Chapter 3
Provisioning Ecosystems Services

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Abstract Chapter provides the analysis and assessment of **five provisioning ES** – *P1 Biomass: Agricultural crops; P2 Biomass: Timber and fibre; P3 Drinking water; P4 Freshwater; P5 Fish and Game/Wildfood.* All ES are described in the unified structure: definition and brief characteristics; methods used for identification and assessment; main types of landscape and ecosystems providing given ES; the importance of ES in terms of nature and landscape protection; and ES assessment for the territory of Slovakia. Spatial assessment is provided as a map of the landscape capacity for given ES provision. For all ES, short conclusions and overview of input data for further assessment of the ES capacity, demand and flow are also given.

3.1 Biomass: Agricultural Crops (P1)

3.1.1 Definition and Brief Characteristics of ES

The production of biomass for food is the basic provisioning ES – it is provided by different types of landscape, among which the most important are *agroecosystems*. In addition to the production of food and related raw materials, these ecosystems also provide another provisioning ES, such as fodder and energy biomass; they also

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play an important role in other regulating and supporting ES. Agricultural landscape provides people space in which food is produced, people can live and the landscape serves as a place for agro-tourism and recreation, providing cultural heritage and aesthetic values, including various cultural ES (Schröter et al. 2019). To a lesser extent, this ES is also provided by seminatural and natural ecosystems.

According to Preston and Raudsepp-Hearne (2017), crops are plant products which people need for bio-nutrition or commercial use (except for field crops such as fruits, seeds, vegetables and herbs). In particular, ecosystems provide soil, nutrients and microbiological and climatic conditions which allow people to cultivate food – through the natural gross primary production and the conversion of solar energy into biomass, partly by energy transfer in food chains and water and nutrient cycles.

Agriculture crop production is one of the key ES for food provision. It depends on a number of factors – from natural (soil quality, climate, water availability, pollination) through socio-economic (labour availability, food demand) to purely economic (macroeconomic, market relations). The productivity and efficiency of plant production are dependent on cropland extent, yields and crops produced. The actual yield produced also depends on other factors, such as the genetic potential of the crop; the amount of solar radiation, water and nutrients absorbed by the crop; the presence of weeds and pests; etc. (available online: www.data.oecd.org). However, crop and biomass production is mainly dependent on ecosystems and their ES. In turn, agricultural ecosystems contribute to other ecosystem services not related to biomass and crop production (Power 2010).

ES Biomass – crop production can be understood as *the ability of ecosystems to provide food provision services*. This ES is mainly dependent on the agricultural ecosystems and their surroundings, which determine the overall ES production capacity in qualitative and quantitative terms. To a large extent, it is linked to other provisioning ES providing additional raw material resources related to biomass and crop production.

3.1.2 Methods Used to Assess and Identify ES

For ES Biomass – agricultural crops, there are different assessment methods which are considered suitable and which are applied. Consideration is given to, for instance, inputs for production (characteristics of agroecosystems providing agricultural production) or direct production (yields of individual crops, sales for production, etc.). In particular, *economic and biophysical assessment methods are used*.

In general, the most used indicators of the assessment of this ES include crop areas and crop and fruit yield (Maes et al. 2014; Czúcz et al. 2018); other indicators used are soil production properties (biomass production, nutrients), climatic parameters, but also, for instance, water quality for irrigation (Pérez-Soba et al. 2015). In some cases, national ES assessments are based on the country's regional statistics on crop production (Denmark, Romania) or from data on the area of agricultural land, arable land and crop areas of individual crops (Luxembourg, Romania). Several assessments are based on the amount of biomass produced, crop yields, soil fertility, taking into account the climatic conditions and calculating various environmental performance and stability indices (Germany, Romania). The assessment of this ES is based, for example, on a simple model of average production for a particular type of crop, taking into account its economic value. The production of a particular crop in a given area (e.g. in kg/ha/year) is determined, which, when converted to the average market value of the crop grown per area, expresses its economic value (UK, Spain). In the national ES assessment of Spain, this outcome was compared with the outputs of the High Nature Farming project, where the relations between the economic and natural value of the agricultural landscape were investigated (Santos-Martín et al. 2016).

One of the tools of the biophysical assessment of ES Biomass – agricultural crops is the InVEST, which is a modern and relatively widespread ES assessment tool. Based on various input parameters, InVEST assesses the capacity and flow of different ES and is applicable in different areas and spatial scales, based on standard GIS methods. The tool contains a number of models, including the *crop production model*. It has been designed to help answer a number of fundamental issues related to agricultural productivity, e.g. what is the impact of different agricultural approaches and measures, crop rotation and intensification of production on the provision of this ES, and how the growing demand for food can be met with minimizing the impact on other ES. Input data for the percentile model operation is formed by a data set that includes information on 175 crops (included in the model installation). Furthermore, there is a need for data on the current landscape structure of the surveyed area, with data on cultivated crops. In addition, for a regression model, fertilizer rate data for each crop should be entered – but this model only works with 12 basic crops. The output of the model includes the data on production volume, nutritional values and production rate of all modelled crops (available online: www.naturalcapitalproject.org).

An interesting assessment may also be provided by the application of a *matrix model* which determines the basic parameters of this ES for agricultural land. Consequently, it is possible to combine these data with the state of protection of individual natural ecosystems in the immediate vicinity, which provide microclimatic and soil protection functions for the given area and also provide space for natural pollinators. Such an assessment will ensure a better understanding of the interactions of intensification of agriculture in contrast to the interconnection of agricultural land to natural ecosystems and their functions, as well as mutual interactions. In basic models, these facts are often omitted.

The production potential of agricultural land in Slovakia is expressed numerically by means of a scoring system for the so-called Soil-Ecological Units (SEU) system (Džatko 2002). The maximum score is 100, the minimum is 2. Vilček (2011) mentions soil assessments in terms of energy potential or energy accumulation. From these statistics and methods of assessment, it is possible to build a further assessment of the soil and agricultural land ES in Slovakia.

3.1.3 The Main Types of Landscape and Ecosystems Which Provide ES

The basic landscape component in terms of the production of agricultural biomass is *soil* as an essential part of agricultural ecosystems (so-called agroecosystems), with another provisioning ES also depending on its quality. Of course, for the proper functioning of the agricultural landscape ecosystems and for crop yields, the favourable condition of other landscape components, their properties (e.g. climatic conditions, state and regime of surface and groundwaters, the occurrence of disturbances) and human activity are also important (Bezáková 2015).

Agroecosystems represent altered ecosystems which have been modified for the purpose of producing food and biomass for use – fibres (Hodgson 2012). A typical agroecosystem contains 1–4 major crops and 6–10 major pests. Typically, an agroecosystem includes less diversity of animal and plant species than a natural ecosystem (forest, meadow) (Karuppuchamy and Venugopal 2016). The intensively used agroecosystem is subject to rapid changes due to anthropogenic influences such as ploughing, fertilization and application of pesticides (Fig. 3.1). While retaining many characteristics from natural ecosystems, from the toxicological point of view, it is characterized by an increased presence of agrochemicals, including pesticides, fertilizers and plant growth regulators (Hodgson 2012).

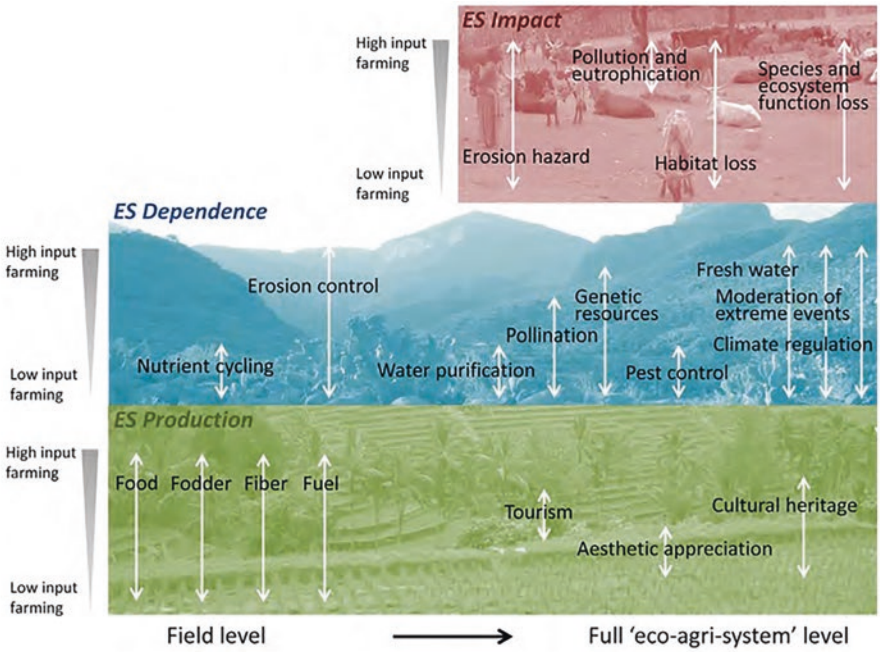

Fig. 3.1 The relationship of agricultural management towards ecosystem services. (Source: Burkhard and Maes 2017)

According to Burkhard and Maes (2017), the agroecosystems producing agricultural crops represent the most important ecosystems for man in modern epoch – Anthropocene. Up to 44% of Europe's land surface is agricultural land. Agroecosystems have a significant impact on the environment, including ecological processes and functions.

ES Biomass – agricultural crops uses most of the total area of agroecosystems. In terms of the structure of the agricultural lands, this ES is based mainly on arable land (growing of cereals, legumes, oilseeds, root crops), but it also includes fruit growing, hop growing, vegetable growing and viticulture. Therefore, the *agroecosystems of permanent crops* – especially gardens, orchards and vineyards – are very important elements of the landscape structure associated with this ES and special agroecosystems. These increase the diversity of the agricultural landscape and often also represent the remnants of historical land use elements and providers of other ecosystem functions and services such as crop production. Indeed, modern intensive farming is mainly focused on the production function of agricultural land, which largely suppresses other ES, in particular regulating services and supporting functions, partly cultural services.

As regards the other types of ecosystems, they are not directly linked to the production of crops. Nevertheless, some of them may have a positive impact on it – especially aquatic ecosystems and wetlands (maintaining water availability for the agroecosystem), scattered vegetation in the country (e.g. pollination support, regulation of threatening processes) and partly forest ecosystems (e.g. influencing local climate and hydrological regime). Even some anthropogenic ecosystems support, to some extent, the plant production, or they make it more efficient (road network, agricultural farms) but do not provide the given ES separately.

3.1.4 Importance of ES in Terms of Nature and Landscape Protection in Slovakia

It has been proven that many agricultural practices and the expansion of agriculture pose a *major threat to the proper functioning of ecosystems*. On the other hand, well-managed agriculture can be an important means of securing and protecting ecosystems and the ES (Burkhard and Maes 2017). Thus, as far as the relationship between agricultural production and nature and landscape protection is concerned, in most cases it is perceived negatively (in accordance with Fig. 3.2) – the expansion and intensification of agriculture is the cause of the loss of environmental diversity and the quality of other types of ecosystems in different world regions. In Slovakia, this was particularly the case in the phase of collectivization and intensive socialist agriculture, but even today's European agriculture based on the system of agro-subsidies is not favourable in Slovakia in terms of the real ecological condition of the landscape (preference of certain crops, preservation of large blocks of agricultural land, excessive application of chemicals, *formal* care for the landscape).

