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Case Study

GIS-based Valuation of Ecosystem Services in Mountain Regions: A Case Study of the Karlovo Municipality in Bulgaria

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Abstract

This study aims to apply approaches, methods, and indicators from the conceptual framework of ecosystem services valuation to a real world, local level case study. It tests a GIS-based mapping and valuation of ecosystem services model in a typical mountain municipality in Bulgaria. Investigation results address opportunities, challenges and limitations in the practical application of the ecosystem services concept. They include an integrated assessment of the ecosystem services in a specific administrative territorial unit and suggest its Total Economic Value. The introduction of the term “ecosystem services dysergy” should contribute to valuation theory and practice. The study upgrades the currently available knowledge base that supports geospatial planning and sustainable development of the Karlovo Municipality and offers recommendations for improvement of the municipal ecosystem services utilization, which include identification, analysis, and visualization of hotspots and dysergy areas.

Keywords

ecosystem services mapping and valuation, ecosystem services dysergy, sustainable governance, mountain regions, Bulgaria

Introduction

The ecosystem services (ES) concept gradually deepens its influence on development of economic theory and practice (Gómez-Baggethun et al. 2010). The financial implications of inventories and ES flows are highly informative and help tracking the effects that changes in the quantity and quality of different types of natural capital and ecosystem services have on the economy and human well-being (Costanza et al. 1997). According to the TEEB Foundations, the process of valuation is "... a regulatory adaptation serving as a feedback mechanism in an economic system ..." (Kumar 2010), while De Groot (De Groot et al. 2010) presents ES valuation as a quantitative indicator of their importance. In general, ES valuation is a complex result of analyses which reflect the levels of their sustainable use both in time and space, while simultaneously taking into account the potential of landscapes to provide specific services and the effect of multifunctional landscape use and the derived services. According to Costanza et al. 1997, economic assessments should be based on dynamic models that "look beyond" the current state of an ES and take into account their possible changes and the critical thresholds in their development.

Brouwer et al. (2013) have synthesized the results of national experimental research and other research initiatives across Europe and offered a unified conceptual framework for choosing of appropriate approaches, methods and scales for assessing and evaluating ES in the context of "The Economics of Ecosystems And Biodiversity "(TEEB). They pay special attention to key issues, such as the financial implications of the ES without available market value, the spatial variability in ES values and the indicators for forming the total economic value (TEV) of ES. Brouwer et al. (2013) underline the importance of environmental accounting as a framework that should provide consistent information on the contribution of natural resources to economic activity, growth and prosperity. The topic is a subject of deep interest in the research circles (Naeem et al. 2009; Jacobs et al. 2014; Johnston et al. 2015; Potschin et al. 2016) where, in addition to the methodological problems of valuation and the interpretation of their results, the actual dimensions of the integration of the processes of the biophysical and economic valuation of ES are analyzed. Qiu and Turner 2013place emphasis on the role of spatial analyses for the understanding of interactions among “multiple ES across heterogeneous landscapes and their spatial concordance”.

Economic assessments of ES in Bulgaria are still limited to individual research initiatives (Dimitrova et al. 2015; Assenov et al. 2016; Ivanova et al. 2016). Due to the necessary involvement of stakeholders, e.g., local authorities, citizens, businesses, associations, public institutions, in the ES valuation processes, these research initiatives have proceeded simultaneously with promotion activities and education of the public. Therefore, the public

acceptance and approbation of the ES concept for the Bulgarian economy and society as a whole, including the degree of readiness to integrate it into everyday practice, is considered of particular importance. The challenges are numerous and include a wide array of factors that range from the general economic development level of the country and the respective geographic region, through the degree of data availability and the adaptiveness of the accounting and statistical systems, to the motivation of participants in the ES management process.

This study is prompted by the challenges in the practical application of the ES concept and aims at testing a mechanism which would make its implementation possible in a particular geographic locality. Some of the elements of such a mechanism include information provision and knowledge transfer to the locality that will make the practical value of the novel concept explicit. This concerns especially the benefits that go beyond the currently used comparable conceptualization of "natural resources". To ensure more than “socialization” and understanding, but also psychological “internalization” and motivation to test the new concept within a given locality, public leaders in all spheres and government levels, a “critical mass” of the socially active population, plus an ever open group of stakeholders should be necessarily and sufficiently convinced that this concept utilization will suit the local geographic conditions and provide the locality with a certain comparative advantage. This advantage is expected to be a significant step towards balanced and sustainable governance of the respective locality.

Bulgaria has moved, in accordance with Action 5 of the EU Biodiversity Strategy 2020 (Commission to the European Parliament, the Council, the Economic and Social Committee and the Committee of the Regions. Com/2011/0244 Final. 2011), to improve public knowledge of ecosystems and their services. The Ministry of Environment and Water (MoEW) used the results of this work for proposing environmental policy initiatives and tools, which ensure the maintenance of ecosystem services and improved the sustainable development of the economy. By April of 2017, the Ministry has produced a national methodology for evaluation and mapping of the major ecosystem types (according to MAES 2013) and the services they provide (consistent with CICES v4.3, Haines-Young and Potschin 2013). The methodological and instrumental provision of the ES economic assessment and the promotion of the integration of their value in the country’s accounting and statistical systems are still forthcoming.

The main goal of this study is to take this valuable theoretical work one step further and attempt to apply some of the approaches, methods, and indicators around the ecosystem services (ES) concept to a real world, local level case study. Thus, the present investigation tests GIS-based mapping and valuation of ES model to support sustainable governance in a typical mountain municipality in Bulgaria.

The geographic analyses of Bulgaria's landscape diversity, its economic development, and political-administrative management unambiguously highlight mountain regions as sensitive, vulnerable areas in terms of landscape sustainability and ES governance. The politically most engaging circumstance for the selection of the Municipality of Karlovo as a case study area is rooted in the strong dependence of the local population on the available

resources, as well as on the effectiveness of the respective economic initiatives. For the purpose of supporting sustainable decision making in an economically, socially and environmentally vulnerable area, the following basic tasks are identified: a/ Identification & selection of the ecosystems, which form the current and future basis of the local economy and the welfare of the population; b/ Selection and valuation of the ESs; c/ Integrated valuation of the selected municipal ESs; d/ Geospatial analysis of the ES distribution, identification of hotspots, caused by particular geographic patterns and their combinations, synergies and dysergies that results from simultaneous utilization of specific ES; e/ Propose recommendations for improvement of ESs utilization to support sustainable geospatial planning and governance.

