Andrzej Mizgajski, Małgorzata Stępniewska

ECOSYSTEM SERVICES ASSESSMENT FOR POLAND – CHALLENGES AND POSSIBLE SOLUTIONS

Prof. Andrzej Mizgajski, Ph.D.; Malgorzata Stepniewska, Ph.D. – Adam Mickiewicz University

address:
Adam Mickiewicz University
Faculty of Geografical and Geological Sciences
Dzięgielowa 27, 61-680 Poznań, Poland
cezas@amu.edu.pl, malgorzata.stepniewska@amu.edu.pl

OCENA ŚWIADCZEŃ EKOSYSTEMÓW DLA POLSKI – WYZWANIA I MOŻLIWE ROZWIĄZANIA

STRESZCZENIE: Świadczenia ekosystemów coraz częściej stają się przedmiotem zainteresowania nie tylko badaczy, a również polityków. Unia Europejska zachęca państwa członkowskie do rozpoznania i oceny stanu ekosystemów i dostarczanych przez nie świadczeń. Przedmiotem pracy jest przedstawienie ramowej koncepcji oceny świadczeń ekosystemów w Polsce. Prezentowana idea opiera się na rekomendacjach Europejskiej Agencji Środowiska (EEA), wykorzystuje istniejące źródła danych jakościowych i ilościowych oraz przywołuje doświadczenia krajów bardziej zaawansowanych w tej dziedzinie.

W analizie wykorzystywano dane Corine Land Cover 2006, które pogrupowano w 7 rodzajów podstawowych jednostek funkcjonalnych pokrycia terenu: tereny zurbanizowane, tereny rolne, tereny trawiaste, lasy, rzeki i jeziora, Morze Bałtyckie i inne. Każdy z wyróżnionych rodzajów został scharakteryzowany ze względu na stan ekosystemów i zestaw dostarczanych przez nie świadczeń.

Polska posiada dobrze ukształtowaną, uporządkowaną hierarchicznie regionalizację fizyczno-geograficzną. Na jej podstawie proponujemy wydzielenie 7 stref krajobrazowo-ekologicznych: Morze Bałtyckie, pojezierza, niziny, wyżyny, kotliny podgórskie, góry średniowysokie i góry wysokie. Wyróżnione strefy krajobrazowe są opisywane przez zróżnicowanie struktury pokrycia terenu, które odzwierciedlają społeczno-ekologiczne jednostki krajobrazowe proponowane przez EEA. Pomiędzy strefami krajobrazowo-ekologicznymi występują istotne różnice w udziale poszczególnych form pokrycia terenu, co jest powiązane z różną kombinacją świadczeń ekosystemów w każdej z nich.

Prezentowane podejście powinno umożliwić ocenę świadczeń ekosystemów w Polsce z perspektywy zagregowanych form użytkowania powierzchni z uwzględnieniem specyfiki głównych jednostek krajobrazowo-ekologicznych.

SŁOWA KLUCZOWE: ekosystemy Polski, ocena świadczeń ekosystemów

Introduction

The global economic crisis in recent years has become an additional catalyst for stronger linking environmental and economic aspects in international politics. Promoted for years, the idea of sustainable growth has not lost its importance and relevance, however there is an increasingly distinct lack of consistent operational concepts for implementation. Rio +20 Earth Summit adopted a document titled: The Future we want.[1] It sets a new stage for the environment policy which is characterized by the prospect of benefits to humans resulting from the functions fulfilled by ecosystems. The part containing the framework for the recommended actions repeatedly points out the importance of emphasizing the ecosystem services and their valuation for the effectiveness of environmental policy in the various thematic areas. This means that this approach finds the recognition of the international community and continues to gain in significance as a field of research and application. The first major global project was Millennium Ecosystem Assessment carried out under the auspices of the Secretary-General of the UN.[2] The evaluation was related to changes in the ecosystems of the World in the second part of the 20th century and the trends at the level of ecosystem services. The subject of particular interest of IUCN is the fuller recognition of the natural capital and its inclusion in the economic account, as well as the implementation of payments for ecosystem services,[3] as a means of effective protection of environmental values. An attempt to operationalize the concept was a project of The Economics of Ecosystems and Biodiversity (TEEB) implemented on the initiative of Germany in cooperation with UNEP, the European Union and governments of some European countries. The reports from this project are now the most extensive compendium of knowledge regarding ecosystem services focused on practical actions.[4]

The European Union aims to play a leading role globally in integrating natural capital and human benefits from ecosystem services with the economic account. Member States implement – to varying degrees – the recommendation to assess ecosystem services in their territories, and Poland is amongst those of which the previous activities have not yet taken the form of a coherent project. Presentation of the state of the research in Poland was made at conferences on ecosystem services as an object of interdisciplinary research (ECOSERV 2010

[1] *The Future We Want: Outcome document adopted at Rio+20,* www.un.org/en/sustainablefuture [Date of entry: 30-09-2012].

[2] *Guide to the Millennium Assessment Reports,* www.maweb.org/en/index.aspx [Date of entry: 30-09-2012].

[3] T. Greiber (ed.), *Payments for Ecosystem Services. Legal and Institutional Frameworks*, IUCN, Gland, Switzerland 2009, p. xvi + 296.