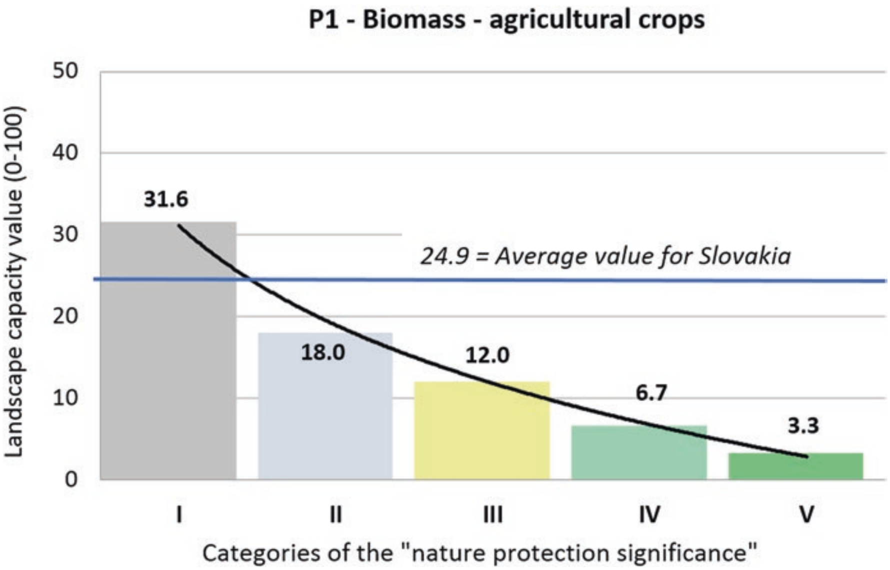

Fig. 3.2 Relationship of ecosystem service P1 and significance of Slovakia territory in terms of nature and landscape protection

Fig. 3.3 Agricultural landscape with important ecosystem elements for animals and raptors (surroundings of Suchá nad Parnou). (Source: D. Štefunková)

Nature and landscape protection itself have targets which are completely different from food production. However, as mentioned earlier, the *support of biodiversity and the ecological quality of the landscape* can indirectly have a positive impact on the production function of agroecosystems (Fig. 3.3) – therefore this relationship may not necessarily have been completely antagonistic. Sufficient food needs to be produced in a sustainable way, taking into account challenges such as climate change and the growing population with changing dietary habits. Maintaining biodiversity in agroecosystems (the diversity and variability of animal species, plants and microorganisms) is important for food production and for preserving the ecological basis necessary for maintaining rural life (available online: www.fao.org). The positive fact is that in the period from 2000 to 2015, the area of land in ecological agriculture production in Slovakia recorded a threefold increase – in 2015 a total of 186.5 thous. ha of land was farmed in this way (available online: www.enviroportal.sk), which represents 7.8% of the total agricultural land area.

The important thing is that the so-called agri-environmental schemes currently preferred in the EU Common Agricultural Policy are also based on the *support of non-production functions of agriculture*, which are in line with the nature and landscape protection objectives in Slovakia (more in detail on this in the chapter of *ES R10* (*soil formation and composition maintenance*). However, their implementation and realization is often controversial, and rules need to be better defined to address the ecological requirements of each species and habitats.

3.1.5 ES Assessment for the Territory of Slovakia

Food production is one of the most important ES in the SR as it is essential for the survival and appropriate nutrition level of the population. Although, it is a fact that at present the agricultural land seems much less important than in the past when local and regional food production was driven by the survival of the majority of the population. This is proven by the fact that the area of agricultural land in Slovakia has been decreasing continuously since 1990 and most significantly in the case of arable land (Pazúr and Bolliger 2017). In the period from 2000 to 2015, 2.1% of the area of agricultural land (510.5 km^2) was lost in Slovakia – the average annual decrease is more than 3400 ha, which means two cadastral areas of average municipalities. At present, agricultural land represents 48.6% of the SR area (23,819 km^2) – of which 59.1% is arable land (14,087 km^2), 35.9% permanent grasslands, 3.2% gardens, 1.1% vineyards and 0.7% orchards.

Nevertheless, the production of some agricultural crops has increased over the last decade, probably due to the intensification of land use and increased inputs into processing. Cereal production has increased, but from the point of view of the ES assessed, it is not positive that the production of oilseeds and technical crops has increased much, while the production of some food crops (especially potatoes and legumes) has decreased.

Typical areas with predominant agroecosystems for food production in Slovakia include the Slovenska Podunajská, Východoslovenská and Záhorská nížina and southern Slovakian basins, although food crops are also grown in cooler areas, especially in basins and sub-mountain areas (Fig. 3.4). Growing of fruits and vegetables is dominant in warm areas of Slovakia; the cultivation of grapes is typical in warm hillsides of low mountains and hills in the south of Slovakia (world-famous is the vineyard region of Tokaj, extending into Zemplín Hills).

There is a lot of available data to assess *the food production in the SR* – from national statistics of individual crops production through statistics at the level of regions to some data at the level of districts and farms (available online: www.statistics.sk). However, other data than just the production, or economic data are also important to determine the landscape's ability to fulfil this ES. For instance, Vilček and Koco (2018) published an integrated soil quality index for agricultural land in

Fig. 3.4 Cereal field in dispersed settlements near Detva. (Source: J. Černecký)

Slovakia, in which, in addition to production parameters, they took into account environmental parameters and threats.

When assessing the landscape's capacity of food production, it is appropriate to base it mainly on data on the natural components – as a rule, economic factors such as real agricultural production infrastructure are not taken into account in the capacity of a landscape. The key factor is the *fertility (production ability) of soils*, which is well and long-term documented in Slovakia on the basis of the SEU system (Soil Science and Conservation Research Institute SSCRI Bratislava – available online: www.vupop.sk). The main factors of soil fertility include soil depth, soil texture, soil skeleton, the dominant paedogenetic process represented by soil subtypes. To some extent, the SEU system also includes the characteristics of other important natural factors, which can also be evaluated on the basis of more precise background information – in particular, this includes the *climatic conditions* (temperature and moisture balance), *relief characteristics* (slope, predisposition to erosion processes) and *geological substrate* (mineral richness, suitability for plant growth, hydrogeological conditions). It is possible to assess the overall production potential of the agricultural landscape or the potential for growing the most important, or selected crops.

The pilot assessment of the landscape's capacity to provide ES P1 was based on two main input indicators and three supplementary indicators (Table 3.1). All the indicators were spatially expressed, and a map of the landscape's capacity was compiled by combination based on the determined calculation algorithms. The resulting values were converted from the original resolution (pixel size 25 m) to 1 × 1 km spatial units and converted to a unified 0–100 scale, where 0 expresses the landscape's lowest capacity to provide this ES (infertile areas, built-up areas, water

Table 3.1 Input data for capacity, demand and flow assessment of ES Biomass – agricultural crops

Input data/ ES	P1 Biomass – Agricultural crops
Capacity	Current landscape structure – categories of agricultural land use and their suitability for growing crops
	Production potential of the SEU (agricultural land) and forest soils
	Slope inclination – reclassification, suitability coefficient 0.25–1.25
	Climatic conditions – temperature and moisture balance
	Hydrological conditions – availability (surface depth) of groundwater
Demand	Population – map of spatial distribution, population density
	Statistical data – consumption of selected food products (municipalities, districts)
Flow	Current landscape structure – categories of agricultural land use
	Statistical data – production of selected crops per area unit (kg/ha)
	Data on production of selected crops (municipalities, districts), conversion to the spatial unit

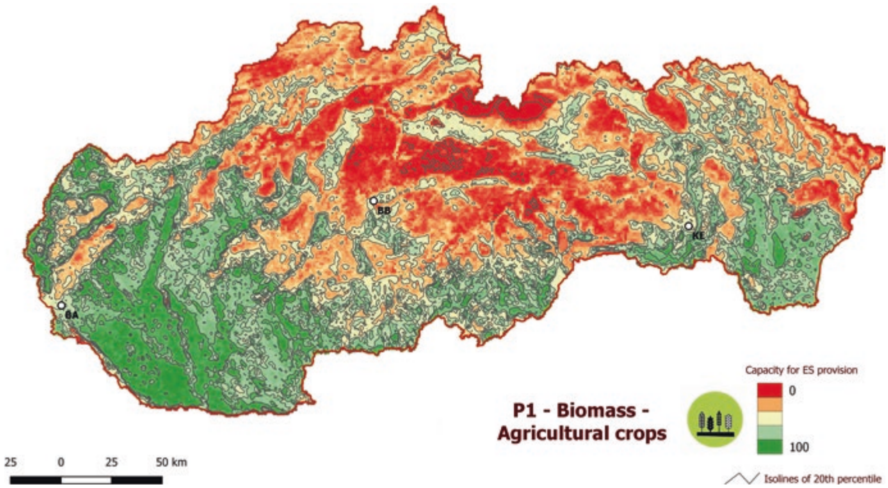

Fig. 3.5 Landscape capacity for provision of ES Biomass – agricultural crops (P1)

areas) and 100 theoretically the highest possible level of capacity (the most fertile soils on a flatland with the most favourable climatic and hydrological conditions). The results are shown in Fig. 3.5, which illustrates ES P1 compliance with the overall agricultural landscape productivity value.

For a comprehensive assessment in the future, the issue of the overall balance of the ES needs to be solved. This should be based on refining the value of capacity, determining the values of demand and real ES flows within the territory of Slovakia. The level of demand for this ES is clearly determined by the number of residents living in a particular territory, combined with the registered or anticipated consumption of different types of food of plant origin. The real use (flow) of this ES is, in turn, given by the number of crops and materials for food of plant origin produced in a particular territory that can be obtained from statistical surveys. However, the problem may be that, while assessing capacity data is appropriate using the natural regions, the ES demand and flow indicators mostly refer to administrative units (districts, municipalities). Therefore, it will be necessary to combine different spatial units in the future.

3.2 Biomass: Timber and Fibre (P2)

3.2.1 Definition and Brief Characteristics of ES

One of the main provisioning ES is the production of biomass, which can be further subdivided into specific subgroups, including timber and fibre production. Among the many ES provided by forests and which are essential for human benefits, the greatest financial importance is attributed to timber production. Timber serves as a raw material for the processing industry, construction or various technical purposes – e.g. as a cellulose source (MEA 2005). In simple terms, timber production can be defined as a *wide range of products derived from timber harvesting mainly from forest ecosystems or plantations* (Maes et al. 2013) as well as from trees outside the forest. In this process, forest ecosystems can be managed in different ways (intensively or extensively), and plantations may include forest or agricultural plantations. In literature, a distinction can be made between natural, seminatural, artificially planted forests and plantations (e.g. FAO).

In addition to timber, the processing industry also uses many other crops to obtain fibres. Thus, this provisioning ES can be understood to mean the cultivation and harvesting of fibres from agricultural crops (worth mentioning is cotton, flax, hemp or jute) or animal sources (this includes in particular wool, mohair or silk, but also various hides and skins; MEA 2005) for the production of, e.g. clothing, fabrics or paper (Kandziora et al. 2013). Fibres can also be obtained from timber – this includes, e.g. artificial silk (*rayon*) or lyocell.

The production of timber and fibres has historically been a particularly significant ES and still plays a crucial economic role nowadays, as reflected in the management of the ecosystems providing it. According to The Economics of Ecosystems and Biodiversity study (TEEB 2013), the production of timber and non-timber products (including fibres) is the primary economic function of up to 34% of the world's forests. With regard to fibres derived from agricultural production, with the exception of cotton and silk, their production has a predominantly downward trend (MEA 2005).

In summary, this provisioning ecosystem service can be defined as the production and collection of selected plant and animal resources predominantly for technical purposes or as the manufacturing input of the processing industry (timber, textile, paper, etc.).