Study Area

Karlovo Municipality occupies almost entirely the eponymous off-Balkan valley (Fig. 1), which consists of the southern slopes of the Troyan Mountain, part of the southern slopes of the Zlatitsa-Teteven Mountain (Highest Peak - Vezhen - 2198 m above sea level) and the Kalofer Mountain (Highest Peak - Botev - 2376 m above sea level). The north and the south borders of the Municipality serve as both administrative and physical boundaries, since they coincide with the ridges of the respective mountains – the Balkan Range to the North and Sredna Gora to the South. A significant difference exists between the lowest point of the Municipality (247 m above sea level near the Pesnopoiski (Stremski) Gorge of the Stryama River) and the highest point (the above mentioned Botev Peak, which is also the highest point of the Stara Planina Mountain (a.k.a., the Balkan Range). The long axis of the Municipality is situated in West - East direction and has a length of about 40 km, while the North - South axis varies between 10 and 15 km. One drainage artery – the Stryama River - covers approximately 90% of the Municipality. The typical Transitional Continental climate, which dominates the area, passes to mountainous in the higher regions. The average annual temperature is 11.4° C and the average annual precipitation - 653 mm/m^2 (Karlovo Municipality 2014,Plan for Development of the Karlovo Municipality for 2014-2020).

Generally, the physical geographic conditions in the municipality are favorable for economic development, particularly in the tourism and agriculture sectors. The balance of the municipal territory, dominated by forests (51%) and agricultural lands (45%), with 3% urbanized areas, 0.9 % water bodies and 0.4 % transport and energy infrastructure, is quite indicative in terms of the specific development areas of its natural capital.

Administratively, the Karlovo Municipality (LAU 1) is a part of the South Central Region (NUTS 2) of Bulgaria and covers 1% (1044 km^2) of Bulgaria's territory. It comprises of 27 settlements, including 4 towns and 23 villages, with a total population of 50 016 people (NSI, 2016). The rate of urbanization (58% urban) and the population density (47.9 persons per km^2) are much lower than the respective average rates for the country (73% and 67.6 persons/km^2. During the last 15 years, a steady negative trend characterizes the demographic processes in the Municipality: the population decreased by more than 28%,

due mainly to the significant decline in fertility and increase in emigration. As a result of the depopulation, which affects mainly younger people, the average age of the population continuously increases.

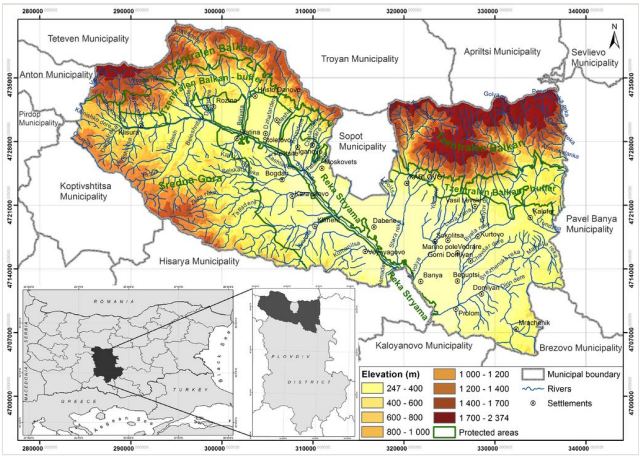

Figure 1.

Case Study - Karlovo Municipality.

The educational characteristics of the municipal population are also worse than the average for its District (NUTS 3) and the country. Only 11% of population of age “seven and older” has higher education and it is predominantly (85%) concentrated in the towns (Karlovo, Klisura, Kalofer, and Banya). The continuing worsening of the demographic potential, the increasing aging of population and the unsatisfactory educational characteristics negatively influence the quantity and quality of the human capital and present one of the most significant limitation factors for the present and future socio-economic development and wellbeing of the Karlovo Municipality.

The continual increase in the number of firms in the nonfinancial sector of the municipal economy during the last 10 years is a positive characteristic, which testifies to the traditional entrepreneurial spirit of the local population. At this stage of development, the increase is due exclusively to the group of the micro enterprises (up to 10 employees), which heavily dominates the municipal economic structure (93% of the total number of enterprises in 2014). Their share is practically the same for the respective NUTS 2 region and the county as a whole. On the negative side, the group of the small enterprises (up to 250 employees) – almost 6% of the total - is continuously decreasing in the municipality, and there are no enterprises of medium size. The three large enterprises, that survived the transition from central planning after 1989, are still in operation. The labor shortage in the municipality is increasing, particularly the lack of highly qualified workers. Altogether, between 2008 and 2014, the overall number of employees has decreased by 6% and this negative tendency is only expected to continue.

Over 16 million euro of foreign direct investments (FDI) entered the nonfinancial sector of Karlovo Municipality in 2014 and over 10 million euro has been invested in tangible fixed assets. Industry heavily dominates the municipal economic structure, in which manufacturing holds the largest share - 57% of the Produced Output, while services produce 35% and agriculture, forestry, and fisheries – about 7%. In terms of Value Added by Factor Costs however, the service sector produces about 50%, manufacturing only 45%, and agriculture, forestry, and fisheries sector – about 4.5%. At present, close to half of the total number of employees (7 563) are engaged in machine building. Metalworking, production of raw materials for the cosmetics industry (Bulgarian Rose Ltd.), wine industry, textile and knitwear industry are among the other economic activities. The large share of industry is not typical in mountain municipalities. Apparently, services hold the most efficient sector in Karlovo and indicate the direction of the future changes in its economic structure.

There are 3825 agricultural farms (including agricultural farms without utilized agricultural area) in the municipality with a total utilized agricultural area of 13010 ha (Ministry of Agriculture and Food, Republic of Bulgaria 2010). The average agricultural farm is very small in size – 5.9 ha – in fact, almost twice smaller than the average Bulgarian farm (10.1 ha). The smaller size of the agricultural farms is typical for mountain municipalities and Karlovo is not an exception. Generally, small-scale agricultural land use is accompanied by lower land productivity. In the case of the Karlovo Municipality however, the very specific natural conditions and the historic agro-industrial traditions combine to increase economic efficiency, mainly through the production of damask rose, lavender and other industrial crops. Cereals (7228 ha) still dominate the structure of the agricultural area, followed by industrial crops, including perennials - 3449 ha, and greenhouse vegetables. Specific for mountain agriculture, farm animals - sheep (29 316), poultries (48 111) and cattle (7 933) are also reared in the municipality.

The significant forest area (45 083 ha, CLC 2010) determines development of timber industry, hunting, educational, and eco-tourism. “The annual output of the timber industry is between 2 and 2.5 million euro” (NSI 2015a). Municipal territory includes parts of the National Park “Central Balkan” and two wildlife sanctuaries - “Stara reka” and “Dzendema”, which are characterized with the wide variety of flora and fauna, and particularly significant areas of oaks and beeches forests of the European varieties. The rich cultural heritage of the municipality adds to its natural recreational resources, preserved in very good condition and serves as a basis for development of cultural, scientific, cognitive, educational, and wellness tourism.