[4] TEEB – *The Economics of Ecosystems and Biodiversity*, www.teebweb.org [Date of entry: 30-09-2012].

and 2012), the results of which have been published in the journal Ekonomia i Środowisko (Economics and Environment)[5] and in this volume. The significant factors are the theoretical and methodological reflections on ecosystem services and their valuation, which should encourage the development of research in Poland.[6]

The aim of the study is to propose a conceptual framework of ecosystem services assessment for Poland. The project's idea is based on European Environmental Agency recommendations and uses existing quantitative and qualitative data sources, adopting experiences of countries that are advanced in the issue.

European Union initiatives as a framework for Polish ecosystem services assessment

European Union Biodiversity Strategy calls on Member States to "map and assess the state of ecosystems and their services on their national territory by 2014, assess the economic value of such services, and promote the integration of these values into accounting and reporting systems at EU and national levels by 2020."[7]

The European institution which coordinates EU actions in this area is the European Environment Agency (EEA). It runs a website dedicated to ecosystem assessments in Europe.[8] This website gives access to the main sources of information on the concepts and methods that are useful for conducting an ecosystem assessment, presents case studies, and holds information about ecosystem assessment related events. The member states progressed their works to varying degrees. United Kingdom, Spain and Portugal completed them, in several other countries, the works on the national ecosystem assessment are currently ongoing. Particularly insightful is the British report[9], which can be a reference point for other countries, including Poland.

[5] „Ekonomia i Środowisko" 2010 No. 1(37).

[6] I. Żylicz, *Wycena usług ekosystemów* (*Valuation of ecosystem services*). *Przegląd wyników badań światowych* (*Review the worldwide results*) (sum.: Valuation of ecosystem services. An overview of world research), „Ekonomia i Środowisko" 2010 No. 1 (37), p. 31-45; I. Żylicz, *Valuating ecosystem services*, „Ekonomia i Środowisko" 2012 No. 2; A. Mizgajski, *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne* (sum.: Ecosystem services as an emerging field of research and application), „Ekonomia i Środowisko" 2010 No. 1 (37), p. 10-19.

[7] European Commission, *Our life insurance, our natural capital: an EU biodiversity strategy to 2020* (target 2, action 5) [COM(2011) 244].

[8] *Ecosystem Assessments in Europe*. http://www.biodiversity.europa.eu/ecosystem-assessments [Date of entry: 30-09-2012].

[9] *UK National Ecosystem Assessment. Technical Report*, http://uknea.unep-wcmc.org [Date of entry: 30-09-2012].

The EEA has also produced two documents that can support actions in the member states. These are the „Proposal for Common International Classification of Ecosystem Services" (CICES)[10] and „An experimental framework for ecosystem capital accounting in Europe" (EFECA).[11] These documents are the framework, because there appears the understandable specificity for each country.

CICES was launched in 2009 as a way of naming and describing ecosystem services. The project aims at providing a standard classification of ecosystem services consistent with accepted categorizations, conceptualizations and allowing an easy translation of statistical data between different applications. CICES Version 4 (update July 2012) has a hierarchical structure with five levels: section – division – group – class – class type. At the highest level are the three sections of provisioning, regulating & maintenance, and cultural services. The sections are divided into ten service divisions, twenty-two service groups and fifty-three service classes. The basic structure of CICES is shown in Table 1.

The discussions on ecosystem accounting at national and European levels led to designing a framework for ecosystem capital accounts (EFECA). The goal was to create the procedural scheme for ecosystem accounts and to identify which key indicators and aggregates that describe the economy – ecosystem interactions could be delivered and involved into enlarged national accounts. The ecosystem capital accounting framework integrates physical and monetary tables. Physical tables include basic quantitative balances and qualitative indexes of the health of ecosystem and the accessibility of ecosystem services. Ecosystem capital accounts measure resource stocks and flows, the factors limiting the use, and the surplus of accessible resources, and compare them with the resource use computed from statistics data. They measure ecosystem degradation, remediation costs and the accumulation of ecological debts, which may result from cumulative degradation on investigated areas.

The concept of ecosystem services evaluation for Poland makes use of the presented two-dimensional approach. On the one hand there is the assessment of the differentiation of ecosystem services according to the main spatial units. On the other, there is the variation according to functional units.

[10] European Environment Agency, *Common International Classification of Ecosystem Services (CICES) version 4 (update July 2012)*, www.cices.eu [Date of entry: 30-09-2012].

[11] European Environment Agency, *An experimental framework for ecosystem capital accounting in Europe,* www.eea.europa.eu/publications/an-experimental-framework-for-ecosystem [Date of entry: 30-09-2012].

Table 1.
The basic structure of „Common International Classification of Ecosystem Services (CICES)" Version 4

CICES Section	Division	Group
Provisioning	Nutrition	Terrestrial plants and animals for food
		Freshwater plants and animals for food
		Marine algae and animals for food
	Water supply	Water for human consumption
		Water for agricultural use
		Water for industrial and energy uses
	Materials	Biotic materials
	Energy	Biomass based energy
Regulation and Maintenance	Regulation of bio-physical environment	Bioremediation
		Dilution and sequestration
	Flow regulation	Air flow regulation
		Water flow regulation
		Mass flow regulation
	Regulation of physico-chemical environment	Atmospheric regulation
		Water quality regulation
	Regulation of biotic environment	Pedogenesis and soil quality regulation
		Lifecycle maintenance, habitat and gene pool protection
Cultural	Symbolic	Aesthetic, Heritage
		Spiritual
	Intellectual and Experiential	Recreation and community activities
		Information & knowledge

Source: EEA 2012 – CICES Version 4.