3.2.2 Methods Used to Assess and Identify ES

In the context of Slovakia, the provisioning ES of production of biomass – timber and fibres – is partly considered when assessing the production functions of the forest, namely, the function of timber production. The value of timber production function of forests as a natural factor of production is usually based on market prices of timber products reduced by logging and transport costs (market method), but other methods of economic evaluation (available online: www.forestportal.sk) can also be used.

At the European level, several indicators have been identified in the context of the ES mapping and assessment process for the provision of biomass by forest ecosystems. These indicators include timber stock and increment, timber production (industrial, fibre timber, etc.) and timber consumption (e.g. logs), usually measured in m^3 (European Commission 2014). In case of biomass in the form of fibres, which is primarily provided by agricultural ecosystems, the indicators include crop yields which serve as a source of fibres crops (measured as, e.g. t/ha; t dry matter/ha; MJ/ha) or the area on which these crops are grown (ha) (European Commission 2014). It is a combination of indicators of landscape capacity, demand and the real use of this ES.

In the ES national assessments in European countries, the values of timber stock, forest growth and sustainable production levels (Germany, Romania, Russia) were mainly considered for this ES. Extraction and timber consumption were also assessed, but they are more about real flow and use of the ES.

For the incorporation of this ES into the natural capital accounting system (UN SEEA 2014), it is proposed to define timber resources by using the volume of timber biomass (including dead trees) and to include all trees regardless of their trunk circumference, as well as parts above the trunk, together with deadwood. Smaller branches and twigs, fallen leaves, flowers, seeds and roots are not included.

The above-mentioned indicators serve for *biophysical assessment* of this ES, whereby data can be obtained directly and expressed in biophysical units. However, in some cases, these data are not available or sufficient, so it is advisable to use indirect methods of measurement (remote sensing, statistical data) or modelling (e.g. crop simulation models such as Forest Vegetation Simulator) (Vihervaara et al. 2018; Binder et al. 2017).

Timber and timber products as well as fibre agricultural resources are generally traded commodities on specific markets, with significant economic value, which means that their *economic assessment* is done through a market mechanism (Binder et al. 2017). The value of the forest production function as a natural production factor can be determined on the basis of the market prices of the timber products reduced by the costs of logging and transport. However, other evaluation methods, such as value transfer (transfer of values from one study to another), substitution costs or contingent valuation, can be used (Forest Europe, available online: www.foresteurope.org/overview-valuation-approaches-methods/).

As far as *sociocultural assessment* is concerned, the production of biomass (timber and fibres) as such is often not assessed by these methods. This does not mean, however, that they cannot also be part of the assessment – these include various deliberative or participatory approaches, using, e.g. semi-structured questionnaires, group discussions, Q-methodology and others. These can be particularly beneficial, for example, when assessing people's preferences for the so-called trade-offs in the use of the ES – that is, the provision of one service (often provisioning) at the expense of the other (regulating, cultural) (DEFRA 2007; De Meo et al. 2018).

3.2.3 The Main Types of Landscape and Ecosystems Which Provide ES

In general, the production of biomass in the form of timber and natural fibres is mainly bound to *forest ecosystems* (forest stands, plantations and non-forest woody stands). Managed forest stands and plantations are used economically in particular. Forest stands differ in terms of production – their productivity depends mainly on the habitat conditions under which a particular type of forest community develops and of course the way of farming and care for the forest.

Forests are extremely important ecosystems in virtually all types of landscapes as they fulfil many functions and are involved in the provision of the full range of ES. Although their production function is undoubtedly very important to humans, its one-sided preference and use means depriving the landscape of other functions and services fulfilled by natural and seminatural forests (Fig. 3.6). The long-term economic use of forest stands has resulted in a gradual decline in natural forests (which are not the most suitable for economic use) and their replacement for more productive managed forests and plantations. In Slovakia, this mainly includes the substitution of beech and fir-beech forests for spruce monocultures and stands with a significant proportion of spruce or planting poplar plantations instead of the original floodplain forests.

According to summary information on the state of forests, the area of forest land in Slovakia reached 20,190 km^2 in 2017 (41.3% of the total area), of which 19,460 km^2 belongs to forest stands. Since 2000, the area of forest land increased by 180 km^2. At the same time, there is a long-term trend of increasing the area of forests and forest stands in Slovakia, but due to the ever-growing timber harvesting, the representation of higher age classes of forests is decreasing with the increase in young forests and harvested areas (MPSR NLC 2018).

Biomass is also provided by non-forest woodland ecosystems – in addition to hedges, e.g. also orchards, woody plants growing along roads and line structures or in urban parks (Binder et al. 2017). These types of stands can be described as an

Fig. 3.6 Lichens as important bioindicators of forest ecosystem quality and P2 ecosystem service. (Source: J. Černecký)

additional source of biomass in less forested areas with other main functions. A negative phenomenon at present is that many trees in the landscape are disappearing just because of the use of timber, and the landscape is thus deprived of their significant regulation and sometimes cultural-historical functions. However, statistical data on biomass recovery from these sources are not available. The agricultural policy of subsidies forces farmers to remove almost all the biomass from grassland habitats, thus losing important ecotone elements from the landscape, losing the transitional border between forest and non-forest habitats and decreasing the number of solitary trees. Such an approach is negative from the point of view of protection of many important types of agricultural landscapes and also from the viewpoint of ecological stability of the territory.

Natural fibres are also provided to a lesser extent by the agricultural ecosystems (cultivation of technical crops), but in Slovakia, it is rather marginal. Growing representation of flax plants (mainly flax and hemp) is negligible – as in 2018, only 439 ha were cropped (0.03% of arable land area).

For other ecosystems, provision for ES production of biomass is limited, e.g. some grassland ecosystems and wetlands (especially reed stands).

3.2.4 Importance of ES in Terms of Nature and Landscape Protection in Slovakia

The production of biomass (timber and natural fibres) is an important factor in terms of nature and landscape protection in Slovakia, as the provision of this ES competes with other services (e.g. water-flow and erosion regulation, biodiversity support, recreation and tourism) and raises the so-called trade-offs (providing one service at the expense of another). This ES is mainly provided by forest stands and woody plants outside the forest – they are currently expected to provide a wide range of ES, but in fact, significant conflicts of interest have been identified (Bradford and D'Amato 2012). One-sided management of forests to maximize timber production or carbon sequestration often results in a *negative impact on biodiversity* (Duncker et al. 2012) and thus on nature and landscape protection.

In Slovakia, forest management is governed primarily by Act no. 326/2005 Coll. on Forests as amended. Forests in Slovakia are divided into three basic categories: commercial, protection and special purpose. Timber production (while providing other important environmental and social services) is mainly intended for commercial forests, support for which is provided by specific forestry measures under the so-called function-integrated forestry. The focus of commercial forests on timber production is limited by the suitability of natural conditions, but they still represent the most represented forest category (72.1%) (MPSR NLC 2018). Protection forests and special-purpose forests are designated for the protection of nature and provision of other ES (water management, erosion protection, etc.), with priority to support non-provisioning ES (regulatory, supporting and cultural).

The analysis of the relationship between the nature conservation significance of the landscape in Slovakia and its capacity to produce timber (Fig. 3.7) shows that the landscape in the II.-IV. significance category has a high potential. It is in these territories that commercial forests prevail over other land use categories. Agricultural and urbanized landscape dominates the I. degree, with rare ecosystems being predominant in the V. degree. These rare ecosystems are either not part of the forest or may include significant representation of protection forests.

Nevertheless, Slovakia's problem is that commercial forests are often also located in protected areas, causing conflicts in relation to the main function which such territory should perform (provisioning function vs. nature protection). These conflicts can be minimized through appropriate management which takes into account the provisioning of multiple ES. For this purpose, modelling of the impacts of different management methods on ES provision may also be used (Carpentier et al. 2017). However, it is clear that consistent conservation of nature and landscape is a kind of *brake* for the intensive use of ES Biomass production, which is already inherent in its core principles.

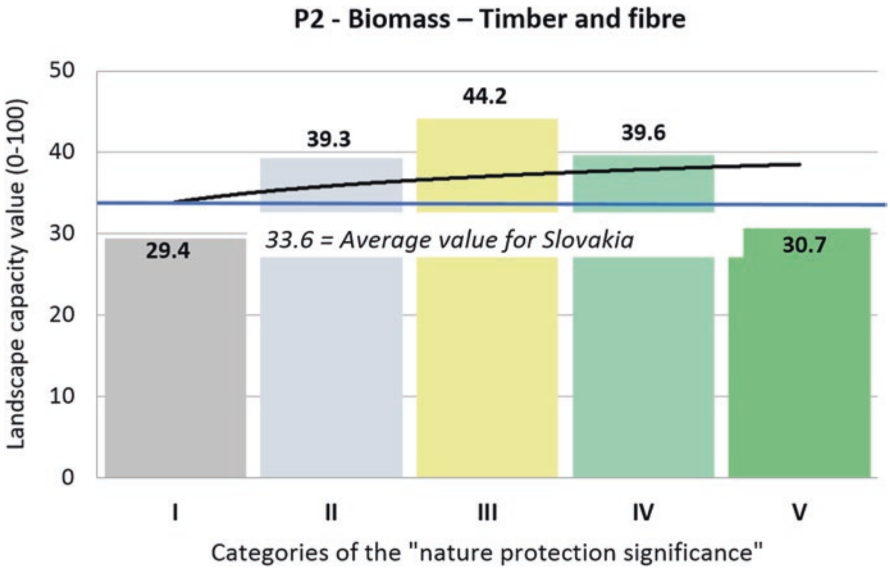

Fig. 3.7 The relationship between ecosystem service P2 and the significance of the territory of Slovakia in terms of nature and landscape protection

Significant conflicts between the use of the provisioning ES and the non-production functions and services of the landscape, including nature protection, occur in the case of biomass harvesting (Fig. 3.8 – especially for energy purposes) as well as in valuable types of non-forest ecosystems such as scattered vegetation in farmland, riparian vegetation and partly wetlands. This has been present mainly in recent years, paradoxically, because of the large subsidies for renewable energy sources and firewood.

3.2.5 ES Assessment for the Territory of Slovakia

As mentioned above, the amount of data for the assessment of ES Biomass production for conditions in Slovakia is sufficient, but only for forest stands. The volume of biomass (timber stock) and its use (timber harvesting) are regularly evaluated in the framework of the *Forest Care Program* for each decade and are statistically monitored. An important indicator is the *average increment*, which expresses the potential for increasing the volume of timber for a given period. Data on reserves and use of non-forest biomass is scarce, with the exception of statistics on the cultivation and yield of agricultural technical crops.

Wood harvesting in Slovakia has a long-term growing trend – while the total timber harvesting was 6218 thous. m^3 in 2000, in 2015 this number reached 9250 thous. m^3 and 9390 thous. m^3 in 2017 (50% increase). A negative phenomenon is that a very high proportion of this harvesting consists of the so-called random (or

Fig. 3.8 Example of intensive harvesting in the Nízke Tatry in spruce monoculture, which is susceptible to windthrow disaster or bark beetle outbreak. (Source: J. Hreško)

unplanned) harvesting – at an average level of 50–60%. Concerning the use of biomass, e.g. for heat production, in 2017 there was a 1425 thous. t of dendromass produced in the SR, which was three times more than in 2000 (476 thous. t). Almost the entire increases in the volume of production are represented by wood pellets (available online: www.enviroportal.sk).