Local authorities aim at increasing the employment opportunities and especially the competitive power of the local economy by encouraging and development of research and development activities, upgrading the business infrastructure, modernizing agriculture, and stimulation of the manufacturing activities which correspond to local traditions and resources. At the same time, raising the quality of education and its close adaptation to local business requirements are seen as pivotal for reaching economic goals and increasing the wellbeing of the local population.

Data and Methods

The study falls under the Conceptual Framework for EU-wide Ecosystem Assessments (MAES 2013, MAES 2014), which identifies and evaluates ESs based on analysis of the current characteristics of their sources – the ecosystems - in terms of typology, ecological status, and dominant functions. The investigation targets the local scale of ES supply flows and includes the following stages (Fig. 2).

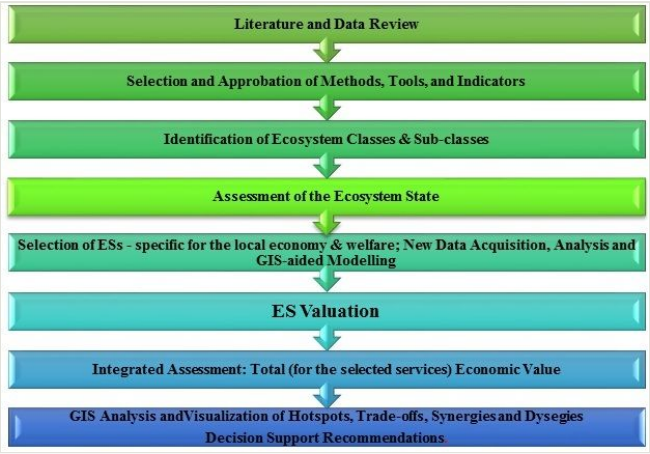

Figure 2.

Methodological Framework of Investigation.

For mapping purposes, ES class types are assigned to the corresponding ecosystem sub-classes (e.g., Non-irrigated Arable Land), which has the potential to provide the respective services. The investigation adheres to the following research propositions: a/ Each ecosystem sub-class can provide more than one ES; and b/ Different ecosystem subclasses can provide one and the same ES class type. The study assigns the monetary value of National Park's forest ES to all forest ecosystems in the Municipality on the grounds that more than 35% of the Park forest area is actual municipal territory.

A GIS-based approach has been applied to support modeling biophysical and economic indicators. The possibilities of GIS mapping of ES on the basis of an integrated biophysical and economic evaluation (Hayha 2014) have been instrumental in this study's methodology. The same approach has already been tested in Bulgaria in the municipality of Chepelare (Ivanova et al. 2016). The investigation interprets the CORINE Land Cover 2012 classes (NRC, Ministry of Environment and Water 2014) as spatial units for identification of ecosystem types, classes, and sub-classes (MAES 2013) and next - for valuation of the ES classes and class types (Haines-Young and Potschin 2013). These polygons are divided among the 35 classes of the CORINE Land Cover classification, which are present in Bulgaria. The minimum map unit is 25 ha and the conceptual scale is 1: 100 000.

The assessment of the ecological status and, respectively, the potential of ecosystems to provide services, is based on analysis of information from: a/ the assessment of the state of the habitat types represented in NATURA 2000 protected sites within the CLC Classes at Karlovo Municipality (BG0000429, BG0002054, BG0001389, BG0000494, BG0001493, BG0002128) (MoEW 2017); b/ the Landscape Ecological Assessment (Anonymous 2016); and c/ field data from the July-September 2016 research season. In addition, the study relies on a wide range of local, regional, and national level statistics (NSI 2015b, NSI 2015a, NSI 2016; Gerginova et al. 2015;Ministry of Agriculture and Food, Republic of Bulgaria 2010; Statistical data from Karlovo Municipality 2016) as well as data from an existing assessment of forest ES produced by the Central Balkan National Park representatives under the OP "Environment 2007-2013" (Dimitrova et al. 2015). A pre-requisite has been set that the used data should be recognizable by the official statistics and the applied indicators – accessible and applicable for regular monitoring purposes. This will enable the future use of ES valuation by a wide variety of stakeholders in support of the sustainable governance of this and similar territorial units.

This assessment also rests on the expert opinion that the listed habitat types adequately and in detail reflect the most significant contemporary features of the environment at the local level of analysis. Despite the fact, that these habitats cover only 59.5% of the municipal territory, their geospatial characteristics (e.g., the degree of territorial connectivity among different habitat types and the degree of overlap of the NATURA 2000 areas and protected areas) give ample grounds to accept their status assessment as representative of this territorial unit as a whole.

The system analysis of the habitats, based on criteria, which reflect the habitat structure and functions, as well as influences and threats, has produced assessment results which vary from "favorable" to "poor". The following criteria are most important for this study: occupied area of the natural habitat within the protected area, dominant species, fragmentation within the habitat, housing habitation, ruderalization, grazing intensity, and fire impact. The integration of information on the ecological status of landscapes at the Central Balkan National Park is linked to the facts that it covers 35% of the municipal area and 70% of its ecosystems are natural. Thus, the Management Plan for the Central Balkan National Park (2016-2025) has also provided information about environmental assessment of landscapes and their adjacent ecosystems with respect to the following criteria: biodiversity, typology, natural character, rarity, size, vulnerability, and stability/instability.

The selection of valuation methods results from a preliminary analysis, which has taken into account a number of factors (Brouwer et al. 2013). These are derived from the characteristics of the study area, among which availability of data and expertise, applicability of key indicators provided by the national statistical system, the possibility and practicality of transferring data or using generalization methods, as well as the spatial variations of representative ES. The employed system of methods, some of which are used indirectly, includes: Market Price, Value Transfer, Replacement Cost, and Net Financial Contribution (NFCu). Analyses and assessments use available, open source local, regional, and national statistics data and indicators.

At the first stage, the economic value for each ES service class type was calculated, using the formula:

$$ESV = s \times e$$

where: *ESV* is the economic value of ES class type (€/ha/year); *s* is the biophysical indicator "value (€) per hectare per year"; and *e* is the economic indicator "value (€) per unit". The resulting values are summed according to their ES classes and included in the GIS as separate layers. For example, the values of the separate ES class types - Vegetables, Wheat, Barley, Oats, Corn, Sunflower, Rye, Plums, Pears, Apples, Dessert Grapes, Wine Grapes - are summed into the common value of the ES class "Cultivated Crops". The GIS model has generated eleven raster layers (L_i) with pixel size 27x27 m which contain information on valuated ecosystem services classes in €/ha/yr.

