabulut, et al., 2016; Bouwma et al., 2018).

Integration of ESS concept into decision-making remains challenging issue, especially in soil and water policy areas (Grêt-Regamey et al., 2017; Bouwma et al., 2018), as a result of *i)* insufficient precision and accuracy of ESS assessment often based on data unavailability, *ii)* missing the demand/supply ratio and available capacity of ESS for their sustainable use, and *iii)* insufficient outputs for decision-making aspects (Schägner et al., 2013; Laurans and Mermet, 2014; Wolff et al., 2015; Bujnovský, 2018). Some other related issues are *iv)* inconsistent approaches to ecosystem service modelling, assessment and valuation, *v)* the expense of applying sophisticated enough methods to adequately answer the questions, *vi)* the lack of appropriate institutional networks and also an underestimation of the role of science in the continuous development of methods for measuring, modelling, valuing and managing ecosystem services at different levels (Seifert-Dähnn et al., 2015; Maes et al., 2016; Constanza et al., 2017; Francesconi et al., 2016).

Given that the ESS mapping and valuation were originally driven by biodiversity protection, it is only natural that primary attention is primary focused to protection of natural and semi-natural areas (Maczka et al., 2019; Mederly et al., 2020; Roy et al.). The use of ESS information can be also expected in the area of spatial planning (Bateman et al., 2013; Tammi et al., 2017) where capacity/value of given environment to provide ESS should be considered before the permanent land take for urban sprawl, industry and infrastructure development. Similarly, when considering the case of permanent urban sprawl on agricultural land, the value of land ESS can serve as a criterion for spatial decisions (Greenhalgh et al., 2017) but the discount rates, expressing the future costs, or long-term benefits/losses at land use change remain the open issue.

Soil production potential or capacity of agricultural land to produce biomass is still used as an indicator for the classification of soils into nine soil quality groups which are specified in the Soil Protection Act. In terms of regulation permanent occupation of agricultural land in Slovakia, the revision of national legislation, redefinition of soils under primary protection as well as the amount of the fee for land take of these soils may be considered. Whereas around ten years ago, the top four soil quality classes (1st to 4th class) were protected nationwide, after the amendment have been made to the national soil protection law in recent years, the protection was limited to the top three classes in a given cadastre (local administrative unit). It means that in less productive/marginal areas even lower quality soils (6th to 8th class) are subject of protection. If the "political will" is clearly directed towards the development of industry and infrastructure, regardless of soil quality and capacity of ESS provided by soils, the valuation of the relevant ESS has no practical application in this regard.

The bio-physical valuation of soil functions or ecosystem services is often seen as basic precondition for their local use with regard to mitigate the anthropogenic pressures and their consequences (degradation processes). To consider payment for ecosystem services – PES (e.g. Bateman et al., 2013; Robinson et al., 2014) seems problematic for now. Main reason is that effect assessment through a change of soil parameters relevant to given ecosystem service is significantly affected by spatial and temporal effects. Shifting the emphasis from compliance with set level of management (what has been a reality so far) to achieving results or increasing ESS capacity and thus, paying for performance (European Commission, 2019), which closely corresponds with the allocation and effectiveness of measures (Talberth et al., 2015; Sidemo-Holm et al., 2018) remains great challenge.

Even though the achievement of WFD environmental objectives a has positive impact on the preservation/improvement of habitats and biodiversity, the term 'ecosystem services' is not explicitly defined in the WFD. Despite that, there is an effort to identify the incorporation of the ESS assessment into water policy (e.g. COWI et al., 2014; Vlachopoulou et al., 2014; Grizzetti et al., 2016). Ecosystem services assessment for potential application of derogations under Article 4 of the WFD, selection of cost-effective measures (Article. 11 WFD) and also for designing of measures beyond legislative requirements and limits within payments for ESS can serve as an example in this regard.