The assessment of biomass production in the form of timber can be based on the procedure proposed for protected areas of Slovakia in the publication by Považan et al. (2014b). The authors propose to assess the production of timber using market prices, using a relatively simple formula.

$$Vt_a = St_a \times H_a \times Pt_a$$

where Vt_a is the value of the timber (EUR) produced in course of year a, St_a is the size of the area (ha) on which the timber has been harvested, and H_a is the average of timber harvesting (m^3/ha) per year, and Pt_a is the price of timber (EUR/m^3) in course of year a. Data from forestry enterprises, or national and regional statistics, can be used as a source of information. In case of insufficient sources of information on the amount of timber and sales prices for a detailed calculation at the level of forest reports or municipalities, it is possible to use the average harvesting and the average (mean) value of the timber price at regional or national level as a basis for such calculation. However, these indicators are representing the real use of this ES and do not present the relationship of timber harvesting with the natural potential and natural capital of the area.

If we want to assess the provision of ES production of biomass comprehensively, it is necessary to assess the indicators of the landscape's capacity to provide this ES, the demand for this service and its real use (flow). The capacity (potential) of the landscape for biomass production can be expressed in the case of forest stands by an indicator of *timber stock and increments*; in the case of agricultural crops, it can be expressed in the same way as the production of food crops (e.g. based on the production of agricultural land). Other biophysical indicators for forest stands may be represented by, for example, the *tree species quality*, expressing the production ability of woody plants or whole stands, or also the *production capacity of forest soils* (it is a similar indicator as in the case of agricultural soils).

A value transfer method can also be used for assessment, whereby the average price of timber (e.g. published for the EU) is based on the average timber production per hectare of area.

The pilot assessment of the landscape's capacity to provide ES P2 was carried out for the production of forest biomass or biomass from woody plants. Two basic and three additional input indicators were used (Table 3.2). The procedure was similar to that of ES P1. In the final map, the lowest capacity of the landscape for the provision of this ES is represented by built-up areas, water areas and infertile soils; the highest possible level of capacity (theoretical value 100) is achieved by the most fertile forest soils in favourable relief and climatic-hydrological conditions. The results are shown in Fig. 3.9. It is not surprising that mountain areas which are now almost continuously forested – especially the lower and medium-high mountain ranges – provide the largest capacity for the provision of this ES. The lowland and basin areas include more significant areas with higher representation of forests and non-forest timber vegetation.

Table 3.2 Input data for capacity, demand and flow assessment of ES Biomass – timber and fibre

Input data/ ES	P2 Biomass – timber and fibres
Capacity	Current landscape structure – selected categories of land use and their suitability for the production of timber and natural fibres
	Production capacity of forest stands (according to stand types in JPRL)
	Soil production potential – reclassification based on subtype, depth and texture
	Climatic conditions (temperature and moisture balance)
	Hydrological conditions (depth of groundwater level)
Demand	Statistical data – biomass consumption – timber and other fibres (municipalities, districts)
	Population – map of the distribution of population or population density (municipalities, districts)
	Value of commercial production (districts, regions)
Flow	Current landscape structure – CLS categories actually used to produce biomass (commercial forests, other trees, part of arable land, etc.)
	Statistical data – production of forest biomass, e.g. per unit area (kg/ha), by forest and agricultural enterprises
	State of forest ecosystems and measures in stands
	Size of crop areas, production of technical crops (municipalities, districts)

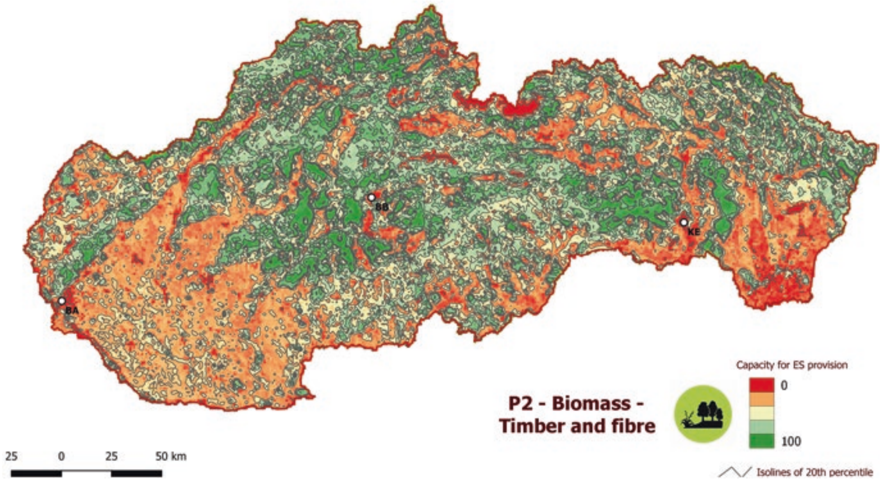

Fig. 3.9 Landscape capacity for provision of ES Biomass – timber and fibre (P2)

In addition to clarifying the value of the landscape's capacity for the provision of this ES, it is also necessary to address demand and actual use issues in the future. Demand for the use of ES Biomass production can be expressed by indicators of *real consumption of timber and other fibres* in different territories (administrative units), but such data is not available. Therefore, this data can be replaced by other related data – e.g. the *number of residents* living in a particular territory, or the *volume of economic production* or other economic indicators.

Real use of ES can be expressed by indicators of *timber production* (volume of production) in a given period in the territory of different forest management areas. In case of timber outside of the forest, such statistics do not exist. The use of other types of fibres (special technical crops) can only be assessed through the use of crop areas and possibly the yield of these crops.

3.3 Drinking Water (P3)

3.3.1 Definition and Brief Characteristics of ES

Drinking water is one of the typical ecosystem products used every day. It is essential for life on Earth, for the development of society and for human well-being. Water intended for consumption is fully dependent on natural conditions or ecosystems. It is particularly at risk by anthropogenic influences (Fisher et al. 2009).

Freshwater ecosystems (rivers, lakes, coastal waters and groundwater) support the provision of more than one type of ES, such as water supply, fishing and recreation. Other important ES are also associated with the hydrological cycle in the watershed – e.g. water purification, water-flow regulation and climate regulation. The supply of drinking water is one of the provisioning ES, which are evident and in most cases economically valued, e.g. by suppliers of this commodity (Grizzetti et al. 2016).

Drinking water is one of the ecosystem services that are used directly. In our conditions and environment, the source of drinking water is mainly groundwater, to a lesser extent surface water (clean rainwater concentrated in rivers, reservoirs and lakes). Drinking water represents only part of the total surface and groundwater volume – only that part which meets certain quality criteria. In the SR these criteria are stipulated by the Act of the National Council of the SR no. 355/2007 Coll. on the protection, promotion and development of public health. Pursuant to Article 17 of this Act drinking water is:

> … in its original state or after treatment intended for drinking, cooking, preparation of food or other domestic purposes without regard to its origin and to whether it was delivered from a distribution network, water tank or as water packed into consumer packaging and water used in food factories in the production, treatment, conservation or sale of products or substances intended for human consumption.

EU legislation uses the equivalent term *water for human consumption* (available online: www.enviroportal.sk)

In EU countries, groundwater resources cover about 50% of drinking water consumption, surface water covers 37%, with the remaining 13% consisting of other anthropogenic sources (filtration, recycling) – (Fig. 3.10) (Schröter et al. 2019). In the SR, mainly underground sources (82%) are used for drinking water consumption, surface sources account for 18% of consumption (available online: www.pitnavoda.enviroportal.sk).

Overall, the ecosystem service of drinking water supply can be expressed as the *capacity of ecosystems (landscapes) to capture sufficient harmless water resources* that are or can be used for drinking purposes. Thus, in addition to the capacity to capture a certain amount of water resources, its quality aspect is also important – for this purpose, it is also necessary to achieve and maintain an adequate quality of the main environmental components (except for water, e.g. soil and substrate). The ultimate user of this ES is the population – unlike the ES Freshwater, which is used, besides the population, for various economic activities.

3.3.2 Methods Used to Assess and Identify ES

Freshwater ES are often quantified by biophysical and economic assessment methods which include standard science practices and models. Spatial models based on GIS and modelling such as QUICKScan, ESTIMAP, InVEST, State and Transition

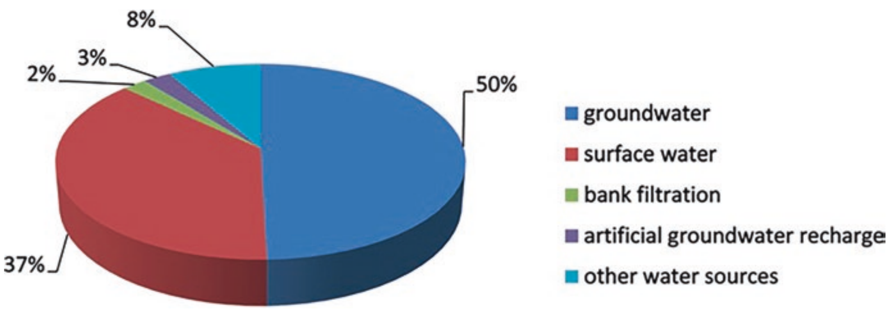

Fig. 3.10 The share of drinking water sources in the 27 EU countries. (Source: Schröter et al. 2019)

models, etc. are also very commonly used. Most of them rely on the spatial mapping of ecosystems and land use.

Biophysical basis for the provision of ES Drinking water is the presence of water reserves. According to Vačkář et al. (2014), the ES capacity is determined by the total amount of water (e.g. m^3/ha), while the performance indicator (sustainability of service) is the maximum sustainable water extraction (m^3/ha/year). However, not only water supplies are important – the amount and quality of water are influenced by complex climate interactions, topography, geology, land cover and management and other anthropogenic influences (Grizzetti et al. 2016). It is possible to obtain background data from the national statistics of the given country (e.g. from the Slovak Hydrometeorological Institute in Slovakia). Spatial projection and water reserves in territorial units have been taken into account in several countries (Denmark, Finland, Luxembourg, Romania) when assessing this ES. The rate of utilization of these reserves is often mentioned (pumped water with respect to reserves – Germany, Romania). More comprehensive indicators of the landscape's potential include, e.g. climatic parameters (precipitation balance), land use, soil and water quality, hydrogeology and vegetation quality (Pérez-Soba et al. 2015).

ES of drinking water can also be assessed from an economic point of view, with three available approaches – cost-based approaches, revealed preferences approaches or stated preferences approaches (Grizzetti et al. 2016). Several national ES assessments are based on the supply/demand formula for drinking water. Available national databases are used for the supply of drinking water as they include data on drinking water supplies, potential or production in the region. Demand for drinking water can be expressed as drinking water consumption, or its price, or as the number of residents living in a particular territory.

For example, the ES national assessment of Spain (Santos-Martín et al. 2016) calculates the contribution of surface water to drinking water, estimated on the basis of the European model. The surface water volume (m^3/ha/year) was expressed as the contribution of inland waterbodies and marshes to the drinking water supply. These values were recalculated according to the price of water, and the result presents the economic value of drinking water (€/ha/year). To determine the demand, water consumption statistics were used, which were subsequently converted to m^3/ha/year or to €/ha/year. Based on the data on drinking water supply and its consumption, an index was calculated, which represents the difference between supply and demand – in this way it is possible to determine the areas with a surplus or deficit of drinking water and express these values in biophysical and economic units. The national ES assessment in Germany (Rabe et al. 2016) is based on a similar principle but uses groundwater data. The input for the calculation is the capacity of the territory to produce drinking water based on soil infiltration capacity, zone saturation, information on groundwater drinking sources as well as factors that are not directly dependent on ecosystems. The definition of water consumption was based on data from all drinking water providers over a period of 3 years. From these inputs, the groundwater usage index was calculated, showing water usage as a percentage of the available quantity of reserves.

