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ECONOMICS AND ENVIRONMENT

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FUNKCJE I ŚWIADCZENIA EKOSYSTEMÓW

STRESZCZENIE: W niektórych sytuacjach występują kolizje pomiędzy pożytkami z funkcjonowania układów przyrodniczych a innymi czynnikami wpływającymi na dobrobyt ludzi. W okolicznościach, gdy trzeba podejmować tego typu nieuniknione, choć trudne do rozstrzygnięcia decyzje, wsparciem może być wycena świadczeń ekosystemów. Niniejsza praca wyjaśnia niektóre kontrowersje związane z definiowaniem pozytywnego wpływu procesów w ekosystemach na ludzki dobrobyt, bez względu na to, czy ludzie uświadamiają sobie ten wpływ, czy też nie. Sklasyfikowano i opisano obszary problemowe, w których zastosowanie mają różne metody szacowania korzyści płynących ze świadczeń ekosystemów. Przedstawiono też kilka najnowszych studiów przypadku oraz rozwój badań nad wyceną świadczeń ekosystemów.

SŁOWA KLUCZOWE: wycena, dobrobyt ludzi, kapitał przyrodniczy, świadczenia ekosystemów, podejście transdyscyplinarne

Ecosystem Services

"Ecosystem services" (ES) are the ecological characteristics, functions, or processes that directly or indirectly contribute to human well-being – the benefits people derive from functioning ecosystems[1]. Ecosystem processes and functions may contribute to ecosystem services but they are not synonymous. Ecosystem processes and functions describe biophysical relationships and exist regardless of whether or not humans benefit[2]. Ecosystem services, on the other hand, only exist if they contribute to human well-being and cannot be defined independently.

The ecosystems that provide the services are sometimes referred to as "natural capital," using the general definition of capital as a stock that yields a flow of services over time[3]. In order for these benefits to be realized, natural capital (which does not require human activity to build or maintain) must be combined with other forms of capital that *do* require human agency to build and maintain. These include: (1) built or manufactured capital; (2) human capital; and (3) social or cultural capital[4].

These four general types of capital are all required in complex combinations to produce any and all human benefits. Ecosystem services thus refer to the relative contribution of natural capital to the production of various human benefits, in combination with the three other forms of capital. These benefits can involve the use, non-use, option to use, or mere appreciation of the existence of natural capital.

The following categorization of ecosystem services has been used by the Millennium Ecosystem Assessment[5].

1. Provisioning services – ecosystem services that combine with built, human, and social capital to produce food, timber, fiber, or other "provisioning" benefits. For example, fish delivered to people as food require fishing boats (built capital), fisher-folk (human capital), and fishing communities (social capital) to produce.
2. Regulating services – services that regulate different aspects of the integrated system. These are services that combine with the other three

[1] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260; *The Millennium Ecosystem Assessment, Ecosystem and Human Well-being: Synthesis*, Island Press,Washington 2005.
[2] J. Boyd, S. Banzhaf, *What are Ecosystem Services?,* "Ecological Economics" 2007 No. 63, p. 616--626; E. F. Granek et al., *Ecosystem services as a common language for coastal ecosystem-based management,* "Conservation Biology" 2010 No. 24, p. 207-216.
[3] R. Costanza, H. E. Daly, *Natural capital and sustainable development, "*Conservation Biology" 1992 No. 6, p. 37-46.
[4] R. Costanza et al., *An Introduction to Ecological Economics,* St. Lucie Press, Boca Raton 1997.
[5] *The Millennium,* op. cit.

capitals to produce flood control, storm protection, water regulation, human disease regulation, water purification, air quality maintenance, pollination, pest control, and climate control. For example, storm protection by coastal wetlands requires built infrastructure, people, and communities to be protected. These services are generally not marketed but have clear value to society.