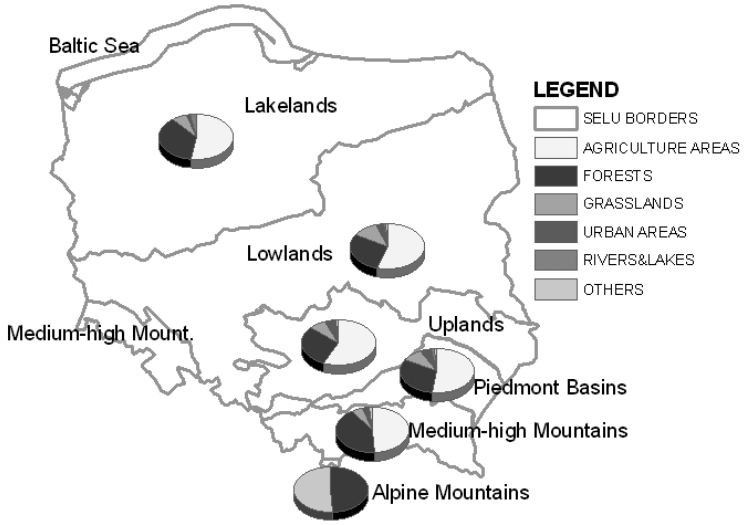
Spatial framework for Ecosystem Services Evaluation for Poland

An application oriented assessment of ecosystem services should have a spatial dimension. From a diagnostic point of view, this is due to regional differentiation of the mosaic of ecosystems and the forms and intensity of human use of the functions performed by ecosystems. The second aspect is of planning and programming nature, because the spatial variation of the condition and the level of provided services should be an important consideration for decision-making regarding the use of the environment.

The environmental and geographical structure of the country reflects the main features of the variation of natural capital and the intensity of its use by humans. In Poland, we have a recognized hierarchical physical-geographical re-

gionalization based on variation of the relief[12] and its origins as the predominant features which, to a large extent, correspond to the character of ecosystem mosaics and the structure of their use. The assessment of the state of ecosystems and the level of services is proposed to be carried out in regards to seven landscape-ecological zones separated, on the basis of a modified division, into sub-provinces. These form a roughly latitudinal band system, which consists of: Baltic Sea with its coastal zone, Lakelands, Lowlands, Uplands, Piedmont Basins, Medium-high Mountains and Alpine Mountains (Fig. 1). They correspond to the principle of social-ecological landscape units (SELU) proposed by EEA.

Figure 1.
Land Cover Structure according to landscape-ecological zones



Source: Own study.

Many materials useful to determine the level of ecosystem services on a regional scale were developed for the preparation of the National Spatial Development Concept 2008-2033. The assessments that were carried out include spatial and quantitative data describing the state of ecosystems in the context of spatial development.[13]

[12] J. Kondracki, *Geografia regionalna Polski* (*Regional geography of Poland*), PWN, Warszawa 2002, p. 440.

[13] K. Saganowski, M. Zagrzejewska-Fiedorowicz, P. Żuber (ed.), *Ekspertyzy do Koncepcji Przestrzennego Zagospodarowania Kraju 2008-2033* (*Expertise to the National Spatial Development Concept 2008-2033*), Vol. 4, Ministry of Regional Development, Warsaw 2008, in particular: M. Degórski, *Przyrodnicze aspekty zagospodarowania przestrzennego kraju – przesłanki i rekomendacje dla KPZK* (*Natural aspects of spatial development of the country – the conditions and recommendations for NSDC*), p. 39-63; E. Nachlik, *Gospodarka wodna w kontekście przestrzennym kraju – rekomendacje dla KPZK* (*Water management in the context of the country's space – recommendations for NSDC*), p. 95-152.

Baltic

This is the least diverse landscape-ecological unit, characterized by duality, because it covers the territorial sea, internal waters and a string of shores. From the point of view of assessing the state of the ecosystem and the level of services for the Polish part of the Baltic Sea, the important factors are the parts of high natural value, including 14 „NATURA 2000" areas and parts of two national parks. On top of those, there is a diverse potential for tourism and recreation, wind energy, fisheries and mineral exploitation.[14]

Along the coast there is the presence of sandy beaches, practically on the entire length of the coast. In the immediate hinterland there are alternately dune embankments and cliffs of a few to a several-dozen meter height. Among the benefits from functioning of this set ecosystems, of the essential significance are the cultural services related to recreation, both in the sea and on the coast. The fishery and the influence on the dynamics of the coastal zone shall be added here.

Lakelands

This zone includes the north part of Poland ranging from the immediate hinterland of the coast to the southern border of the last glaciation, which gave way about 10,000 years ago. Its footprint is the highly diverse mosaic of ecosystems whose special feature is the presence of lakes and marginal zones characterized by a significant enrichment of relief and land cover in comparison to the lowlands lying outside the range of the last glaciation. At the lake districts there is a significant but regionally diverse share of forest ecosystems associated with less fertile soils. Proportionally less important are intense forms of use of the environment, including urban areas, road infrastructure and agriculture. The mentioned features of the Lakelands result in a high level of regulation and cultural services, which are associated with biodiversity and recreational values, as well as provisioning services provided by forest ecosystems. In agriculture, there is the distinctive importance of cattle grazing.

Lowlands

These are areas of low diversity of relief, segmented by major river valleys. They are characterized by above-average share of arable land with agricultural pastures, while the share of forests is lower than the average. These characteristics determine the low level of regulation and cultural services on regional-scale.