3.3.3 The Main Types of Landscape and Ecosystems Which Provide ES

Simply put, almost all types of ecosystems provide hydrological services, of course, to a different extent. Every ecosystem affects the properties of the water which runs through it (Brauman et al. 2007). Plants, as an important component of almost every ecosystem, act as natural filters which remove impurities and sediments before storing water in the recipient. In turn, forests and permanent vegetation affect how much water will be available in a given location and also affect water quality.

For drinking water production, the most important *ecosystem* is the geological environment in which groundwater is collected and from which most of the usable drinking water reserves are obtained (Fig. 3.11), which either comes to the surface via natural water springs or artificial wells and boreholes. From a global perspective, groundwater is particularly vulnerable to contamination of anthropogenic origin (chemicals, waste, nutrients, etc.), climate change and excessive groundwater abstraction. Each of these threats has the potential to alter the structure and functioning of groundwater and thereby provision of ES Drinking water, while these threats are concurrent (Schröter et al. 2019).

The amount of groundwater itself depends on their long-term reserves in different underground levels, partly also from immediate- and short-term processes and phenomena on the surface, in the subsurface layer of the soil and in layers of shallow groundwater circulation (Fig. 3.12). It is the subsurface layer that is heavily influenced by the amount of reserves, regime and quality characteristics as well as by the state and use of other types of ecosystems. In this respect, the most important types of ecosystems with the capacity to positively influence the provision of ES Drinking water include especially wetland ecosystems; forest ecosystems and permanent vegetation in the landscape; to some extent, grasslands and permanent agricultural crops.

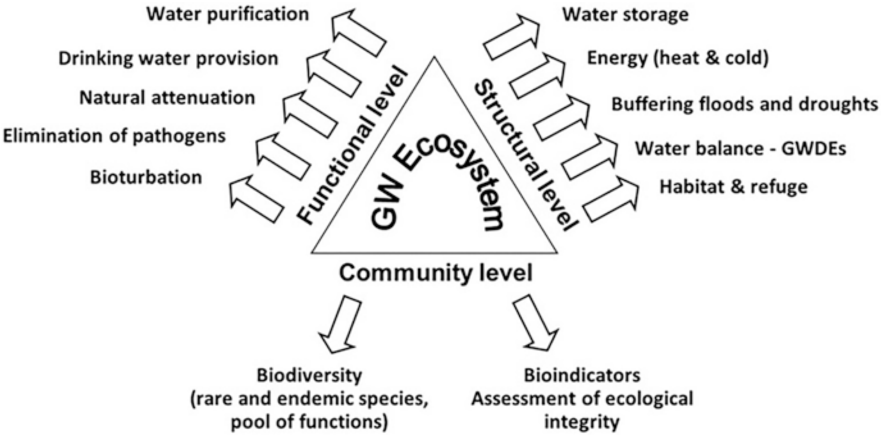

Fig. 3.11 Groundwater ecosystem services. (Source: Schröter et al. 2019)

Fig. 3.12 Springs and groundwater as an important part of ES Drinking water – Vojtovský prameň spring, Čadca. (Source: D. Kaisová)

The second most important source of drinking water comes from freshwater surface water resources (water reservoirs and watercourses). The threat to these resources comes mainly from the loss and destruction of habitats, river embankment and widespread water regime changes, environmental pollution and eutrophication, invasive species occurrence, climate change, and intensive use of water for other purposes (transport, energy, agriculture and fish stock). In terms of maintaining and improving the quality of surface water resources, the ecosystems similar to those for groundwater are the most important.

Water quality indicators are expressed by selected physical, chemical, biological and microbiological properties. In Slovakia, 28 water quality indicators are regularly monitored (e.g. presence of coliform bacteria and enterococci, microorganisms; content of selected metals, nitrates, nitrites and fluorides; biological and chemical oxygen consumption, water acidity, colour, turbidity and radiological indicators). It is the secondary contamination of water by human and animal faeces that is considered to be the greatest threat to drinking water – global mortality from drinking-water-related diseases exceeds 5 mil. people a year (Schröter et al. 2019).

3.3.4 Importance of ES in Terms of Nature and Landscape Protection in Slovakia

The hydrological component is one of the essential parts of ecosystems – it is essential for the existence and for the proper functioning of almost all types of ecosystems. ES Drinking water is especially important for humans – our nutrition and health – and to some extent for the existence and health of animals.

A large number of anthropogenic impacts on water resources have a significant influence on the quality of drinking water in Europe as well as in Slovakia. Drinking water, as one of the most important ES, is a vulnerable resource, protection of which requires integrated management. Extensive water purification is necessary, but it is not the only solution. Instead, the system's resilience should be strengthened by consistently reducing polluting factors. Responsible polluters should be actively involved in measures to reduce these threats, including the context of relevant legislation (Schröter et al. 2019).

In terms of nature and landscape protection, the proper functioning of the ES Freshwater is crucial. For this area (and for the favourable development of ecosystems and habitats in general), drinking water is not the most determining factor – of course, some quality status of water resources is particularly needed for animal nutrition. The relationship between water availability, hydrological regime on the one hand and nature and landscape protection on the other is described in the characteristic of ES Freshwater.

On the other hand, good practice of nature and landscape protection is a relatively important positive factor for better availability and quality of drinking water in adjacent areas (Fig. 3.13). Maintaining natural forests, non-intervention areas and appropriate management of protected areas contributes significantly to the mitigation of climate extremes, to the improvement of the hydrological regime of the area and thus to the increase of drinking water reserves in the landscape and to its better usability.

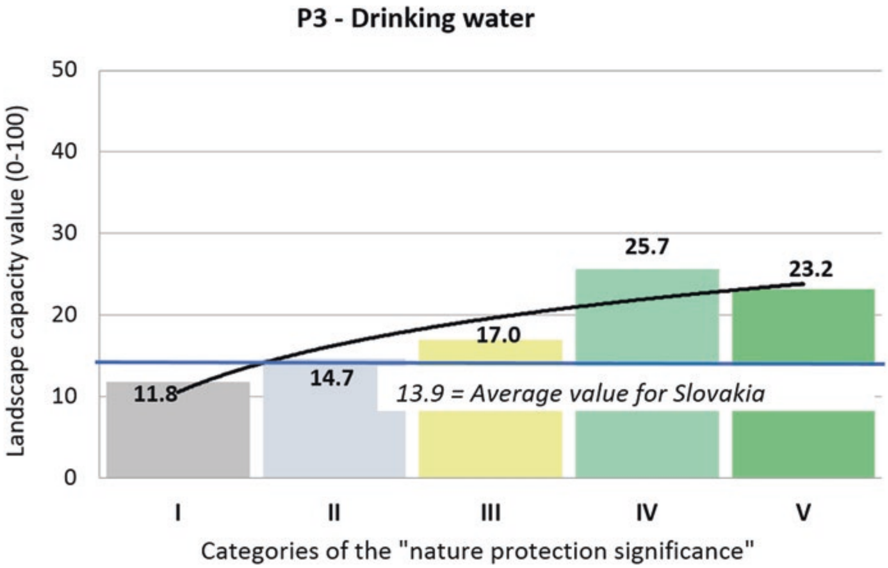

Fig. 3.13 The relationship between ecosystem service P3 and the significance of the territory of Slovakia in terms of nature and landscape protection

3.3.5 ES Assessment for the Territory of Slovakia

Drinking water sources in Slovakia are mostly located subsurface (springs, wells, boreholes) and to a lesser extent on the surface (water reservoirs and watercourses). The distribution of drinking water is provided via the public water supply network and to a lesser extent by individual wells. Recording and monitoring of water supplies (both drinking and freshwater) as well as its protection is ensured in long-term by organizations within the purview of the MoE (WRI, SWME).

At present, ten protected water management areas with a total area of 6942 km^2 have been declared in the Slovak Republic, representing 14.2% of the Slovak territory. About 1138 hygienic protection zones (HPZ) of groundwater sources are established in the SR. For the abstraction of surface water for drinking purposes, 73 HPZ have been set up in the territory of the Slovak Republic, of which 8 are related to abstraction from water reservoirs (Fig. 3.14), and 65 HPZ is set for direct abstraction from surface streams, which are situated mainly in the region of Eastern Slovakia (available online: www.mpsr.sk). Slovakia uses 102 watercourses and 8 water reservoirs (available online: www.shmu.sk). A substantial part of the water from surface water sources flows to Slovakia from neighbouring countries – Austria, the Czech Republic and Ukraine – and only a small part comes from our territory (14%). Groundwater sources are distributed unevenly depending on geological conditions. In Slovakia, natural groundwater reserves account for 146.7 m^3/s, of which 51.7% are usable (available online: www.mpsr.sk).

Fig. 3.14 Water reservoirs and their use for drinking water purposes – Starina water reservoir. (Source: M. Jančovič)

In 2017, 45.0 mil. m^3 of drinking water was taken from surface sources, which meant 19% of total surface water abstraction; and 7855 l/s (247.6 mil. m^3 per year) of subsurface resources, which represents up to 74% of total groundwater abstraction. Water losses in the SR pipeline network, however, amount to 25% (MoE SR 2017). At present, 88.9% of the population of Slovakia (4.84 mil.) is provided with a supply of drinking water from public water network, while part of the municipalities is supplied from local sources and garden wells.

The total water balance in the territory of Slovakia is positive – the share of total abstraction to the overall water supply volume is less than 10%. The long-term abstraction of water is decreasing considerably, but a gradual slight increase is currently expected. Surface and groundwater reserves are likely to decline due to changing climatic conditions**.**

Importantly, the quality of drinking water on the territory of Slovakia is high, with the proportion of unsatisfactory samples in long-term being at a level of less than 2–2.5%. In 2017 this was only 0.3%. In international statistics, the availability of safe drinking water for Slovakia is reported at 100%.

The most important reservoir of usable drinking water in Slovakia is Žitný ostrov area. With its area, it forms the largest inland *island* within Europe with an area of 1885 km^2 (Dušek and Velísková 2017). Almost one third of the total usable groundwater quantities in the SR is concentrated here, with approximately 10 billion m^3 located below the surface (available online: www.shmu.sk). Another important source of drinking water represents the Starina water reservoir in the north-eastern part of Slovakia, which has an area of 3.11 km^2 with a volume of 59.8 mil. m^3. The

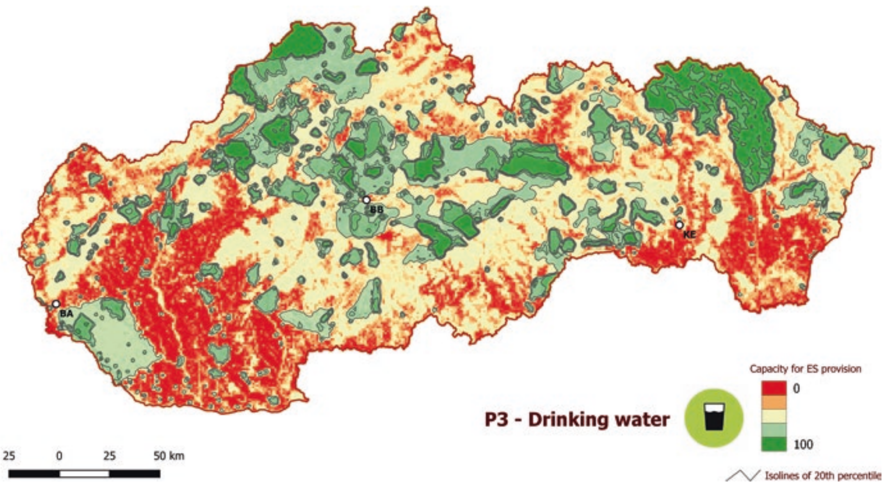

Fig. 3.15 Capacity of the landscape to provide ES Drinking water (P3)

Table 3.3 Input data for assessment of ES Drinking water

Input data/ ES	P3 – Drinking water
Capacity	Important water management areas: watercourses, water reservoirs; water resources and their HPZ
	Protected water management areas and watercourse basins
	Data on drinking water supply, discharge of water resources
	Standardization of ecosystems/landscape types supporting ES Drinking water (CLS map reclassification)
	Environmental limit data – e.g. environmental quality (water pollution in terms of drinking water parameters) – not yet taken into account
Demand	Data on population distribution – urban settlements and densely populated areas
	Number of inhabitants in municipalities/districts – recalculated according to average water consumption
	Drinking water consumption by municipalities/districts (place of drinking water delivery)
Flow	Surface water and groundwater abstraction from individual river basins and waterbodies (for drinking purposes) – drinking water abstraction areas, the quantity of water collected

longest water-supply river sections are located on the Ondava and Topľa watercourses (available online: www.shmu.sk).