3. Cultural services – ecosystem services that combine with built, human, and social capital to produce recreation, aesthetic, scientific, cultural identity, sense of place, or other "cultural" benefits. For example, to produce a recreational benefit requires a beautiful natural asset (a lake), in combination with built infrastructure (a road, trail, dock, etc.), human capital (people able to appreciate the lake experience), and social capital (family, friends and institutions that make the lake accessible and safe). Even "existence" and other "non-use" values" require people (human capital) and their cultures (social and built capital) to appreciate.
4. Supporting "services" – services that maintain basic ecosystem processes and functions such as soil formation, primary productivity, biogeochemistry, and provisioning of habitat. These services affect human well-being indirectly by maintaining processes necessary for provisioning, regulating, and cultural services. They also refer to the ecosystem services that have not yet, or may never be intentionally combined with built, human, and social capital to produce human benefits but that support or underlie these benefits and may sometimes be used as proxies for benefits when the benefits cannot be easily measured directly. For example, net primary production (NPP) is an ecosystem function that supports carbon sequestration and removal from the atmosphere, which combines with built, human, and social capital to provide the benefit of climate regulation. Some would argue that these "supporting" services should rightly be defined as ecosystem "functions", since they may not yet have interacted with the other three forms of capital to create benefits. We agree with this in principle, but recognize that supporting services/functions may sometimes be used as proxies for services in the other categories.

This categorization suggests a very broad definition of services, limited only by the requirement of a contribution to human well-being. Even without any subsequent valuation, explicitly listing the services derived from an ecosystem can help ensure appropriate recognition of the full range of potential impacts of a given policy option. This can help make the analysis of ecological systems more transparent and can help inform decision makers of the relative merits of different options before them.

Valuation

Many ecosystem services are public goods. This means they are non-excludable and multiple users can simultaneously benefit from using them. This creates circumstances where individual choices are not the most appropriate approach to valuation. Instead, some form of community or group choice process is needed. Furthermore, ecosystem services (being public goods) are generally not traded in markets. We therefore need to develop other methods to assess their value.

There are a number of methods that can be used to estimate or measure benefits from ecosystems. Valuation can be expressed in multiple ways, including monetary units, physical units, or indices. Economists have developed a number of valuation methods that typically use metrics expressed in monetary units[6] while ecologists and others have developed measures or indices expressed in a variety of non-monetary units such as biophysical trade-offs[7].

There are two main methods for estimating monetary values: revealed and stated preferences. Both of these typically involve the use of sophisticated statistical methods to tease out the values[8]. Revealed preference methods involve analyzing individuals' choices in real-world settings and inferring value from those observed choices. Examples of such methods include production-oriented valuation that focuses on changes in direct use values from products actually extracted from the environment (e.g. fish). This method may also be applicable to indirect use values, such as the erosion control benefits forests provide to agricultural production. Other revealed preference methods include hedonic pricing, which infers ecosystem service values from closely linked housing markets. For example, urban forest ecosystems and wetlands may improve water quality and that may be (partially) captured in property values[9]. The travel cost valuation method is used to value recreation ecosystem services and estimates values based on the resources, money and time visitors spend to visit recreation sites.

Stated preference methods rely on individuals' responses to hypothetical scenarios involving ecosystem services and include contingent valuation and structured choice experiments. Contingent valuation utilizes a highly structured survey methodology that acquaints survey respondents with ecosystem improvements (e.g. better stream quality) and the ecosystem services they will generate (e.g. increased salmon stocks). Respondents are then asked to value ecosystem improvements usually using a referendum method[10].

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[6] A. M. Freeman, *The Measurement of Environmental and Resource Values: Theories and Methods*, 2nd Edition, RFF Press, Washington DC 2003.

[7] R. Costanza, *Value theory and energy,* in: *Encyclopedia of Energy* Vol. 6, ed. C. Cleveland, Elsevier, Amsterdam 2004, p. 337-346.

[8] T. Haab, K. McConnell, *Valuing Environmental and Natural Resources: The Econometrics of Non-Market Valuation,* Edward Elgar Publishing Ltd: Cheltenham, UK 2002.

[9] D. J. Phaneuf, V. K. Smith, R. B. Palmquist, J. C. Pope, *Integrating property value and local recreation models to value ecosystem services in urban watersheds,* „Land Economics" 2008 No. 84, p.361-381.

[10] A. Boardman, D. Greenberg, A. Vining, D. Weimer, *Cost-Benefit Analysis: Concepts and Practice*, 4th Edition, Prentice Hall, Inc: Upper Saddle River, New York 2006.