The total economic value (*TEV*) of an ecosystem pixel in €/ha/yr for the territory of the Karlovo Municipality is calculated as:

$$TEV = \sum_{i=1}^{n} \sum_{j=1}^{m} ESV_j$$

where: *TEV* is total (for selected services) economic value of ecosystem services; *n=11* is the number of the raster layers; ESV_j is the economic value of ES class type *j*; and *m* is the number of ecosystem services class types in layer *i*.

The fact that the actual provision of one ES is dynamically linked to the provision of other services has been accounted for in the analytical process, which accompanies the valuation. The actual flows of a particular service can be interpreted either as a result of other ecosystem functions and services or as a prerequisite for the occurrence of concomitant or derived functions and services. Thus, an intermediate step has been included where necessary in the course of the valuation: an intermediate assessment which accounts for the complex and dynamic character of ecosystem interactions and their mutual interdependencies.

Results

Identification of Ecosystem Classes and Sub-classes

Due to the geographic character of the municipality, only terrestrial ecosystems are considered in this study. The structure of the assessment involves five ecosystem classes (level 2 in MAES 2013): Urban, Cropland, Grassland, Woodland & Forest, Sparsely Vegetated Areas and 11 ecosystem sub-classes (level 3 in MAES 2013), represented by respective CLC Classes (Fig. 3). The data analysis demonstrates that three basic sub-classes - Broad-leaved Forest (30.5%), Non-irrigated Arable Land (15.1%) and Natural Grassland (13.9%) - dominate the Municipality's ecosystems. The participation of Mixed Forest (11.4%), Land Principally Occupied by Agriculture with Significant Areas of Natural

Vegetation (8.7%) and Transitional Woodland/Shrub (8.5%) also plays an important role, particularly for the landscape heterogeneity. Despite their limited area size, the Pastures (1.5%) и Discontinuous Urban Fabric (2.3%) classes are key for a number of vital ecosystem functions and services across the territory.

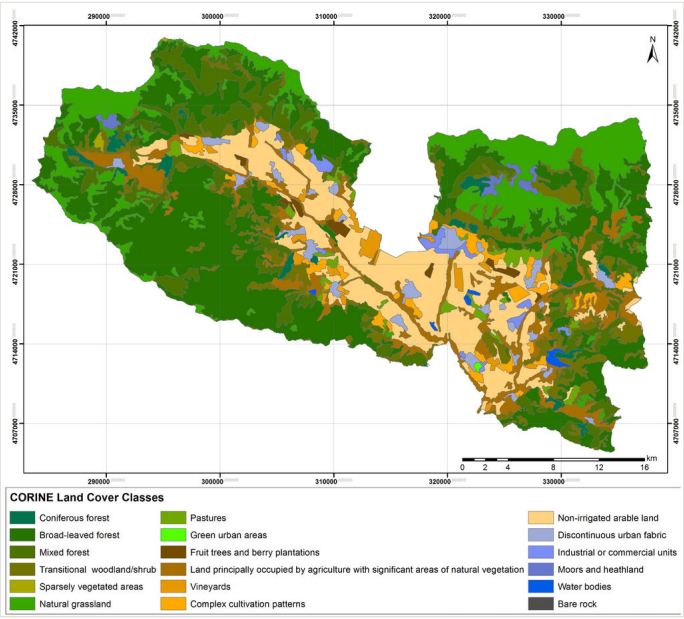

Figure 3.

Ecosystem Sub-classes at Karlovo Municipality, Represented by Respective CLC Classes.

Assessment of the Ecosystems State

The summary evaluation results prompt a generally satisfactory assessment of the ecological status of the habitats that build the main ecosystem subtypes of the municipal territory, with a necessary note to its vulnerability to natural (drought) and anthropogenic factors (pastoral farming, fire). Against this backdrop, the state of the habitats involved in the structure of the riparian landscapes and, more generally, the landscapes of the valley bottom, stands out as unfavorable. The complex anthropogenic overload and especially, the intensive agricultural utilization, is the main cause for this assessment. In conclusion, the overall situation necessitates far greater attention to the regulation of the territorial balances in the process of consumption of material and regulatory services, since over a certain period of time the functional potential of these ecosystems can significantly deteriorate.

The analysis of the assessment results, presented in Table 1, serves both for selection of the ES that are subject to valuation in the next stage of the study, as well as for identification of the geospatial variations of the ES synergies and dysergies

Table 1.

Assessment of Ecosystems' State of Karlovo Municipality.

Assessment of the of Ecosystem State					
In scale: favorable – satisfactory – unfavorable - poor					
Habitat Types	**Ecosystem sub-classes at Karlovo Municipality**	**Ecosystem's State Assessment /by Sources/**			**Integrated Assessment of Ecosystem's state of Karlovo Municipality**
		National ecological network NATURA 2000 Bulgaria /Data Base/	**Management Plan for The Central Balkan National Park. 2016-2025 /SEA/**	**Field Observations /July-September 2017 /**	
4060 Alpine and Boreal heaths	Transitional Woodland/ Shrub	Favorable	Favorable but highly vulnerable due to grazing and trekking	Favorable	Favorable
6210 Semi-natural dry grasslands and scrubland facies on calcareous substrates (Festuco-Brometalia. * important orchid sites)	Pastures	Unfavorable	Favorable but highly vulnerable due to grazing and trekking	Favorable but vulnerable (ruderalization)	Satisfactory
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	Natural Grassland	Favorable	Favorable but highly vulnerable due to grazing and river stream corrections	Favorable but vulnerable (grazing)	Favorable
9110 Beech forest (Luzulo-Fagetum)	Broad-leaved Forest	Favorable but vulnerable	Favorable but vulnerable due to grazing. heavy winds and snow. fires	Favorable but vulnerable (grazing)	Favorable
9150 Medio-European limestone beech forests (Cephalanthero-Fagion)	Broad-leaved Forest	Unfavorable	Favorable but vulnerable due to grazing. heavy winds and snow. fires	Satisfactory but vulnerable (grazing. erosion)	Satisfactory
9170 Galio-Carpinetum oak-hornbeam forests	Mixed Forest	Unfavorable	Favorable but highly vulnerable due to trekking and afforestation with coniferous species	Satisfactory but vulnerable (grazing. erosion. fires)	Satisfactory
91W0. Moesian beech forests	Broad-leaved Forest	Favorable	Favorable	Favorable	Favorable
91Ca. Rhodopide and Balkan Range Scots pine forests	Coniferous Forest	Unfavorable	Favorable but highly vulnerable	Satisfactory but vulnerable	Satisfactory