[14] K. Szefler, K. Furmańczyk, *Zagospodarowanie i przestrzenne aspekty rozwoju strefy przybrzeżnej Bałtyku* (*Development and spatial aspects of the Baltic Sea coastal zone*), in: K. Saganowski, M. Zagrzejewska-Fiedorowicz, P. Żuber (ed.), *Ekspertyzy do Koncepcji Przestrzennego Zagospodarowania Kraju 2008-2033* (*Expertise to the National Spatial Development Concept 2008-2033*), Ibidem, p. 185-238.

On the other hand, higher than average are the provisioning services related to agricultural production. This unit is characterized by a significant role of intensive forms of use of the environment. The share of urban area is close to the average, but there are three major metropolitan areas: those of Warsaw, Lodz and Wroclaw and there located are the major international routes of communication. Very high and spatial concentrated level of anthropogenic impact on the environment is evident in the mining areas associated with open-pit brown coal mining in the areas of Konin, Turek and Belchatow and pit mining of cupriferous shales in the Lubin-Glogowski Basin. Based on these raw materials, highly urbanized industrial districts have developed in which deep quantitative and qualitative changes in ecosystems have occurred.

Uplands

This landscape-ecological unit covers the areas of Silesian-Malopolska and Lublin heights which, despite the diverse origins of their relief, have some common characteristics in the structure of ecosystems building them. The western part is characterized by the country's largest environmental transformation associated with the mining industry and urbanization. Intensive farming involves mostly fertile soils in the central and eastern part of the zone. This resulted in a low percentage of forest ecosystems, which are unevenly distributed and concentrated in the Swietokrzyskie (Holy Cross) Mountains and the Roztocze. Watershed nature of this part makes it poor in surface water. The special nature of the uplands area is that the services of a substantial part of ecosystems are carried out in conditions of severe strain caused by various forms of anthropogenic impact on the environment. It is about transforming the surface, changes in water relations, air pollution, changes in vegetation cover and stimulating soil erosion.

Piedmont Basins

Between the uplands zone and the Carpathian arc there is a sequence of basins whose axes are the valleys of the Upper Vistula and San. In the structure of land cover an above-average share of urban areas can be distinguished, which extend especially along the valleys. It is there that the main east-west communication in Southern Poland is running. The agriculture is very important, which, although very fragmented, is the basis for existence of a large part of the population. Slightly lower than the national average is the share of forests, which are concentrated in the Sandomierz Basin. A special feature of this area is the overlaping of the sensitive and dynamic valley ecosystems with intensive land use forms, causing collisions with the maintenance of the level of ecosystem services and the natural capital of the river valleys. The problem is to maintain the services regulating the flow of flood water and contributing to the flood protection.

Medium-high Mountains

It is a dual area composed of fragments of the Sudetes belonging to Poland and the Carpathian Mountains. Its specificity stems from the significant role of relief as a determinant of the variance of ecosystems and the forms of use of the environment. In this zone there is a high share of forests, which cover the higher and more strongly inclined slopes and those elevations that do not cross the climate conditioned upper line of the forest. Valleys and low-lying gently sloping hills are in agricultural use; the intensity of settlement increases in these areas. The feature of the spatial development in this zone is strong dispersion of settlement, which makes it difficult to provide adequate environmental protection infrastructure and increases the level of collisions of investment with ecosystem services. Wood production, the attractiveness for recreation, and water regulation, are the services, the importance of which, on the country scale, can be considered as the greatest. Provisioning services associated with agricultural production are the primary or secondary source of income for a large part of the inhabitants of these areas.

Alpine Mountains

This type overlaps the Polish part of the Tatra Mountains and occupies the southern patch of the country. Low-lying parts are covered with coniferous forests with the domination of spruce, while those areas classified as other, above the forest line, are bare rock and alpine grasslands. Isolating this fragment as a separate unit is due to the uniqueness and social importance of the ecosystem services occurring there, with a special meaning for culture, recreation and education. The consequence of this is a strong tourist pressure on this area and the expansion of urbanization in its immediate vicinity.

Functional framework for Ecosystem Services Evaluation for Poland

The featured landscape-ecological units are described by different land cover structure, which leads to a specific ecosystem services-mix for each one. We propose to group land-cover types into 7 basic units: Urban areas, Agriculture areas, Grasslands, Forests, Rivers&lakes, Baltic Sea, Others. These correspond to Land Cover Functional Units (LCFU) proposed by EEA. The exception to this is when we combine broad pattern agriculture and agriculture associations and mosaics as agriculture areas. Each LCFU has been characterized by a specific status of ecosystems and a set of their services. For each LCFU we propose guidelines for the assessment of the status of ecosystems and we assign important for Poland ecosystem services (on the level of classes) according to CICES nomenclature. Viewing LCFU in order from the most intensive use to the extensive. A part of the included

ecosystem services varies locally, while other may be rated for the country or for individual LCFU. One of the problems that needs to be perceived is the competitiveness of the various functions performed by ecosystems, and consequently, non-uniform perception of the benefits provided by them.

Urban areas

Urban areas play an important role in the functional structure of ecosystems, because they are places of concentration of population. W 2010 urban population amounted to 23264,4 thousand. people, which accounted for 60.9% of the population of the country.[15] However, this figure does not include the suburbs that do not have the formal status of urban municipalities. It can therefore be assumed that approximately three-quarters of the Polish population lives in urban areas.