Choice experiments are sometimes called conjoint analysis. This method presents respondents with combinations of ecosystem services and monetary costs and asks for the most preferred combinations. Based on these choices, ecosystem service values are inferred.

A key challenge in any valuation is imperfect information. Individuals might, for example, place no value on an ecosystem service if they do not know the role that the service is playing in their well-being[11]. Here is an analogy. If a tree falls in the forest and there is no one around to hear it, does it still make a sound? Assume in this case that the "sound" is the ecosystem service. The answer to this old question obviously depends on how one defines "sound". If "sound" is defined as the perception of sound waves by people, then the answer is no. If "sound" is defined as the pattern of physical energy in the air, then the answer is yes. In this second case, choices in both revealed and stated preference models would not reflect the true benefit of the ecosystem service. Another key challenge is accurately measuring the functioning of the system to correctly quantify the amount of a given service derived from that system[12].

But recognizing the importance of information does not obviate the limitations of human perception-centered valuation. As the tree analogy demonstrates, perceived value can be a quite limiting valuation criterion, because natural capital can provide positive contributions to human well-being that are either never (or only vaguely) perceived or may only manifest themselves at a future time. A broader notion of value allows a more comprehensive view of value and benefits, including, for example, valuation relative to alternative goals/ends, like fairness and sustainability, within the broader goal of human well-being[13]. Whether these values are perceived or not and how well or accurately they can be measured are separate (and important) questions.

Case Studies

Early valuation syntheses

Scientists and economists have discussed the general concepts behind natural capital, ecosystem services, and their value for decades, with some early work as far back as the 1920's. However, the first explicit mention of the term "eco-

[11] B. Norton, R. Costanza, R. Bishop, *The evolution of preferences: why "sovereign" preferences may not lead to sustainable policies and what to do about it,* "Ecological Economics" 1998 No. 24, p. 193-211.

[12] E. B. Barbier et al., *Coastal ecosystem-based management with non-linear ecological functions and values,* "Science" 2008 No. 319, p. 321-323; E. W. Koch et al., N*on-linearity in ecosystem services: temporal and spatial variability in coastal protection,* "Frontiers in Ecology and the Environment" 2009 No. 7, p. 29-37.

[13] R. Costanza, *Social goals and the valuation of ecosystem services,* "Ecosystems" 2000 No. 3, p. 4-10.

system services" was in Ehrlich and Mooney in 1983[14]. More than 6,000 papers have been published on the topic of ecosystem services since then. The first mention of the term "natural capital" was in Costanza and Daly[15].

One of the first studies to estimate the value of ecosystem services globally was published in *Nature* entitled 'The value of the world's ecosystem services and natural capital'[16]. This paper estimated the value of 17 ecosystem services for 16 biomes to be in the range of USD 16-54 trillion per year, with an average of USD 33 trillion per year, a figure larger than annual GDP at the time. Some have argued that global society would not be able to pay more than their annual income for these services, so a value larger than global GDP does not make sense. However, not all benefits are picked up in GDP and many ecosystem services are non-marketed, so GDP does not represent a limit on real benefits[17].

In this study, estimates of global ecosystem services were derived from a synthesis of previous studies that utilized a wide variety of techniques like those mentioned above to value specific ecosystem services in specific biomes. This technique, called "benefit transfer," uses studies that have been done at other locations or in different contexts, but can be applied with some modification. See Costanza (1998) for a collection of commentaries and critiques of the methodology. Such a methodology, although useful as an initial estimate, is just a first cut and much progress has been made since then[18].

Major World Reports on Ecosystem Services

More recently the concept of ecosystem services gained attention with a broader academic audience and the public when the Millennium Ecosystem Assessment (MEA) was published[19]. The MEA was a 4-year, 1,300 scientist study commissioned by the United Nations in 2005. The report analyzed the state of the world's ecosystems and provided recommendations for policymakers. It determined that human actions have depleted the world's natural capital to the point that the ability of a majority of the globe's ecosystems to sustain future generations can no longer be taken for granted.

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[14] P. R. Ehrlich, H. Mooney, *Extinction, substitution, and ecosystem services,* "BioScience" 1983 No. 33, p. 248-254.