The result of the pilot assessment of the landscape's capacity to provide ES P3 is shown in Fig. 3.15. Multiple layers were entered into the calculation (Table 3.3) – locations of water resources, water reservoirs, natural balneo-therapeutical resources and their protection zones, watercourse basins and protected water management areas. The land use was subsequently incorporated into the calculation as a coefficient of improvement or deterioration of the given level of capacity (reclassification of the landscape structure). The processing of the calculations, their scaling and the graphical representation was similar to that of the other ES. The results illustrate the spatial distribution and relative significance of water resource protection categories. For the future, it is advisable to consider supplementing environmental quality indicators – especially surface and groundwater quality, but also soil and air quality, possibly with the occurrence of threats in terms of water quality (large landfills, other environmental risks).

Table 3.3 also shows some indicators which should be assessed for future expression of the level of demand for ES Drinking water as well as its actual use. Demand is given similarly as in the case of other production ES mainly by the number of inhabitants living in the territory, in combination with registered or expected water consumption. The flow of this ES is conditional on real use – abstraction of surface and groundwater for drinking purposes in river basins or administrative units. Here, it will be also necessary to combine data for different spatial units – natural (river basins) and socio-economic (municipalities, districts) in the subsequent comparison of capacity, demand and flow of the ES.

3.4 Freshwater (P4)

3.4.1 Definition and Brief Characteristics of ES

Human society uses water not only for drinking but also for various other purposes. Traditionally, freshwater is considered to be water used in industry and agriculture, the water necessary to produce hydroenergy, water for sanitation, or water needed for fishing purposes and genetic resources, etc. (available online: www.freshwater-tools.eu). The term also includes water used for waste management, transport or recreation. At the same time, water is an essential input to food and fibre production and is also used for many basic and complementary activities (Preston and Raudsepp-Hearne 2017). Ensuring reliable water supply is therefore of great importance for the functioning of the whole society (Becerra-Jurado et al. 2016).

Freshwater is obtained similarly to drinking water, mainly from subsurface and surface sources. However, its resources are much larger compared to drinking water, because they do not have to meet all the specified quality parameters. Although such parameters exist in some cases (e.g. water for recreation), they are considerably less stringent than for drinking water.

Annually, humanity uses 1000–1700 billion m^3 of water from subsurface and surface sources, while the estimated supply of these resources is 1100–4500 billion m^3/year (Hoekstra and Wiedmann 2014). While in 1990 the total specific drinking water demand was 425 litres per capita per day, it was only 164.96 litres per capita per day in 2016 (available online: www.enviroportal.sk).

Water supply is part of the so-called hydrological ES – Brauman et al. (2007) defined these as including benefits to people produced by the effects of terrestrial ecosystems on freshwater, with each service being determined by features such as quantity, quality, location and timing. ES related to water quality have also been described in detail by Keeler et al. (2012).

Accordingly, ES Freshwater can be defined as the *capacity of ecosystems and landscape to capture sufficient water resources which are or can be used for different purposes*. The water quality aspect of this ES is mostly not important. The end-users of this ES include various economic and non-production activities and also to a lesser extent the population.

3.4.2 Methods Used to Assess and Identify ES

The pilot study by Maes et al. (2016) analysed the freshwater-related ES by ecosystem typology, taking into account services provided by rivers, lakes, groundwater and wetlands. A different approach was taken by Brauman et al. (2007), who analysed individual relevant *hydrological services*. These are two basic approaches to ES assessment associated with drinking or freshwater. Both approaches deal with the integration of all services, with the first analysing all ecosystems and the other integrating all processes within the basin. ES relevant to water management are those related to aquatic ecosystems, water and soil interaction in different ecosystems such as forests, agricultural land, wetlands and other waterbodies.

There is a great demand for assessment tools which estimate the impact of landscape management on water supply services, such as irrigation, domestic consumption or hydroenergy production. Methods for assessing drinking and freshwater are often overlapping, with the assessments being applicable mostly for both ES using different statistical data. ES national assessments focus mainly on the assessment of drinking water, which may appear to be more important than freshwater. On the other hand, in case of freshwater, several uses can be dealt with, and more resource capacity can be considered.

As mentioned in the previous chapter, ES Drinking water and Freshwater are mainly assessed by two basic groups of methods – biophysical and economic. The amount of produced (available) water is an essential biophysical attribute in assessing water-related provisioning ES. This includes the volume of water available for drinking, agricultural purposes or the volume of flood discharge (Brauman et al. 2007) or the amount of water available for energy production. Many suitable or applied assessment indicators used by Pérez-Soba et al. (2015) are given in the characteristics of ES Drinking water.

The use of models presents a suitable way to assess water-related ES – e.g. Guswa et al. (2014) investigated the link between hydrological modelling and ES relevant for river basin management. The InVEST Water Yield model – the main purpose of which is to assess the energy obtained from water – is used as a tool for assessment of provisioning freshwater services, but its outputs are much wider. The model primarily seeks to answer the question of how changes in landscape use affect annual surface water reserves and thus affect water energy production. The model calculates the relative contribution of each partial area to the annual water supply and the value of this contribution in terms of energy production. Inputs to the model include the average rainfall, evapotranspiration, soil depth limit for root growth, water retention capacity, land use map, river catchment areas, landscape management information, ES demand and water energy price. It then provides the following outputs: current evapotranspiration (mm/year), water yield (supply) (mm/year), water demand (m^3/year) and energy available for hydropower plant (kW/year). It is a classic biophysical modelling approach (available online: www.naturalcapitalproject.org).

3.4.3 The Main Types of Landscape and Ecosystems Which Provide ES

Freshwater is essential for the functioning of all terrestrial ecosystems. The condition of aquatic ecosystems affects the provision of many ES necessary for the well-being of society (Jäppinen and Heliölä 2015). Water-related ES are derived directly from aquatic ecosystems, including rivers (Fig. 3.16), lakes, floodplains, wetlands and their adjacent riparian areas. In the case of provisioning ES such as water supply, it is desirable to increase its amount. On the contrary, in case of regulatory ES such as flood mitigation, it is beneficial to slow down and reduce the runoff.

Although the ecosystems themselves do not create water in any significant manner, but they do change the amount of water circulating in the landscape (Brauman et al. 2007) and thus influence the hydrological regime. This regime is dependent on a number of external factors which are influenced by the structure and status of ecosystems and the related ecosystem processes. The whole hydrological system is also greatly influenced by human activity, which is certainly one of the most important external factors influencing not only the quality but also the quantity and regime of water resources.

Fig. 3.16 Water in watercourses as an important source of freshwater – the Turiec river used to feed horses and cattle. (Source: J. Černecký)

ES Freshwater is directly provided by freshwater ecosystems, namely, surface and groundwater (of course, these include marine and ocean ecosystems in a wider European and global context). Water reservoirs, larger watercourses and groundwater sources are considered the most important ones. However, from the above mentioned, all wetland ecosystems, forest ecosystems and permanent vegetation in the landscape can also be included among (as in the case of ES Drinking water) other types of ecosystems which have a positive impact on the provision of this ES. These cocreate the *hydrological regime and the water cycle in the landscape* and contribute to the transformation of runoff, its attenuation and the creation of long-term reserves of surface and partly groundwater. To some extent, grasslands and permanent agricultural cultures can also be included in this category. On the other hand, urbanized areas, especially built-up areas and sealed surfaces, are considered to be the least contributing ecosystems to the provision of this ES.

3.4.4 Importance of ES in Terms of Nature and Landscape Protection in Slovakia

ES Freshwater is crucial not only for natural and seminatural ecosystems (which form a priority of nature and landscape protection) but also for the functioning of ecosystems used by people, which are again represented by various forms of land use. The availability of freshwater and the proper functioning of this ES can, therefore, be considered as one of the important preconditions for good health of habitats, which are important for nature and landscape protection in Slovakia. Areas with sufficient water reserves and an appropriate hydrological regime have proper conditions for the favourable state of protected areas of nature as well as conditions for the occurrence of protected and endangered species of plants and animals. Obviously, aquatic and wetland habitats are among the most important for the availability of water and a favourable hydrological regime. The same habitats are also included in the priorities with respect to nature and landscape protection.

It is the changes in land use, continuing urbanization and high water consumption during irrigation and climate change, which are currently changing the state of water reserves and the nature of the hydrological cycle. The results show, for example, that agriculture uses about 30% of the total amount of water in Europe and up to 80% of the total water collected in some parts of southern Europe. Currently, water scarcity affects about 10% of the European population, while 20–40% of water is lost unnecessarily in the pipeline network. Water consumption by the public, industry and agriculture is expected to increase by about 16% (Schröter et al. 2019), but as a result of climate change, the usable amount of water is likely to decrease. All this creates a great deal of pressure on the consumption of freshwater and drinking water and forms a precondition for the gradual reduction of its availability for natural ecosystems, protected areas, as well as plants and animals in the wild. Therefore, understanding the relationship between anthropogenic pressures

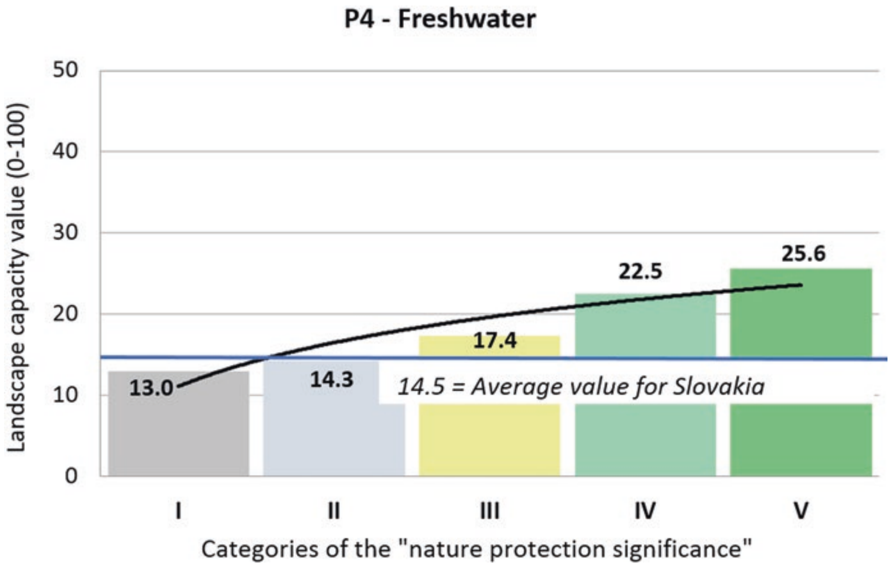

Fig. 3.17 The relationship between ecosystem service P4 and the significance of the territory of Slovakia in terms of nature and landscape protection

and the ecological status of aquatic ecosystems forms the basis for designing effective measures to achieve good ecological status not only for waterbodies and for water production but also for nature and landscape protection. In recent years, this fact has been also directly related to Slovakia, when a high water yield drop has been recorded, e.g. in the area of Záhorie, but also in many other areas.