The set of ecosystem services related to urban areas is shown in table 2. Ecosystem services in urban areas must be seen from a dual perspective. From the general-national point of view of, special attention should primarily be paid to the services related to the cultural character of landscape. Broader significance is also involved in the share of biological area in the urban municipalities as a factor retarding the flow of precipitation water to watercourses and influencing the response of the river to precipitation. However, we consider the ecosystem services in urban areas that serve their residents as equally important. In Polish conditions, the reduction of the effect of an urban heat island can be mentioned, achieved by reducing albedo and by facilitating ventilation of the city (green wedges). Another type of service is providing conditions for infiltration, and thus, replenishing the groundwater which serves the urban vegetation and reduces the load on storm water systems. Of particular importance are the aesthetic and recreational values as factors affecting the price of the property. Studies have shown the relationship between prices of building plots and the distance to the attractive recreational local landscape elements such as lakes and forests.[16] This demonstrates not only the level of the cultural services, but also the economic benefits for the urban municipalities in the form of higher taxes paid by wealthy residents settling in an attractive surrounding.

Quality of ecosystems and their role in urban areas is associated with the amount of emissions to air and water and the soil contamination. Another important factor is the spatial distribution and the share of biologically active surfaces in urban areas. The classification of cities in terms of the quality of air water and soil, as well as the share and the availability of green infrastructure will reflect the ability of ecosystems to provide the services.

[15] Główny Urząd Statystyczny, *Miasta w liczbach 2010* (*Central Statistical Office, Townsin figures 2010*), www.stat.gov.pl/gus/5840_731_PLK_HTML.htm [Date of entry: 30-09-2012].

[16] D. Łowicki, *Wartość krajobrazu w świetle cen terenów pod zabudowę w latach 1995-2000* (*The value of landscape in the light of the price of land for development in 1995-2000*), „Ekonomia i Środowisko" 2010 No. 1(37), p. 147-156.

Table 2.
Ecosystem services classes in the Urban areas as a Land Cover Unit

STATUS – Potential for ES assuring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Air quality statistics • Water availability • Soil contamination • Sanitation • Noise • Green infrastructure	• Remediation by plants • Remediation by micro-organisms • Remediation by animals • Filtration • Sequestration and absorption • Urban microclimatic regulation • Attenuation of runoff and discharge rates • Local & Regional climate regulation
	• Landscape character • Cultural landscapes • Scientific • Educational

CICES Section	
	Regulation and Maintenance
	Cultural

Source: Own study.

Agriculture areas

This group includes the arable land and orchards, which occupy a total area of 11320 thousand hectares and constitute a little more than 36% of the country's surface. From this unit we excluded meadows and pastures, which are characterized by a different structure of ecosystem services. It should be noted that the ecological role of agriculture areas is diversified depending on the area structure of the fields and, strongly associated with it, the participation of marginal habitats. In general, in the areas with highly fragmented agriculture there is a large share of marginal habitats in the form of baulks, trees and midfield bushes. In Poland, the structure of the field area is historically conditioned. Finely fragmented are the areas in the south, centre and east of the country, while in the north and west there is a significant share of large-scale agriculture and the average size of the plot is much larger. In the total area of Polish arable land, 1/3 constitute low fertility soils, which is mainly due to their excessive permeability. This means that the agriculture in Poland is very sensitive to water shortage. This is connected with the large need to stimulate regulatory properties of these areas by the retention of water in ecosystems.

Services for agriculture areas significant for Poland are summarized in table 3. These areas are the basis for a range of provisioning services, related especially to the delivery of food. In 2010 agricultural sector produced among others 23476 thousand tonnes cereals, 7972,4 thousand tonnes sugar beet, 7756,6 thousand tonnes potatoes, 1481,5 thousand tonnes oilseeds, 660,9 thousand

Table 3.
Ecosystem services classes in the Agriculture areas as Land Cover Unit

STATUS – Potential for ES assurring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Soil fertility • Water availability for agriculture • Soil contamination • The share of marginal habitats as refuge habitats	• Crops • Livestock and dairy products • Water for livestock (consumptive) • Non-food animal fibres • Ornamental resources • Genetic resources • Medicinal and cosmetic resources • Biomass based energy: Vegetal based resources • Biomass based energy: Animal based resources
	• Remediation by plants • Filtration • Sequestration and absorption • Global climate regulation (incl. C-sequestration) • Local & Regional climate regulation • Water purification • Maintenance of soil fertility • Maintenance of soil structure • Pollination • Biological control mechanisms • Maintaining nursery populations
	• Landscape character • Cultural landscapes • Charismatic or iconic wildlife or habitats • Prey for hunting or collecting • Scientific • Educational

CICES Section	
	Provisioning
	Regulation and Maintenance
	Cultural

Source: Own study.

tones feed root plants, 337,1 thousand tonnes pulses for grain, 4189 thousand tones field vegetables, 2195,6 thousand tonnes tree fruit and 457,2 berry fruit. Animal production included, amongst other things, 5205 thousand tonnes animals for slaughter, 11921 thousand tonnes cows' milk, 11124 million hen eggs and 620 tonnes sheep's wool. Procurement value of agricultural products amounted to 13777,6 million PLN for crop products and 27546,9 million PLN for animal products. Per 1 ha of agricultural land, the value of agricultural output amounted to 889 zloty for crop products and 1777 PLN for animal products.[17]

[17] Główny Urząd Statystyczny, *Rocznik statystyczny rolnictwa 2011* (*Central Statistical Office, Statistical Yearbook of Agriculture 2011*). www.stat.gov.pl/gus/5840 _4127_PLK_HTML.htm [Date of entry: 30-09-2012].