9410. Acidophilous Picea forests of the montane to alpine levels (Vaccinio-Piceetea)	Coniferous Forest	Unfavorable	Favorable but vulnerable due to grazing. heavy winds and snow. fires	Satisfactory but vulnerable	Satisfactory
9530. (Sub-) Mediterranean pine forests with endemic black pines	Coniferous Forest	Poor	Satisfactory but highly vulnerable due to reduced share of old forests	Poor (changes in the composition of typical species)	Poor
91E0. *Alluvial Forest Alnus Glutinosa and Fraxinus Excelsior	Broad-leaved Forest	Poor	Satisfactory but highly vulnerable due to grazing and logging	Poor (complex anthropogenic pressure)	Poor
6430 Hydrophilous tall herb fringe communities of plains and of the montane to alpine levels	Natural Grassland	Unfavorable	Favorable but highly vulnerable due to complex anthropogenic pressure	Satisfactory (complex anthropogenic pressure)	Satisfactory
6510 Lowland hay meadows (Alopecurus pratensis. Sanguisorba officinalis)	Natural Grassland	Unfavorable	Satisfactory but highly vulnerable due to grazing and ruderalization	Satisfactory (complex anthropogenic pressure)	Satisfactory

Selection of Ecosystem Services

The selection of the ES, that are representative for Karlovo Municipality, is based on synthesis of the results of the statuses of the local demography, economy and ecosystems. In sum, the selection includes the following key ESs: Provisioning (Cultivated Crops, Reared Animals and their Outputs, Wild Plants, Algae and their Outputs, Surface Water for Drinking), Regulation (Mass Stabilisation and Control of Erosion Rates, Hydrological Cycle and Water Flow Maintenance, Global Climate Regulation by Reduction of Greenhouse Gas Concentrations), and Cultural (Physical Use of Land-/Seascapes in Different Environmental Settings). The selected ES belong to 11 ES classes (CICES 4.3) and 29 ES class types (Table 2).

Table 2.

Selection of Ecosystem Services, Representative for Karlovo Municipality.

Section	Division	Group	Class	Class type
Provisioning	Nutrition	Biomass	Cultivated crops	Vegetables. wheat. barley. oats. corn. sunflower. rye. plums. pears. apples. dessert grapes. wine grapes
			Reared animals and their outputs	Meat and milk (Cow. Goat. Sheep Buffalo). Eggs. Honey

			Wild plants. algae and their outputs	Wild berries and herbs
		Water	Surface water for drinking	By amount
	Materials	Biomass	Fibres and other materials from plants. algae and animals for direct use or processing	TimberWool
			Materials from plants. algae and animals for agricultural use	Fodder
			Genetic materials from all biota	Game and Wild plants by forest ecosystems. Damask roseDamask rose
Regulation & Maintenance	Mediation of flows	Mass flows	Mass stabilisation and control of erosion rates	Erosion regulation
		Liquid flows	Hydrological cycle and water flow maintenance	Water flow maintenance
	Maintenance of physical. chemical. biological conditions	Atmospheric composition and climate regulation	Global climate regulation by reduction of greenhouse gas concentrations	Greenhouse gas/carbon sequestration
Cultural	Physical and intellectual interactions with biota. ecosystems. and land/ seascapes [environmental settings]	Physical and experiential interactions	Physical use of land-/ seascapes in different environmental settings	Recreation and tourism

Data availability is generally one of the main factors which restrict ES selection. In this sense, the present study is not an exception. The Provisioning ES dominate investigators' selection, not just because of their fundamental significance for the economy, but also due to the relative availability of statistical data. The value of the key Regulation ES in the Municipality is estimated through indirect valuation methods. The results from Dimitrova et al. (2015) assessment of the forest ecosystems in the Central Balkan National Park have been used here as reference data.

The investigation considers Pollination, Water Purification and Natural Hazard Protection as very important for the development of the territory, but the lack of a reliable information base does not allow their inclusion in the present study. The Karlovo Municipality offers a wide range of Cultural Services the majority of which also remain outside the current selection. This is due to the lack of established practice in Bulgaria for data collection regarding this class of services, either at local or national level, which severely limits the choice of a representative valuation indicator.

Ecosystem Services Valuation

The present economic assessment of the selected ES is based on indicators and parameters (Table 3) that are recognizable and adequate to the available statistical information. A major goal that the study achieved has been the adoption and production of methods, indicators, parameters, and data, which are accessible and allow for repeated valuations and analytical interpretations by a range of stakeholders.

Table 3.

Methods and Indicators for Representative Ecosystem Services in the Karlovo Municipality.

ECOSYSTEM SERVICES (CICES 4.3)						**Indicator**	**Economic method**	**Data**
Ecosystem types (level 2)				**Class**	**Class type**			
Cropland				Cultivated crops	*vegetables. wheat. barley. oats. corn. sunflower. rye. plums. pears. apples. dessert grapes. wine grapes*	Average yield per year (t/ha/ yr. 2015-2016)	Market price	National and regional statistics. 2015; Municipality Karlovo statistics. 2016
Woodland and forest				Surface water for drinking	*By amount*	Investments in forest plantations	Net financial contribution (NFCu)	Central Balkan National Park. Dimitrova et al. 2015
Grass land	Sparsely vegetated	Cropland	Urban	Reared animals and their outputs	*Meat and milk (Cow. Goat. Sheep Buffalo). Eggs. Honey*	Average yield per year (t/ha/ yr. 2015)	Market price	National and regional statistics. 2015
Woodland and forest	Grassland	Sparsely vegetated land		Wild plants. algae and their outputs	*Wild berries and herbs*	Quantities of non-timber products gathered from the Central Balkan NP. (kg/ yr. 2010-2014)	Market price	Central Balkan National Park. Dimitrova et al. 2015
Woodland and forest		Grassland		Fibres and other materials from plants. algae and animals for direct use or processing	*Timber*	Quantities of timber harvested from the Central Balkan NP. (m^3/ ha/yr. 2010-2014)	Market price	Central Balkan National Park. Dimitrova et al. 2015

			Wool	Average yield per year (kg/yr. 2015)	Market price	National and regional statistics. 2015; Municipality Karlovo statistics. 2016
Grassland		Materials from plants. algae and animals for agricultural use	*Fodder*	Average yield per year (kg/ha/yr. 2015)	Market price	National and regional statistics. 2015
Woodland and forest	Cropland	Genetic materials from all biota	*Game and Wild plants by forest ecosystems*	Number of permits. Central Balkan NP (2014)	Value transfer	Central Balkan National Park. Dimitrova et al. 2015
			Damask rose	Average yield per year (t/ha/yr)	Market price	National and regional statistics. 2015
Woodland and forest		Mass stabilization and control of erosion rates	*Erosion regulation*	Cost of restoring soil quality	Replacement cost	Central Balkan National Park. Dimitrova et al. 2015
Woodland and forest		Hydrological cycle and water flow maintenance	*Water flow maintenance*	Investments in forest plantations	Net financial contribution (NFCu)	Central Balkan National Park. Dimitrova et al. 2015
Woodland and forest		Global climate regulation by reduction of greenhouse gas concentrations	*Greenhouse gas/carbon sequestration*	Carbon sequestration – forest ecosystems (CO_2/yr/ha)	Value transfer	Central Balkan National Park. Dimitrova et al. 2015
Woodland and forest	Urban	Physical use of land-/seascapes in different environmental settings	*Recreation and tourism*	Number and capacity of accommodation sites. Site visitation (number/yr)	Market price	Municipality Karlovo statistics. 2016
National Statistical Institute. Republic of Bulgaria. Karlovo Municipality http://www.karlovo.bg (Dimitrova et al. 2015).						