On the other hand, good nature conservation practice supports the landscape's capacity to provide this ES. Natural and seminatural ecosystems, left to spontaneous development or appropriately managed, can contribute to improving the landscape's hydrological regime and thereby improve the availability and spatial distribution of freshwater within a landscape (see Fig. 3.17). These mainly include natural watercourses and areas, wetland communities (marshes, bogs, riparian and alluvial forests), wet meadows as well as natural forests of various types with varied species and age structures.

3.4.5 ES Assessment for the Territory of Slovakia

Based on hydrological assessment and surveys, there was 76,508 l/s of available groundwater volume in the SR in 2017 – in the long-term assessment, the increase in usable volume compared to 1990 is 1733 l/s, i.e. 2.3% (available online: www.eviroportal.sk). Slovakia is divided into 110 hydrogeological regions, and their balance status is mostly good. Of the total reserves, 10,607 l/s was being used, i.e.

13.9% of the total available volume (available online: www.shmu.sk). The freshwater from the total amount of groundwater collected represents 26% – mainly used in agriculture and in various other industries. In terms of spatial distribution, these available volumes of groundwater in Slovakia are diversified considerably.

A substantial part of the surface water fund of Slovakia flows from neighbouring countries, and its usability is limited. In total, about 2514 m^3/s of water flows in the long-term average, representing about 86% of the total surface reserves. Approximately 398 m^3/s of water originate from Slovakia considering the long-term average, accounting for 14% of the water fund and is thus not sufficient to meet the commercial needs of major economic and residential agglomerations. It is important that, in addition to the commercial requirements, the authorized quantities of surface water abstracted respect the requirements for the ecological limits of the relevant waterbody, so that the exploitation of these resources does not damage adjacent aquatic ecosystems.

In 2017, surface water abstraction amounted to 244.1 mil. m^3, which represented a decrease of 567.4 mil. m^3 compared to 1997 and 492.9 mil. m^3 compared to 2000. More than 80% of this volume was formed by freshwater, which is mainly used in industry and energy, to a lesser extent in agriculture (Fig. 3.18, available online: www.enviroportal.sk). According to the water management balance of water reservoirs for 2017, the total usable water volume is about 1300 mil. m^3. The total water reserves as of 1 January 2017 in the reservoirs (32, of which 20 are accumulation reservoirs) for 2016 amounted to 926.6 mil. m^3, which represents 80% of the total usable water volume (available online: www.shmu.sk).

In addition to the quantity of water resources, their quality is important. The overall quality of surface water in Slovakia is assessed in more than 1500 natural formations (watercourses and waterbodies). In the reference period from 2009 to

Fig. 3.18 Amelioration canals are significant water management elements, especially in the lowland country (Podunajská nížina). (Source: J. Špulerová)

2012, poor and very poor status was documented in about 9% of the number of monitored waterbodies, with 56% of the bodies showing very good and good ecological status. In terms of bathing water quality, a total of 79 natural waterbodies were assessed in 2017, with 25.4% of the samples being unsatisfactory. Groundwater quality is also regularly monitored in 75 bodies of groundwater (quaternary and prequaternary formations). In 2017, 14% of groundwater bodies were showing poor chemical status.

Pilot assessment of the landscape's capacity to provide ES P4 Freshwater was performed in a similar way to the ES Drinking water. Layers entering the calculation are listed in Table 3.4 – these include, in particular, groundwater reserves in individual regions, water reservoirs and watercourses significant from the water management point of view. The method of land use subsequently entered the calculation as a coefficient of improvement or worsening of the given level of capacity (reclassification of the landscape structure). The assessment results are shown in Fig. 3.19, in which the relative potential of the regions of Slovakia in terms of total surface and groundwater supply is expressed.

As regards the assessment of supply and demand with respect to ES Freshwater, similar indicators as those used for ES Drinking water may be considered suitable. Demand is determined by the intensity of use of freshwater resources – it is registered or assumed water consumption. It also depends to a certain extent on the number of inhabitants living in the territory, but the level of economic activity is also very important. The flow and real use of ES are given by surface and groundwater abstraction for commercial purposes in river basins or administrative units.

Table 3.4 Input data for assessment of ES Freshwater

Input data/ES	P4 – Freshwater
Capacity	Hydrogeological regions + groundwater reserves
	Hydropedological data (permeability, infiltration ability)
	Watercourses significant for the water management
	Water reservoirs according to purpose
	Classification of ecosystems/landscape types supporting ES Freshwater (CLS map reclassification)
	Other suitable data:
	Watercourses with average discharge values
	Climatological and hydrological data – precipitation, evaporation, precipitation-runoff balance
Demand	Data on population distribution – urban settlements and densely populated areas
	Consumption of freshwater by municipalities/districts (water delivery areas)
	Freshwater requirements (municipalities, agricultural and industrial enterprises, etc.)
Flow	Quantities of surface water and groundwater abstraction from individual river basins and waterbodies – water delivery areas

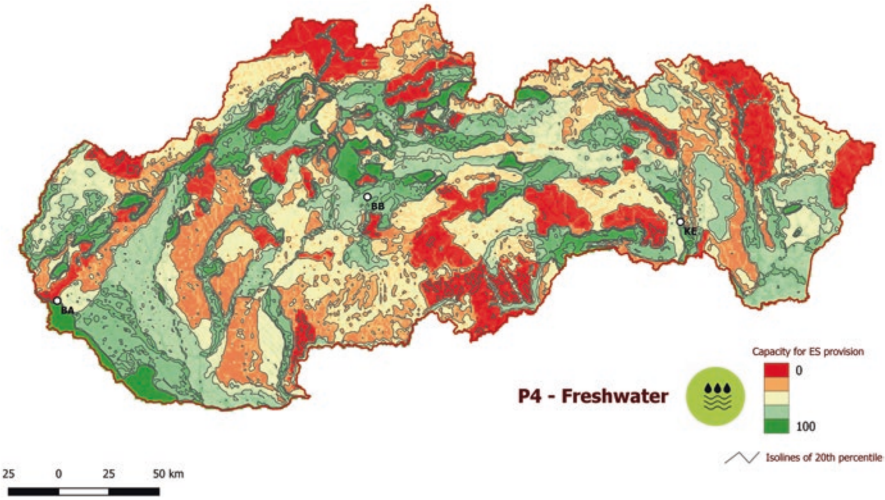

Fig. 3.19 Capacity of the landscape to provide ES Freshwater (P4)

3.5 Fish and Game/Wildfood (P5)

3.5.1 Definition and Brief Characteristics of ES

In addition to other functions, ecosystems provide people with fish, game and wildfood. According to Preston and Raudsepp-Hearne (2017), the ultimate benefit, in this case, comes in form of edible products derived from animals, plants and fungi which people use for their nutrition or commercial purposes (in addition to meet this includes fruits, seeds, mushrooms, tubers/roots, herbs, oils and the like).

Game hunting is considered an important part of rural traditions not only in Slovakia (Špiaková and Jančo 2017) but, for example, also in Sweden (Ljung et al. 2012) and Greece (Tsachalidis and Hadjisterkotis 2008). In Scotland and other parts of the UK, hunting is an old tradition which is important in defining social status (MacMillan and Leitch 2008). The economic factor also plays an important role in hunting. In countries with high average incomes, hunting is considered to be a symbol of the rich, with higher importance being attributed to the benefits of cultural ES (Murray and Simcox 2003), whereas in countries with lower average income, game hunting is primarily a provisioning service – a source of food (Tsachalidis and Hadjisterkotis 2008). The notion of wild game (from the point of view of provisioning ES in Slovakia) represents hunting game (including feathered game) and freshwater fish.

Maes et al. (2013) define the ES Wildfood as forest fruits (berries, fruits, nuts, mushrooms and seeds) and plants which are collected in nature to be used as food, or for medical purposes. The main incentives for collecting wildfood primarily include their availability and use in traditional cuisine (Pieroni 1999), medical purposes (Cruz Garcia and Price 2012) and their resale or artistic creations (Landor-Yamagata et al. 2018). In addition to the provisioning service, the collection of wildfood is also considered to be part of the identity of people, local traditions and the manifestation of natural and cultural heritage within cultural ES (Seeland and Staniszewski 2007). The collection is usually carried out in close proximity to human settlements (Stryamets et al. 2012), but higher participation rate is visible in rural communities (Łuczaj 2012).

The interest in collecting wildfood is decreasing due to population ageing and increasing urbanization. This occurs in many parts of Europe including Spain, Italy and Poland (Hadjichambis et al. 2008; Łuczaj 2010; Seeland and Staniszewski 2007). On the other hand, there is an assumption that the influence of industrialization and globalization will also cause an increased interest in the collection of wildfood, mainly due to cultural motives and traditions (Łuczaj 2012; Menendez-Baceta et al. 2012).

3.5.2 Methods Used to Assess and Identify ES

National assessment of ES Fish and Game/Wildfood was carried out in Finland (Jäppinen and Heliölä 2015), the Czech Republic (Vačkář et al. 2014), Romania (NEPA 2017), Luxembourg (Becerra-Jurado et al. 2016) and partly for selected protected areas also in Slovakia (Považan et al. 2015). Wildfood indicators have been proposed to assess total production based on the estimation of wildfood production per unit area. In Finland and Slovakia, the questionnaire survey method was used, with the national statistics (hunting licenses, hunting game total amount, hunted game amount, fishing permits) being the main source in Romania and Luxembourg. For most assessments of ES Fish and Game/Wildfood, a regional level was used. Input data included land cover type and land use in GIS, and also statistics on the amount of service produced (in kg/ha or number) were used to identify locations of supply and demand.

ES Fish and Game/Wildfood is not a commercially traded service but is a common part of market relations. The assessment method for calculating market prices proposed by Považan et al. (2014a) can be used for both wildfood and fish and game. Typical products which are included in the category of wildfood are medicinal plants, mushrooms, forest fruits and natural fibres. The value of wildfood V_{NT} is the price at which local people sell these products, e.g. to tourists or processing plants. The value of fishing and hunting V_{FH} mostly consists of two parts, namely, the value of the products sold, determined by market prices and the value of the license set by the national or local price level. These methods for calculating the value of wildfood, fish and game are described in more detail in the section of ES assessment for the territory of Slovakia.

Mapping the potential and occurrence of forest fruits and mushrooms and game hunting is also carried out by biophysical methods – e.g. in the environment of geographic information systems, it is possible to use a combination of landscape cover layers, habitat maps of assessed species with different spatial layers (e.g. climatic, hydrological factors, landscape management) and with data on the accessibility of the given territories as well as the time required for getting to the territory from inhabited settlements. Sampling-based direct mapping is appropriate for data acquisition in areas for which there is insufficient data (Burkhard and Maes 2017). It is possible to use statistical data from national databases on the population of individual species and data from hunting associations on the number of individual catches, the European Federation for Hunting and Conservation (FACE 2012).

The sociocultural assessment methods include in particular, questionnaires, semi-structured interviews and observations of gatherer, hunters or fishermen during their activities. These methods are suitable for detecting the species, quantity, area of harvest of wildfood and hunting of game and fishing. They also provide an opportunity for stakeholder representatives to express their views, which can be integrated into the decision-making process that is necessary for the proper management of the landscape (Chambers 2010; Sayer et al. 2013). Participative methods of mapping include mapping through analogue or digital data with participation from stakeholders and native people. In this way, we can identify the habitats of individual species of wildlife or forest fruits (Burkhard and Maes 2017).