Seifert-Dähnn et al. (2015) pointed out to several shortcomings in the use of ecosystem service approach in the implementation of the WFD. Challenges include both methodological (namely, selection of proper valuation method, proper consideration of the trade-offs and side effects) and practical parts. Moreover, practical application of ESS valuation presupposes the use of models that should enable to consider trade-offs and side effects of specific measures. Mentioned problem is also reminded by Maes et al. (2016) who state that the fundamental problem of a complete assessment of the ESS is insufficient data. That leads to the use of such indicators which reflect pressures on ecosystems rather than the contribution of ecosystems to regulation and maintenance.

Concerning freshwater, Everard (2012) is of the opinion that ecosystem services provide a more effective means of communication of the benefits of implementing measures to deliver the WFD than a more mechanistic focus on compliance with technical standards. The assessment of the proposed measures to address specific problems in river basins as well as the description of the associated positive and negative impacts can be expressed in a more socially relevant way by using the language of ecosystem services which can serve also for justification the cost-effectiveness of the proposed measures.

In other words, valuation of freshwater ecosystem services can serve mainly as the support for selection of cost-effective measures by considering co-benefits of measures (COWI, 2014).

The specific objectives of the WFD – such as "good status" and "no deterioration" – do not directly describe the benefits of which the EU citizens could experience. Hence, translating these objectives into the ecosystem services that benefits the population could significantly improve the whole stakeholder involvement throughout the implementation process (COWI, 2014). Public engagement represents an essential aspect of WFD implementation. But, as stated by Everard (2012), support for WFD implementation may be regarded as an altruistic task, as the public may not be able to appreciate the benefits of delivering its aims and the effects on their life quality.

The information on the significance and economic value of ESS could serve as the basis for development of social awareness. However, it appears that an increase in environmental awareness alone is not sufficient in terms of the protection of ecosystems and their services (Schröter et al., 2014; OECD, 2017). In this regard Bujnovský and Vilček (2011) recall that to achieve unambiguous and lasting improvement of environment and related ESS (which clearly includes the sustainable use of agricultural land and inland waters), it is necessary to address deeper causes, closely related to human thinking and activities which are not punishable/solvable solely by the ESS concept.

Without having a thorough knowledge of the real problems, we only address symptoms instead of getting to the root cause. One of the main driving forces of current environmental problems is growing consumption. People are trying to satisfy their infinite desires instead of simply meeting the needs, that are finite.

CONCLUDING REMARKS

In Slovakia, similar to other countries, the protection of nature and biodiversity accelerated the interest for the ESS from the research side. In the case of soil, this was originally the concept of its functions (Blum, 1990; European Commission, 2006). It is undisputed that economic valuation of soil and water resources through ecosystem services offers a broader view of their real importance and value for society. Besides that, the sustainable use of ESS capacities is a basic precondition for the preservation of relevant natural capital.

There is an effort to integrate the concept of ecosystem services into individual policies at the global level (Bouwma et al., 2018). Integration of the ESS concept into decision-making, in the field of soil and water policy, remains challenging. The area of knowledge creation in the field of ESS assessment is, however, equally important as the decision-making, policy implementation, and governance (Primmer et al., 2015). While the soil policy is currently partly covered by the EU's Common Agricultural Policy, the water policy is on the table for at least 20 years up to now. Until the concept of the ESS becomes a systematic government agenda, implementing the relevant research results into practice will be difficult.

Defining the total and sustainable capacity of individual ESS (in the field of agricultural soils and water-related ESS in particular) remains a challenging issue in Slovakia. In many cases, this can be done only through modelling, which is, Defining the total and sustainable capacity of individual ESS (in the field of agricultural soils and water-related ESS in particular) remains a challenging issue in Slovakia. In many cases, this can be done only through modelling, which is, either way, necessary for water pressure measurements, as well as for assessing environmental and cost-effectiveness measures, proposed/adopted in terms of achieving the WFD objectives.

At least for now, the ESS concept in the land area has its immediate use in spatial planning through better regulation the irreversible soil losses which occur during urban sprawl, industry, and infrastructure development. In the freshwater area, the use of the ESS concept could find application in the evaluation of the benefits of some measures (cost/benefit analysis) provided that the ESS assessment will be specified for the conditions of a particular water body and/or related its surrounding watershed.

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