[15] R. Costanza, H. E. Daly, *Natural capital and sustainable development,* "Conservation Biology" 1992 No. 6, p. 37-46.

[16] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260.

[17] R. Costanza et al., *The value of the world's ecosystem services: putting the issues in perspective,* "Ecological Economics" 1998 No. 25, p. 67-72.

[18] R. Boumans et al., *Modeling the Dynamics of the Integrated Earth System and the Value of Global Ecosystem Services Using the GUMBO Model*, "Ecological Economics" 2002 No. 41, p. 529-560; U.S. Environmental Protection Agency Science Advisory Board, *Valuing the Protection of Ecological Systems and Services: A Report of the EPA Science Advisory Board,* EPA-SAB-09-012. Washington, DC: EPA. http://yosemite.epa.gov/sab/sabproduct.nsf/WebBOARD/ValProtEcolSys&Serv?OpenDocument, 2009 [Date of entry: 20-07-2012].

[19] *The Millennium*, op. cit.

In 2008, a second international study was published on The Economics of Ecosystems and Biodiversity (TEEB)[20], hosted by United Nations Environment Programme (UNEP). TEEB's primary purpose was to draw attention to the global economic benefits of biodiversity, to highlight the growing costs of biodiversity loss and ecosystem degradation, and to draw together expertise from the fields of science, economics, and policy to enable practical actions moving forward. The TEEB report was picked up extensively by the mass media, bringing ecosystem services to a broad audience.

The Ecosystem Services Partnership and ongoing work

With such high profile reports being published, ecosystem services have entered not only the public media[21], but also into business. Dow Chemical recently established a USD 10 million collaboration with The Nature Conservatory to tally up the ecosystem costs and benefits of every business decision[22]. Such collaboration will provide a significant addition to ecosystem services valuation knowledge and techniques. However, there is significant research that is still required. Our scientific institutions can help lead this process through transdisciplinary graduate education, such as the Ecosystem Services for Urbanizing Regions program funded by the National Science Foundation's Integrative Graduate Research and Education Traineeship program[23].

Hundreds of projects and groups are currently working toward better understanding, modeling, valuation, and management of ecosystem services and natural capital. It would be impossible to list all of them here, but the new Ecosystem Services Partnership[24] is a global network that does just that and helps to coordinate the activities and build consensus.

The following lays out the research agenda as agreed to by a group of 30 participants at a meeting in Salzau, Germany, in June 2010, at the launch of the ESP.

Integrated Measurement, Modeling, Valuation and Decision Science in Support of Ecosystem Services

The scientific community needs to continue to develop better methods to measure, monitor, map, model, and value ecosystem services at multiple scales. Ideally, these efforts should take place using interdisciplinary teams and strategies and in close collaboration with ecosystem stakeholders. Moreover, this in-

[20] P. Sukhdev, P. Kumar, *The economics of ecosystems & biodiversity*, http://www.teebweb.org/, 2008 [Date of entry: 20-05-2012].
[21] J. D. Schwartz, *Should We Put A Dollar Value On Nature?*, "Time Magazine", Time Inc., http://www.time.com/time/business/article/0,8599,1970173,00.html, 2010 [Date of entry: 20-05-2012].
[22] B. Walsh, *Paying for Nature,* "Time Magazine", Time Inc., http://www.time.com/time/magazine/article/0,9171,2048324,00.html, 2011 [Date of entry: 20-05-2012].
[23] *Ecosystem Services for Urbanizing Regions,* http://www.pdx.edu/esur-igert, Portland State University 2011 [Date of entry: 20-05-2012].
[24] *Ecosystem Services Partnership*, http://www.es-partnership.org/ [Date of entry: 20-05-2012].

formation must be provided to decision makers in an appropriate, transparent, and viable way, to clearly identify differences in outcomes among policy choices. At the same time, we cannot wait for high levels of certainty and precision to act when confronting significant irreversible and catastrophic consequences. We must synergistically continue to improve the measurements with evolving institutions and approaches that can effectively utilize these measurements.