3.5.3 The Main Types of Landscape and Ecosystems Which Provide ES

Wild game, such as roe deer or deer typically, occurs in forest communities (Fig. 3.20). Meadows, forest edges, fields as well as shrubs and hedges are suitable ecosystems for wild boar, pheasants or hares (Eliáš 2011). The landscape in which these species of game occurs should be as heterogeneous as possible to provide a shelter for the game. The agricultural landscape is, therefore, less suitable if it has large block fields without line vegetation and hedges where the game has no possibilities for shelter and breeding.

Watercourses are important for fish, such as unregulated rivers and streams, as well as waterbodies such as lakes (Jäppinen and Heliölä 2015). Lakes, ponds, watercourses and their riparian vegetation form typical environments where water birds live. They are being threatened by the removal of shrubs from the surroundings of watercourses, either for the purpose of flood control or biomass recovery.

Ecosystems, in which forest fruits grow, such as blueberries and cranberries, are represented by mountain grassland areas, or forest communities, where these plants form undergrowth. They occur mainly in areas with acidic soils. Raspberries and

Fig. 3.20 Mimicry of a young red deer (*Cervus elaphus*) merging with the environment of the forest ecosystem as part of an important ES for man in the form of a future hunting game. (Source: J. Černecký)

blackberries favour the clear-cuts or the edges of forest roads where they have enough sunlight to grow (Eliáš 1991). Forest communities are typical for mushroom growth, but some species can be found on meadows and pastures. The collection of medicinal plants is mainly linked to seminatural and natural grass-herb habitats, but pastures and forest communities are also important. Some species thrive on bare substrates (Eliáš 1991; Jäppinen and Heliölä 2015).

3.5.4 Importance of ES in Terms of Nature and Landscape Protection in Slovakia

Collecting wildfood, game hunting or fishing benefits both the gatherer/hunters and other consumers, whether as a source of food, income or cultural services – experiences. These services could positively influence nature and landscape protection management, through various obligations/measures related to the regulation of the overexploitation and displacement of natural species; or to the preservation of old forest stands as areas for breeding and conservation of game (Emanuelsson 2009). Nature and landscape protection is an essential part of preserving the provisioning service of collecting wildfood, game hunting and fishing. In most cases (whether it is wildfood collection, game hunting or fishing), their number is limited and bound to unique ecosystems that are very sensitive and responsive to change. At the same time, supporting nature and landscape protection in Slovakia promotes biodiversity. The more varied and valuable the territory, the better the prevalence of wildlife, precious plants and fruits, which can be described as a *positive correlation* relationship (see Fig. 3.21).

From the legislative point of view, the collection of freely growing wildfood in protected areas of Slovakia is regulated by Act no. 543/2002 Coll. on Nature and Landscape Protection, which states that the collection of plants, including their fruits, is prohibited for the general public in a territory where the third or higher level of protection applies. There are a number of reasons for such a strict limitation:

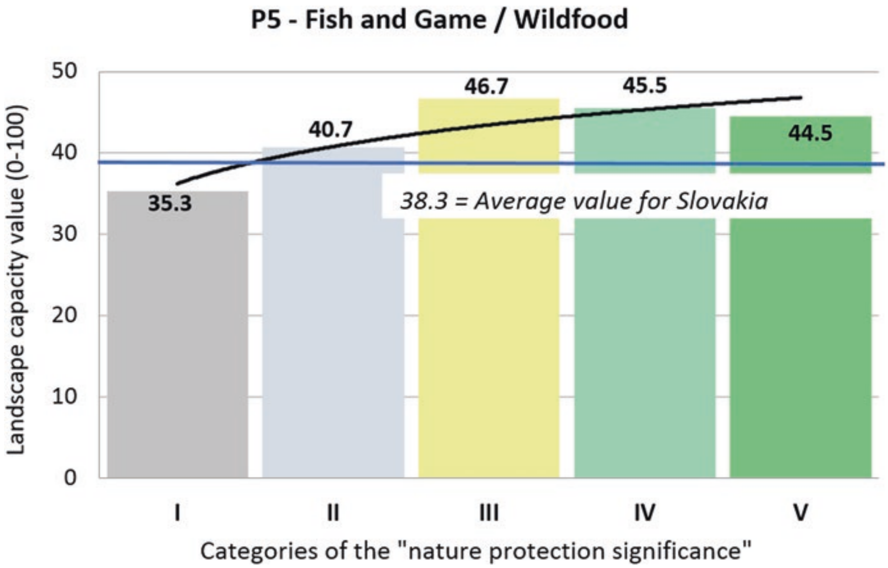

Fig. 3.21 The relationship between ecosystem service P5 and the significance of the territory of Slovakia in terms of nature and landscape protection

on the one hand, they are in many cases the only source of food for animals, of which there are a large number of protected ones (e.g. for western capercaillie (*Tetrao urogallus*) or brown bears (*Ursus arctos*), blueberries are significant seasonal food sources). On the other hand, in the case of insensitive collection of fruits with the help of various tools, the bushes and shrubs are damaged. Also, paths are created and these form a base for further erosion. Further reasons include disturbance of nature, waste and the pollution of the protected areas. The spatial restriction does not apply to protected species of plants and animals whose collection/hunting is prohibited throughout Slovakia. It is by collecting of plants that some protected species of European importance are endangered in the Slovak Republic, e.g. *Aconitum firmum* subsp. *moravicum* or *Daphne arbuscula* (Petrášová et al. 2013), as well as some animals – especially invertebrates (e.g. butterfly *Parnassius apollo*).

The hunting of game in Slovakia is governed by several Acts, especially Act no. 274/2009 Coll. on Hunting, as well as Act no. 543/2002 Coll. on nature and landscape protection, which limits the possibility of hunting game up to the fourth degree of nature protection (inclusive). The set of measures respecting nature protection also includes the Framework of Hunting Development of the SR 2017, as well as several regulations of the Ministry of Agriculture, directives, regulations and methodological instructions of the Slovak Hunting Union.

3.5.5 ES Assessment for the Territory of Slovakia

Formulas for calculating the value of wildfood and fish and game in the Carpathian protected areas are reported by Považan et al. (2014b). When calculating the value of wildfood, data from the management of the protected area, forest enterprises and national statistics may be used. The variables are as follows: yearly collection by product i – A_i (kg); average (median) product price at local level P_i (EUR/kg); i – type no. i. The value of nonwoody products: $V_{NT} = \Sigma A_i * P_i$. The data used comes from the reports of the relevant protected area administration, forest enterprises and national statistics (Považan et al. 2014b).

When calculating the value of wild game, it is appropriate to use data from reports of protected areas administrations, hunting associations, forest enterprises, national statistics and hunting statistical yearbook of the SR. The value of fishing and hunting V_{FH} mostly consists of two parts, namely, the value of the products sold, determined by market prices and the value of the license determined by the national or local price level. The variables are as follows: number of fishing and hunting licenses for I species – N_{FHi}; license price – P_{FHi} (EUR); number of units sold for species I – N_{Pi}; price of unit sold for species I – VPi. The value of fishing and hunting: $V_{FH} = \Sigma N_{FHi} * P_{FHi} + \Sigma N_{Pi} + V_{Pi}$ (Považan et al. 2014b).

For the spatial representation of the territories where the ES fish and game is located, it is possible to use the Forestry GIS, where the state administration maintains registers of hunting organizations, hunting grounds, users of hunting grounds and hunting guards (available online: www.forestportal.sk). Fishing grounds data can be retrieved for the fishing statistic.

An alternative way of assessment comes in the form of *value transfer* of the average cost of the game and wildfood, combined with the size of the ecosystems which produce the ES in some quality.

Due to the absence of statistical and other data, the assessment of the collection of wildfood (Fig. 3.22) in Slovakia is problematic. Considering the nature of the service, it is not possible to estimate the demand for this service (questionnaire survey) without more detailed research. The potential (supply) can be assessed based on data from the Catalogue of Habitats of Slovakia, the Atlas of Medicinal Plants and Berries and local case studies (Tutka et al. 2009; Považan et al. 2015).

For the assessment of ES Fish and Game/Wildfood for the territory of Slovakia in terms of capacity, demand and flow, it is important to obtain the correct data to be included in the assessment. The above-mentioned procedures and sources are suitable from the local to the regional level. That is why we have conducted the pilot assessment at the national level using appropriate and especially available spatial data (section Capacity in Table 3.5). The basic step was the reclassification of land use data (definition of CLS categories suitable for providing this service) and forestry (game enclosures, game reserves and pheasantries). At the basic level, hunting and fishing areas were defined according to the Landscape Atlas of the SR. These layers were the basis for determining the capacity of the landscape – data on the structure and quality of forest stands were then also included as the coefficients

Fig. 3.22 Collection of forest fruits as ES and also a part of the culture and traditions of Slovak people. (Source: J. Černecký)

Table 3.5 Input data for capacity, demand and flow assessment of ES Fish and Game/Wildfood

Input data/ES	P5 – Wildfood	Fish and Game
Capacity	Map of the current landscape structure – reclassification according to the suitability	Map of the current landscape structure – reclassification according to suitability for fish and game
	Forest stands quality and structure – reclassification	Game enclosures, game reserves and pheasantries – spatial projection
		Map of hunting/fishing grounds and areas
Demand	Data from questionnaire survey on demand for wildfood	Statistical data on the quantity of hunting permits/per unit area/per species
	Number of inhabitants and visitors of the municipality/region	Number of hunting/fishing permits
Flow	Statistical data on collected wildfood per unit area (kg/ha; kg/A)	Statistical data on the quantity of game hunted/fish caught per unit area (kg/ha; kg/A)
	Map of the current landscape structure	The real use of hunting/fishing grounds

improving or worsening this capacity. The overall assessment result is shown in Fig. 3.23.

Table 3.5 also shows the basic indicators which can be used for future expression of the level of ES demand as well as its real use. Demand can be expressed in a similar way to other provisioning ES by the number of inhabitants living in the territory, in combination with data on the number of hunting permits or by a survey among residents. The ES flow is conditioned by its real use – the amount of collected fruits, hunted game or caught fish. At national level, such data can only be obtained for regions, hunting associations or hunting grounds.

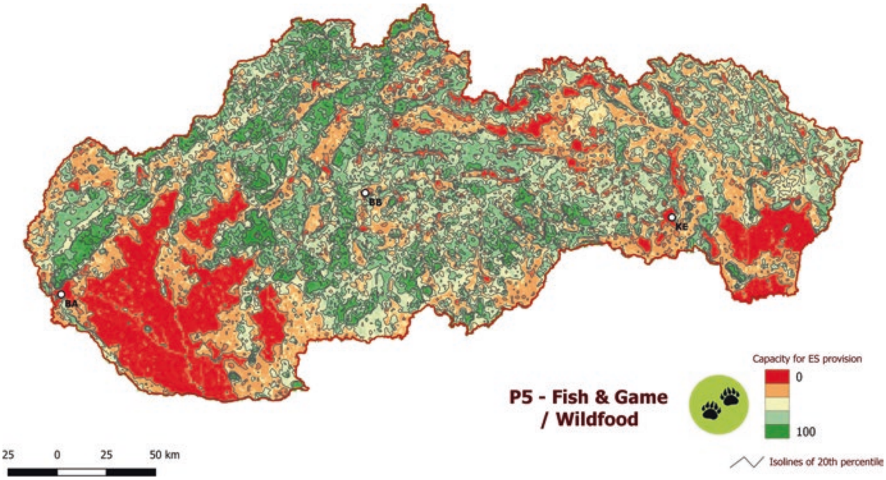

Fig. 3.23 Capacity of the landscape to provide ES Fish and Game/Wildfood

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