The complex and dynamic geospatial interdependencies and interactions that exist among ecosystems often produce ES synergies – positive effects - which additionally increase the added value of the services they produce. The basic concepts used here, such as ES trade-offs and synergies, are theoretically consistent with their terminological interpretation in Bennett et al. (2009), Raudsepp-Hearne et al. (2010) and Haase et al. (2012), whose research is strongly influenced by the landscape ecological approach in the ES analysis.This research has also evidenced relatively negative effects – ES dysergies – in cases where ecosystem interactions subtract from the added value of the produced services. The study ventures to analyze such dysergies, their impact on real ES flows and attempts to account for their financial value in the case of the Karlovo Municipality. For example, the value of the Fodder ES is reduced by the value of the Carbon Sequestration and Erosion Regulation services (Table 4).

Table 4.

Intermediate Valuation of Ecosystem Services with Consideration of the Interactions Among Ecosystems (€/ha/y).

№	Ecosystem subclasses (represented by CLC2012) with potential to provide particular ES	Currently provided ecosystem services		Ecosystem services consumed from other ecosystems		Economic value accounting the interaction between ecosystems (€/ha/y)
		by class type	Economic value (€/ha/y)	by class type	Economic value (€/ha/y)	
C1	C2	C3	C4	C5	C6	C7=C4-C6
1	Forests: coniferous forest, broad-leaved & mixed forest	Water for drinking purpose; Timber; Game and wild plants by forest ecosystems; Erosion regulation; Water flow maintenance; Carbon sequestration; Recreation and tourism	719.3			719.3
2	Heathland and shrub & Sparsely vegetated areas	Goat milk	145.92			145.92

3	Fruit trees and berry plantations; Transitional woodland/shrub; Pastures; Natural grasslands; Land principally occupied by agriculture with significant areas of natural vegetation; Non-irrigated arable land; Complex cultivation patterns	Honey	1.9			1.9
4	Pastures and Natural grasslands	Milk (Cow, Sheep and Buffalo); Wool; Fodder	1969.61	Carbon sequestration; Erosion regulation	433.63	1535.98
5	Land principally occupied by agriculture with significant areas of natural vegetation	Pattern of cultivated crops (vegetables)	2733	Carbon sequestration; Water flow maintenance; Water for drinking purpose	621.04	2111.96
6	Non-irrigated arable land & Complex cultivation patterns:	Pattern of cultivated crops (wheat, barley, oats, corn, sunflower, rye); Damask rose	1812.76	Carbon sequestration; Water flow maintenance; Erosion regulation	467.89	1344.87
7	Fruit trees and berry plantations	Pattern of cultivated crops (plums, pears, apples)	2678.01			2678.01
8	Vineyards	Pattern of cultivated crops (dessert grapes; wine grapes)	2535.03	Carbon sequestration; Erosion regulation	433.63	2101.4
9	Forests (coniferous forest, broad-leaved & mixed forest); Sparsely vegetated areas; Transitional woodland/ shrub; Pastures; Natural grasslands	Wild berries and herbs	1.56			1.56

10	Discontinuous urban fabric & Pastures	Eggs	682.56	Carbon sequestration; Water for drinking purpose; Erosion regulation	652.89	29.67
11	Discontinuous urban fabric	Recreation and tourism - Karlovo	1501.41	Carbon sequestration; Water for drinking purpose; Physical use of land in environmental settings	611.67	889.74
		Recreation and tourism - Kalofer	4587.21		611.67	3975.54
		Recreation and tourism - Bania	1554.56		611.67	942.89
		Recreation and tourism - Klisura	1115.1		611.67	503.43
		Recreation and tourism - Sokolitsa	773.71		611.67	162.04

Integrated Assessment – Total Economic Value

The estimated TEV of the selected, currently utilized ES in the Karlovo Municipality is close to €115 million. The ecosystems of the valley bottom, which are most intensively used for agricultural purposes, are responsible for the majority of the ES production (Fig. 4).

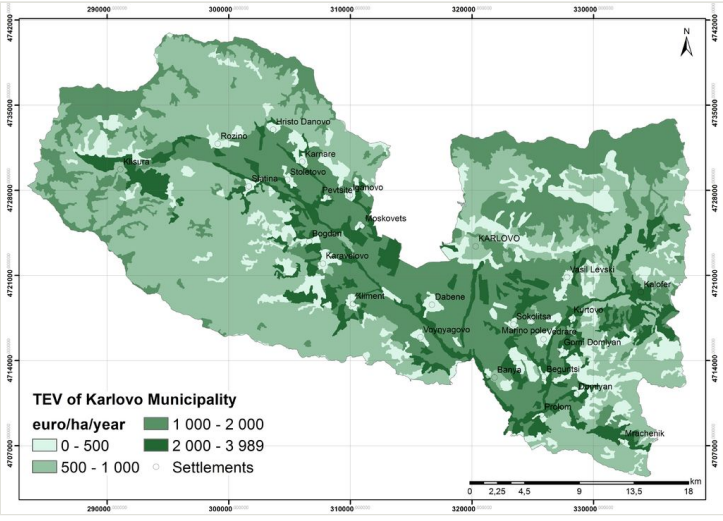

Figure 4.

Total Economic Value (TEV) of the Selected Ecosystem Services in Karlovo Municipality.

The following three ES – Cultivated Crops, Rearing Animals (a.k.a., animal husbandry), and Global Climate Regulation by Reduction of Greenhouse Gas Concentrations – exhibit highest shares in the TEV structure (Table 5). Other high TEV share services include Surface Water for Drinking and Genetic Material from All Biota. These TV ratios fully reflect the geographic characteristics of the territory, the habitats' statuses, and the functional specialization of the Municipality's territory (Fig. 5, Fig. 6, Fig. 7). At the same time, they unambiguously focus the local authorities' attention on the necessity of adequate geospatial analysis and territorial coordination in the ES utilization.

Table 5.

Annual Financial Benefits (Euro) Per Ecosystem Services Class and Total Economic Value (TEV).