1. *Trade-offs*
   Ecological conflicts arise from two sources: (1) scarcity and restrictions in the amount of ES that can be provided and (2) the distribution of the costs and benefits of the provisioning of the ES. ES science makes trade-offs explicit and, thus, facilitates management and planning discourse. It enables stakeholders to make sound value judgments. ES science thus generates relevant social-ecological knowledge for stakeholders and policy decision makers and sets of planning options that can help resolve sociopolitical conflicts.
2. *Accounting and Assessment*
   Accounting attempts to look at the flow of materials with relative objectivity, while assessment evaluates a system or process with a goal in mind and is more normative. Both are integrating frameworks with distinctive roles. Both ecosystem service accounting and assessment need to be developed and pursued using a broader socio-ecological lens. Within the broader lens we also need to balance expert and local knowledge across scales.
3. *Modeling*
   We need modeling to synthesize and quantify our understanding of ES and to understand dynamic, non-linear, spatially explicit trade-offs as part of the larger socio-ecological systems. Stakeholders should be active collaborators in this model development process to assure relevancy. These models can incorporate and aid accounting and assessment exercises and link directly with the policy process at multiple time and space scales. In particular, modeling can quantify potential shifts in ES under different environmental and socioeconomic scenarios.
4. *Bundling*
   Most ES are produced as joint products (or bundles) from intact ecosystems. The relative rates of production of each service vary from system-to-system, site-to-site, and time-to-time. We must consider the full range of services and the characteristics of their bundling in order to prevent creating dysfunctional incentives and to maximize the net benefits to society[25]. For example, focusing only on the carbon sequestration service

[25] E. Nelson et al., *Modeling multiple ecosystem services, biodiversity conservation, commodity production, and tradeoffs at landscape scales*, "Frontiers in Ecology and the Environment" 2009 No. 7, p. 4-11; S. Polasky, E. Nelson, D. Pennington, K. Johnson, *The impact of land-use change on ecosystem services, biodiversity and returns to landowners: a case study in the State of Minnesota,* "Environmental and Resource Economics" 2011 No. 48, p. 219-242.

of ecosystems may in some instances reduce the overall value of the full range of ES.

5. *Scaling*
   ES are relevant over a broad range of scales in space, time, governance and complexity, including the legacy of past behavior. We need measurement, models, accounts, assessments and policy discussions that address these multiple scales, as well as interactions, feedbacks, and hierarchies among them.

Adaptive Management and New Institutions for Ecosystem Services

Given that pervasive uncertainty always exists in ecosystem service measurement, monitoring, modeling, valuation, and management, we should continuously gather and integrate appropriate information regarding ES, with the goal of learning and adaptive improvement. To do this we should constantly evaluate the impacts of existing systems and design new systems with stakeholder participation as experiments from which we can more effectively quantify performance and learn ways to manage such complex systems.

1. *Property Rights*
   Given the public goods nature of most ecosystem services, we need institutions that can effectively deal with this characteristic using a sophisticated suite of property rights regimes. We need institutions that employ an appropriate combination of private, state and common property rights systems to establish clear property rights over ecosystems without privatizing them. Systems of payment for ecosystem services (PES) and common asset trusts can be effective elements in these institutions.
2. *Scale-matching*
   The spatial and temporal scale of the institutions to manage ecosystem services must be matched with the scales of the services themselves. Mutually reinforcing institutions at local, regional and global scales over short, medium and long time scales will be required. Institutions should be designed to ensure the flow of information across scales, to take ownership regimes, cultures, and actors into account, and to fully internalize costs and benefits.
3. *Distribution Issues*
   Systems should be designed to ensure inclusion of the poor, since they are generally more dependent on common property assets like ecosystem services. Free-riding, especially by wealthier segments of society, should be deterred and beneficiaries should pay for the services they receive from bio-diverse and productive ecosystems.
4. *Information Dissemination*
   One key limiting factor in sustaining natural capital is lack of knowledge of how ecosystems function and how they support human well-being. This can be overcome with targeted educational campaigns that are tai-

lored to disseminate success and failures to both the general public and elected officials and through true collaboration among public, private and government entities.