Agriculture areas constitute biologically active surfaces, on which infiltration takes place, and thus the groundwater replenishment. Moreover, their regulation functions depend on the spatial position in the use structure. Agricultural land amidst forests enrich the mosaic of landscape and increase the associated cultural values, whereas (agricultural land) located amidst urban areas contribute to reducing the urban heat island effect, they are also a very important location because they replenish groundwater in the neighborhood of the sealed surfaces.

An important significance for the level of agricultural ecosystems services has the degree of connection of crop production with livestock production, reflected in the share of own feed on the farm. This serves the rational use of animal manure as fertilizer.

Another factor in defining the level of services of agro-ecosystems is the degree of the use of doses of fertilizer by crops. This translates into the amount of biogenes that, penetrating into the environment, lead to overfertilization of ecosystems. Impact on the level of services has also the level of education and awareness of farmers and their adherence to the rules set by the Code of Good Agricultural Practice.[18] Especially, it concerns the maintaining of marginal habitats within the arable fields.

Grasslands

The LCFU includes agricultural meadows and pastures, as well as extensively used grasslands in the hinterland of the coast, wetlands in the bottoms of river valleys, especially Biebrza, and small fragments of natural grasslands above the tree line in the mountains. Meadows occupy 2629,2 thousand hectares, whereas pastures 654,3 thousand hectares, which totals 10,5% of the country's surface. The highest percentage of meadows and pastures falls on the eastern provinces (mazowieckie 13,5% of the total area of grasslands, podlaskie 10,2%, warmińsko-mazurskie 10,1%, lubelskie 8,4%). Ecosystem services of grasslands are shown in table 4. Provisioning services include grazed vegetation of the pastures and hay production. In 2010 in Poland these reached the value of 12893 thousand tonnes of hay from meadows and 2372 thousand tonnes from pastures. Per 1 ha, the production of dry hay was 49,0 dt/ha for meadows and 36,3 dt/ha for pastures.[19]

Grasslands are characterized by a specific biodiversity. Regulatory functions of these ecosystems are associated with the prevention of wind and water erosion due to permanent plant cover. The plant cover also reduces the heating of

[18] Ministerstwo Rolnictwa i Rozwoju Wsi, Ministerstwo Środowiska, *Kodeks Dobrej Praktyki Rolniczej* (*Ministry of Agriculture and Rural Development, Ministry of Environment,Code of Good Agricultural Practice*), www.kzgw.gov.pl/files/file/Materialy_i_Informacje/Dyrektywy_Unijne/Azotowa/kodeks_dobrej_praktyki_rolniczej.pdf [Date of entry: 30-09-2012].

[19] Główny Urząd Statystyczny, *Rocznik statystyczny rolnictwa 2011* (*Central Statistical Office, Statistical Yearbook of Agriculture 2011*), op. cit.

Table 4.
Ecosystem services classes in the Grasslands as Land Cover Unit

STATUS – Potential for ES assurring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Soil fertility – Water availability for plants • Soil contamination • The share of marginal habitats as refuge habitats	• Crops • Genetic resources
	• Remediation by plants • Filtration • Sequestration and absorption • Attenuation of runoff and discharge rates • Water storage for flow regulation • Avalanche and gravity flow protection • Global climate regulation (incl. C-sequestration) • Local & Regional climate regulation • Water purification • Maintenance of soil fertility • Maintenance of soil structure • Pollination • Biological control mechanisms • Maintaining nursery populations
	• Landscape character • Cultural landscapes • Charismatic or iconic wildlife or habitats • Prey for hunting or collecting • Scientific • Educational

CICES Section	
	Provisioning
	Regulation and Maintenance
	Cultural

Source: Own study.

the surface, which is important for water relations. Another factor is the importance of grasslands for the absorption of biogenes from agricultural production. Negative correlation was demonstrated between the share of pastures and wetlands in the catchment and the amount of biogenes in surface waters.[20] Grasslands also introduce a mosaic landscape, particularly in areas with a significant share of forests, increasing their aesthetic and recreational appeal.

Grasslands quality, in relation to the optimum services from them, seems high in Poland. Some restrictions may result from the succession of shrub and tree vegetation that occurs as a result of failure of traditional forms of farming, i.e. grazing and mowing. Another factor limiting the level of services are high doses of fertilizers on intensively used parts of the grasslands.

[20] D. Łowicki, *Prediction of flowing water pollution on the basis of landscape metrics as a tool supporting delimitation of Nitrate Vulnerable Zones*, "Ecological Indicators" 2012 No. 23, p. 27-33.

Forests

Forest areas occupy 9121 thous. ha, representing 29,2% of the country's surface. The vast majority of Polish forests occur in lowland habitats (88% of forest area), 7% occur in mountain habitats, and the remaining 5% in upland habitats. The forest structure is dominated by coniferous trees (87% forest area), which include pine, larch, spruce, fir and Douglas spruce. The species composition of broadleaved trees is formed by oak, ash, maple, sycamore, elm, beech, hornbeam, birch, false acacia, alder, aspen, linden and willow. Average age of tree stands in 2010 was 59 years for coniferous and 53 for broadleaved trees. Tree stands in age over 60 years were in 27% of the stand area.[21]