ES section	**ES class**	**Ecosystem services class type**	**Annual financial benefits (euro)**
Provisioning	Cultivated crops	Vegetables. wheat. barley. oats. corn. sunflower. rye. plums. pears. apples. dessert grapes; wine grapes	37 423 402.69
	Reared animals and their outputs	Milk (Cow. Sheep. Buffalo and Goat); Eggs; Honey	31 100 149.92
	Wild plants. algae and their outputs	Wild berries and herbs	109 400.58
	Surface water for drinking	Water for drinking purpose (by amount)	9 885 080.57
	Fibers and others materials from plants. algae and animals for direct use or processing	Timber; Wool	222 811.56
	Materials from plants. algae and animals for agricultural use	Fodder	4 680 547.78
	Genetic materials from all biota	Game and wild plants by forest ecosystems; Cultivated Damask rose	8 420 102.87
Regulation & Maintenance	Mass stabilization and control of erosion rates	Erosion regulation	2 980 492.00
	Hydrological cycle and water flow maintenance	Water flow maintenance	1 544 572.02
	Global climate regulation by reduction of greenhouse gas concentrations	Carbon sequestration	16 569 209.20
Cultural	Physical use of land-/seascapes in different environmental settings	Recreation and tourism	2 617 013.43
Total Economic Value (TEV)			115 552 782.62

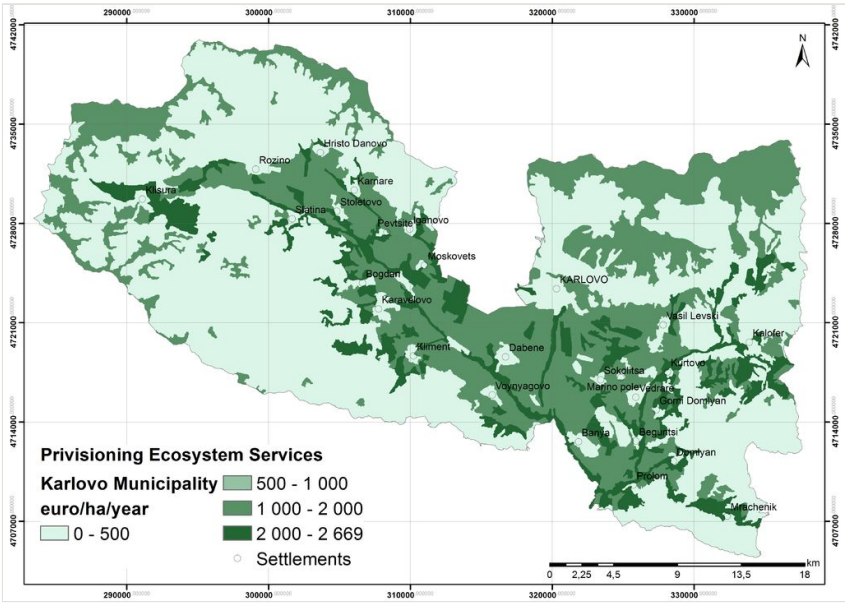

Figure 5.

Economic Value of Provisioning Ecosystem Services in Karlovo Municipality.

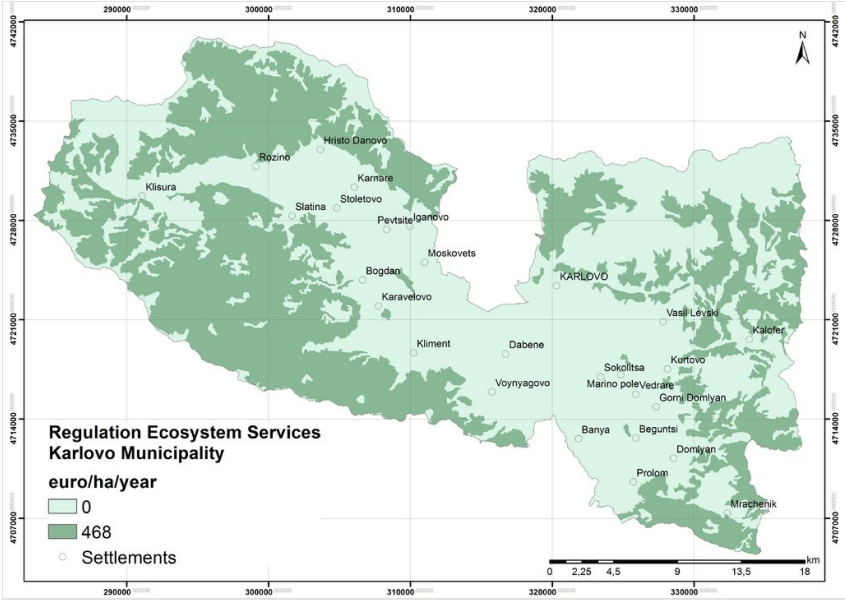

Figure 6.

Economic Value of Regulation Ecosystem Services in Karlovo Municipality.

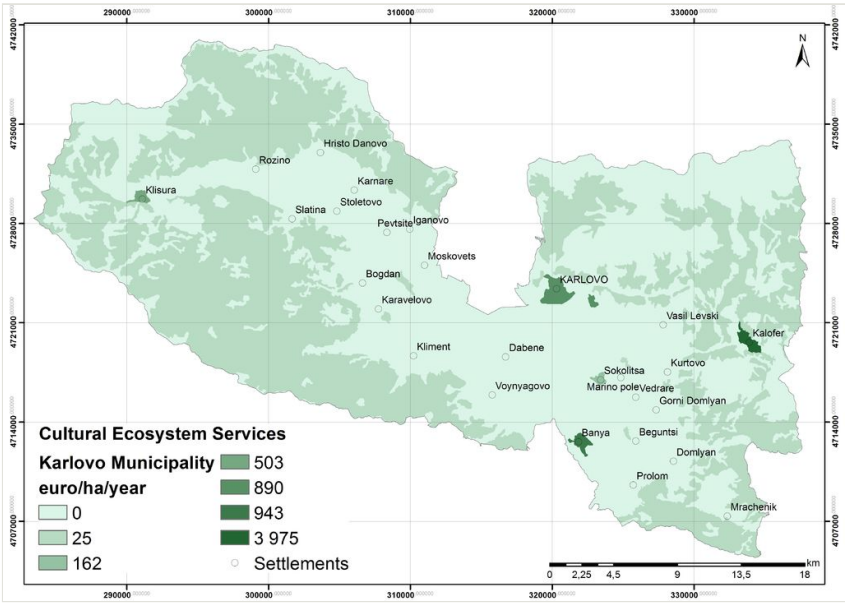

Figure 7.

Economic Value of Cultural Ecosystem Services in Karlovo Municipality.

Further geospatial analysis of the valuation results (Fig. 8) reveals that the mountain landscapes in the Municipality create hotspots - areas which deliver multiple ESs. In fact, such multifunctional areas produce up to eight of the total of eleven ES classes that are evaluated here. The Broad-leaved & Mixed Forests are the most important ecosystem subclasses in this respect. Taking into consideration the fact that regulating and provisioning services predominate, as well as the existing synergistic interactions among them, mountain landscapes emerge as one of the most significant factors for the diversity and sustainability of services provision in all ecosystems of the Municipality.

Serious economic prerequisites and even traditions exist in general, as well as in the municipality, to economically “absorb” the highest value ecological assets, particularly for development of alternative types of tourism and local production of clean, renewable, and eco- products. However, this analysis shows that the stimulation of synergistic links between the ecosystems of the valley and those of the surrounding mountains will be advantageous to the municipal economy, society and its environment. Such a venture requires regulators to pay special attention to the environmental status and economic use of the riparian areas (currently occupied mainly by arable land) and the slopes, and in particular, the Land Occupied by Agriculture with Significant Areas of Natural Vegetation and the Transitional Woodland/Shrub lands, which account for almost 18% of the municipality's territory. In conclusion, regulatory measures in that respect will have a positive impact on the balanced and sustainable provision of services in the territory and, at the same time, support the economic specialization of the municipality and people’s welbeing.

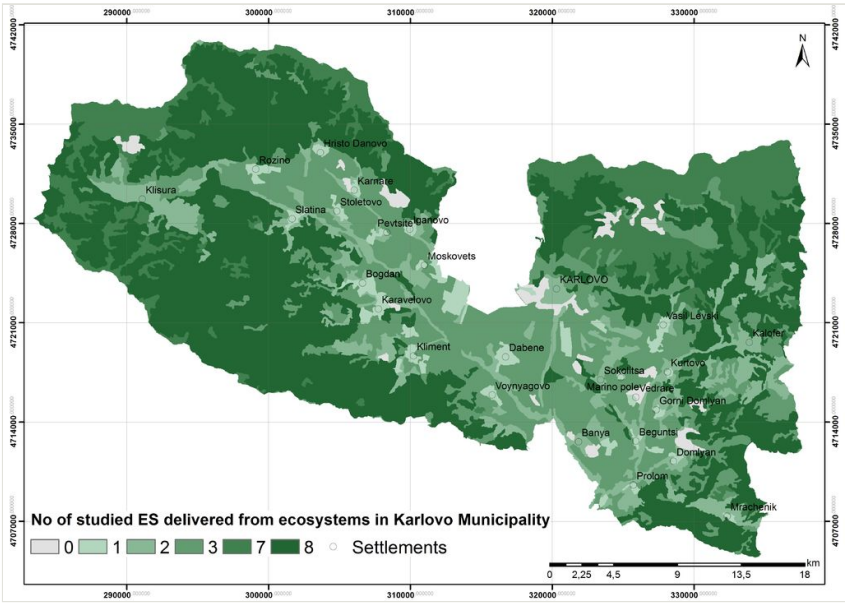

Figure 8.

Hotspots of Ecosystem Services in Karlovo Municipality.

Discussion

The proposed GIS-aided model of spatial valuation of ES is intended to mainly serve as a benchmark for future valuation research, especially in bringing to light a substantial share of currently underreported and undervalued ES, for comparative purposes, as well as for an instrument for stimulation of public interest in the concepts of ES and sustainable territorial development. A lot of assumptions and serious limitations related to economic ES valuation exist in this investigation. They include lack of data, reduction of services to "products" and vice versa, exclusion of a multitude of ES that need, first, much deeper investigation (e.g., pollination) and, second, are currently “unrecognized” by the market and even society as a whole.

For example, a large proportion (39.6 %) of annual financial benefits from the studied ES in the Karlovo Municipality belongs to cultivated crops – around 45.7 million euro. These benefits are highly dependent on insect pollination. Based on Eurostat statistical data, Zulian et al. (2013) report that absence of insect pollination would result in a reduction of the crop production in Bulgaria by 30.8 %. For Karlovo Municipality this reduction accounts for about 14.1 million euro per year. The relative pollination potential from the Pollination Supply Model at EU level (Zulian et al. 2013) can also be adapted in this research to generate spatial patterns of crop pollination monetary values of the ecosystems, based on the avoided cost method. Modeled biophysical indicators need to be included in this

approach, in order to evaluate the regulating ES. The modeled indicators can be generated directly at the local scale or can be up-scaled from European level.

Ecosystem multi-functionality is one extremely intricate scientific issue that requires much deeper investigations, including field studies. From a practical point of view, stakeholders and specialists in territorial planning and management have to take into account the complexity of the existing functional dependencies and real and potential ES trade-offs, not only in the distinct ecosystems of interest, but also in the neighboring ecosystems. Moreover, the process cannot be limited by administrative or political boundaries. In valley conditions, this is clearly visible in the vulnerability of the regulating functions, as well as in some material services, such as Surface Water for Drinking or in forest ecosystems in conditions of inappropriate use of the Fibers and other Materials from Plants, Algae and Animals for Direct Use or Processing.

Conclusion

This investigation succeeded to: a/ Update the basic terminology supporting ES classification and evaluation; b/ Overcome some of the challenges of the application of ES valuation methods at the municipal level and the geospatial analysis of their results; c/ Enlarge the currently available information and knowledge basis that support geospatial planning & sustainable development of the Karlovo Municipality.

The following main problems in ES valuation stand out:

1. Data availability for the valuation purposes is a serious problem: Eurostat does not include the local levels (LAU) at this time. Data transfer from regional, national, and even global statistics is currently used, which greatly lowers the degree of valuation objectivity and hampers its validation.
2. The Provisioning ESs account for the largest share in the structure of the TEV, which artificially increases their overall importance. This is, however, due to the fact that the majority of data that concerns the regulation and cultural ES is more circumstantial and much less objective. Monitoring needs to be further improved in order to include these two ES groups and make the ES concept readily applicable.
3. The data collection and mapping approaches used in this case study involve significant generalizations that are suitable for strategic analyses, but show weaknesses in the case of concrete ecosystems or business localizations. Result distortions take place in cases where ES data from a concrete polygon of one ecosystem type is transferred to all polygons of this ES type, even within the same municipality. This is most clearly seen in the "transfer" of the value of the regulating functions from the forest ecosystems of the Central Balkan to those ecosystems in the Sredna Gora Mountain. Another “mapping” discrepancy which is often overlooked is related to the fact that a great share of the tourism and recreation services are consumed in the natural ecosystems, but the largest part of the actual accounting happens and is, therefore, mapped in the urban areas’ services. These

challenges can only be avoided through detailed field work, targeted territorial evidence gathering, and in situ monitoring on a case-by-case basis.

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