The set of services associated with forest ecosystems is shown in table 5. Significant services of forests are associated with the supply of non-food vegetal fibers. Resources of gross timber per 1 ha of forest area in 2010 amounted to 257 m^3. Logging was at the level of 35467 thousand. m^3. Dominant share in the management of forests in Poland has National Forest Holding, it covers nearly 80% of the forest area. Timber sales in the National Forest Holding in 2010 reached the value of 5283,7 milion PLN, with an average price 114,5 PLN per 1 m^3. Forests are also the source of wild plants and animals and their products. In 2010, 8374 tonnes forest fruit (bilberry, elder, mountain ash, dog rose), 4467 tonnes mushrooms (chanterelle, boletus, king boletus) and 8 988 tonnes game animals (mainly deer, roe deer, wild boars) were purchased. Value of procurement of forest fruits amounted to 55540,2 thous. PLN, forest mushrooms 55328,9 thous. PLN and game animals 63435,9 thous. PLN.[22] Regulation services of the forest in the light of the efforts to reduce emissions of CO_2 rely especially on the absorption and storage of carbon. The size of absorption of CO_2 by forests in Poland in 2007 was estimated to be just over 54132 Gg.[23]

The level of services is related to the structure of the species and the age structure of forests, as well as their spatial distribution and health status. In recent years, the health of the forest improved. Efforts are also made to bring the structure of the stand closer to the natural characteristics of the habitat. Debatable direction of changes is the increase the forest cover areas, which are already characterized by a very high percentage of forest. It seems that this reduces the level of services arising from the cultural mosaic, moreover, as a result of increasingly limited accessibility it leads to peripheralisation of significant areas and limits their economic importance.

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[21] Główny Urząd Statystyczny, *Leśnictwo 2011* (*Central Statistical Office, Forestry 2011*), www.stat.gov.pl/gus/5840_1540_PLK_HTML.htm [Date of entry: 30-09-2012].

[22] Ibidem.

[23] Krajowy Administrator Systemu Handlu Uprawnieniami Do Emisji, *Krajowa inwentaryzacja emisji i pochłaniania gazów cieplarnianych za rok 2007*(*National Administrator of the System of Tradiing Permissions to Emission, National inventory of emisions and adsorption of greenhouse gases in 2007*) www.kashue.pl/materialy/Inwentaryzacje_krajowe/NIR_2009_Polska_05-09.pdf [Date of entry: 30-09-2012].

Table 5.
Ecosystem services classes in the Forests as Land Cover Unit

STATUS – Potential for ES assuring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Forest age structure • The structure of species, and their accordance to habitats • Foliar damage	• Wild plants and animals and their products • Non-food vegetal fibres • Genetic resources • Biomass based energy: Vegetal based resources
	• Remediation by plants • Filtration • Sequestration and absorption • Attenuation of runoff and discharge rates • Water storage for flow regulation • Avalanche and gravity flow protection • Global climate regulation (incl. C-sequestration) • Local & Regional climate regulation • Water purification • Pollination • Biological control mechanisms • Maintaining nursery populations
	• Landscape character • Wilderness, naturalness • Charismatic or iconic wildlife or habitats • Prey for hunting or collecting • Scientific • Educational

CICES Section	
	Provisioning
	Regulation and Maintenance
	Cultural

Source: Own study.

Rivers and lakes

Area under surface water occupies 561 thous. ha (1,8% of the surface of Poland), including 495 thous. ha under flowing water and 66 thous. ha under standing water. In the country's territory there is just over 7 thousand. lakes larger than 1 ha, of which 6.8 thousand are within the Baltic glaciation area (Pomeranian Lake District, the Mazury Lake District, Wielkopolska-Kujawskie Lake District). The disappearance of 2,2 thousand lakes occurred over the last few decades. The reasons for the disappearance of lakes are: lowering the groundwater as a result of growing demand for water for crops, the acceleration of outflow caused by drainage systems and shallowing of the lakes due to eutrophication resulting from the significant amount of biogenes' intake from agricultural areas.[24]

[24] A. Choiński, *Katalog jezior Polski* (*Polish lakes catalogue*), Wydawnictwo Naukowe UAM, Poznań 2006.

Table 6.
Ecosystem services classes in the Rivers and lakes as Land Cover Unit

STATUS – Potential for ES assurring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Water quality • Water regime • Flood hazards • Recreational attractiveness	• Fish (wild populations) • Aquaculture products • Drinking water • Domestic water use • Irrigation water (consumptive) • Cooling water (non consumptive) • Genetic resources
	• Dilution, decomposition, remineralisation and recycling • Attenuation of runoff and discharge rates • Water storage for flow regulation • Local & Regional climate regulation • Water purification and oxygenation • Biological control mechanisms • Maintaining nursery populations
	• Landscape character • Cultural landscapes • Wilderness, naturalness • Charismatic or iconic wildlife or habitats • Prey for hunting, fishing or collecting • Scientific • Educational

CICES Section	
	Provisioning
	Regulation and Maintenance
	Cultural

Source: Own study.

The main services of river and lake ecosystems are shown in table 6. Provisioning services are expressed in the supply of fresh water fish and the water supply for domestic, agricultural and industrial use. The level of services including water supply is related to providing access to water in the required quantity and quality and in the specific location. The changes taking place in Poland in this respect are multidirectional. The decrease in water consumption by the municipal and industry sector and decreasing load of pollutants in the discharged waste water can be included in the positive processes. Against this background, the factor limiting access to water is agriculture. Water consumption in agriculture is growing, as a result of more intensive crop production and the increasing share of crops with high water requirements, such as corn or energy crops. Intensification of agriculture leads to the deterioration of water quality by increasing the amount of biogenes discharged into them, which cause over-fertilization of aquatic and water-dependent ecosystems. To this, the one-

sided drainage systems without provisions for retention of groundwater when it drops to the appropriate level must be added. The factor affecting the level of water provisioning services is the retention capabilities in water-dependent ecosystems in the bottoms of river valleys. A limitation for the services associated with water storage for flow regulation are embankments outside the built-up areas which constrict the active flooding terrace. They increase vulnerability of a river valley to catastrophic flood and drought. The increase of water retention in the ecosystem also reduces the fluctuations in the first level of groundwater, at least in the valley parts of the catchment.

Cultural services of rivers, and especially lakes are related to water sports, tourism and recreation, the servicing of which represents a significant source of income for the inhabitants of lakelands.

Baltic Sea including coastal zone

LCFU occupies an area of the sea and the contact zone between the sea and land. The length of the coastline of Poland equals 770 km. The area of the territorial sea is 8682 km^2, further 2005 km^2 are the internal waters. Total sea area represents 3,3% of the country. Ecosystem benefits associated with this unit are summarized in table 7. Provisioning services of the sea include fishery, and cultural services are related to fishing from the boats and sunbathing. The attractiveness of this area causes increasing urbanization of contiguous areas and recreational services becomes dominant in relation to the previous fishing functions. Using the cultural services of marine ecosystems is of the utmost importance where the hinterland of the beaches are moraine uplands, which are attractive areas for building. Cultural services are mainly associated with tourism and recreation, as well as cultural, social, historical, artistic, and health benefits to society. In summer, the coastal region accommodates the most domestic tourists. In the summer of 2010, Pomeranian district accommodated 2.35 million travels, whereas West-Pomeranian there were 1.90 million, which accounted for just over 60% of the total domestic tourist traffic in July and August. [25]

Positive effects on the level of Baltic Sea services are exerted by the strong reduction of pollution load in the waste water entering the sea. The negative factor is overfishing, which causes the decline of the fish stocks. Another factor that could potentially limit the Baltic Sea ecosystem services is the ability to build offshore wind farms. Reference is made to the reduction of aesthetic values and difficulties for fishing.

The level of services of the coast is combined with its accessibility, especially with the width of the beach. Well programmed investment works can effectively increase the surface of the available beach.

[25] Instytut Turystyki, *Uczestnictwo Polaków w wyjazdach turystycznych w 2010 roku* (*Institute of Tourism, participation of Poles in tourist trips in 2010*) www.msport.gov.pl/statystyka-turystyka/552-Uczestnictwo-Polakow-w-wyjazdach-turystycznych [Date of entry: 30-09-2012].

Table 7.
Ecosystem services classes in the Baltic Sea as Land Cover Unit

STATUS – Potential for ES assurring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Water quality • Fish stocks • Coastal erosion	• Fish (wild populations) • Genetic resources • Medicinal and cosmetic resources
	• Dilution, decomposition, remineralisation and recycling • Global climate regulation (incl. C-sequestration) • Local & Regional climate regulation • Biological control mechanisms • Maintaining nursery populations
	• Landscape character • Wilderness, naturalness • Charismatic or iconic wildlife or habitats • Scientific • Educational

CICES Section	
	Provisioning
	Regulation and Maintenance
	Cultural

Source: Own study.

Others

The LCFU create surfaces that are not invested and without vegetation cover. They consist of the highest parts of the mountains and the non-recultivated land after open-pit mining. They have a marginal share of the SELU surface. Only in the high Tatra (Alpine Mountains) they are the dominant type of land surface. Services from ecosystems related to them are diverse. Where they are natural or semi-natural surfaces, they provide cultural services associated with tourism and recreation. This is particularly evident in the highest parts of the mountains. At the opposite extreme are the non-recultivated post-mining areas, not only because they do not provide cultural services, but they reduce their level in adjacent areas. However, there are examples of the recultivation work carried out properly which allows the ecosystems to gain extraordinary value. Surfaces located in the pits also serve the replenishment of groundwater and ground retention.

Table 8
Ecosystem services classes in the Others as Land Cover Unit

STATUS – Potential for ES assurring compared to the optimum	Ecosystem Services Class (the CICES Classification)
• Intensity of tourist penetration (in relation to the highest parts of the mountains) • Trends and progress of recultivation work	• Filtration • Water storage for flow regulation • Local & Regional climate regulation • Maintaining nursery populations
	• Landscape character • Cultural landscapes • Wilderness, naturalness • Sacred places or species • Landscape character for recreational opportunities • Scientific • Educational

CICES Section	
	Regulation and Maintenance
	Cultural

Source: Own study.

Conclusions

The frameworks proposed by EEA has been inspiring for the ES assessment for Poland. The use of a recognized geographical regionalization provides a good basis for spatial variation in the structure of ecosystems on Polish territory. It is proposed to distinguish the following landscape-ecological units: Baltic Sea, Lakelands, Lowlands, Uplands, Piedmont Basins, Medium-high Mountains and Alpine Mountains. Among these units the significant distinctions can be noticed in the characteristics of ecosystem services. A useful tool for this purpose can be the spatial database Corine Land Cover 2006 (CLC), which allows one to quantitatively vary the land cover structure at different levels of detail. Analysis of the structure of the land cover in Poland has led the authors to conclude that LCFU award at the regional level requires adjustments in relation to the proposed by EEA set of basic land cover types compliant to CLC classification. It is proposed to combine agriculture into one group, and include in it the arable land with the exception of grasslands included in the separate unit. This created 7 units: Urban areas, Agriculture areas, Grasslands, Forests, Rivers&lakes, Baltic Sea and Others. Assignment of proposed ES-types to particular Land Cover Functional Units (LCFU) needs to be discussed in an interdisciplinary manner.