5. *Participation*
   Relevant stakeholders (local, regional, national, and global) should be engaged in the formulation and implementation of management decisions. Full stakeholder awareness and participation, not only improves ES analyses, but contributes to credible, accepted rules that identify and assign the corresponding responsibilities appropriately, and that can be effectively enforced.
6. *Science/Policy Interface*
   ES concepts can be an effective link between science and policy by making the trade-offs more transparent[26]. An ES framework can therefore be a beneficial *addition* to policy-making institutions and frameworks and to integrating science and policy.

Conclusions

Natural capital and ecosystem services are key concepts that are changing the way we view, value, and manage the natural environment. They are changing the framing of the issue away from "jobs vs. the environment" to a more balanced assessment of all the assets that contribute to human well-being. Significant transdisciplinary research has been done in recent years on ecosystem services, but there is still much more to do and this will be an active and vibrant research area for the coming years, because better understanding of ecosystem services is critical for creating a sustainable and desirable future. Placing credible values on the full suite of ecosystem services is key to improving their sustainable management.

[26] E. F. Granek et al., *Ecosystem services as a common language for coastal ecosystem-based management,* "Conservation Biology" 2010 No. 24, p. 207-216.

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VALUATING ECOSYSTEM SERVICES

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WYCENA USŁUG EKOSYSTEMOWYCH

STRESZCZENIE: W artykule dokonano przeglądu piśmiennictwa ekonomicznego w dziedzinie wyceny usług ekosystemowych. Jako punkt wyjścia służy znany artykuł z 1997 roku autorstwa Costanzy i współpracowników, który zapoczątkował szeroką dyskusję na ten temat. Następnie zarysowano w skrócie zakres ekonomii. Szczególną uwagę zwrócono na pomiar dobrobytu. Tak zwane zazielenienie PKB stanowi dobry przykład uwzględnienia wkładu usług ekosystemowych w tworzenie wartości ekonomicznych. Ze względu na to, że wiele spośród tych usług nie pojawia się na rynku, problem ich wyceny jest trudny. W artykule sporo miejsca poświęcono więc sposobom szacowania wartości ekonomicznej bez wykorzystania rynku. Na zakończenie przedstawiono doświadczenia zdobyte w praktyce sporządzania wycen potrzebnych właścicielom zasobów przyrodniczych, którzy chcieliby zrobić z nich jak najcenniejszy użytek.

SŁOWA KLUCZOWE: wycena ekonomiczna, zielony PKB, usługi ekosystemowe

Costanza's project

In a well-known paper published in *Nature* and reprinted in *Ecological Economics* a year later, the value of world's nature was tentatively estimated at 33 B UDS/year in 1994 dollars. This number was ridiculed by many commentators. One strain of criticism was to indicate that the number is clearly arbitrary since it is larger than the global GDP. This, however, is not a valid point since GDP measures the value of certain market transactions carried out in a year. It may well be (in fact, it is true) that some (in fact, most) of the services included in Costanza's study never show up in the market and therefore they cannot be included in the GDP.

Nevertheless the assessment is not theoretically correct which was acknowledged by its authors. First of all, not every 'monetization' of a service can be considered its value. For instance the price we pay for an orange, say, 1 EUR/kg is not necessarily the value of the natural product. For some of us the value is higher, but we take advantage of paying a lower price which is the outcome of matching demand with supply. Moreover, the price covers not only the value of the natural product, but also the value of accompanying services to pick it, transport, store etc. Thus even for market services it is not quite easy to attach a number which characterizes the economic value of an element of interest. Moreover, the number sometimes reflects an equilibrium price, but occasionally something else – like e.g. a consumer surplus, that is a difference between the (hypothetical) price and a person's willingness to pay. If sufficient information is available, then it is possible to convert consumer surpluses into prices and vice versa. This information is usually unavailable, and Costanza's team could not take advantage of it.

However, what is of paramount importance, economic analyses capture marginal values, i.e. the values of small changes introduced into systems where 'everything else' remains constant. Thus, if one concludes that the economic value of 1 m^3 of water is a certain number of euros, this does not mean that the total value of water is this number times the amount of water. Consequently the 'value of nature' – whatever is the number resulting from economic analyses – can be treated only metaphorically. In the same vein, GDP does not inform about the value of what we trade in markets; nevertheless its changes inform about directions the economy is moving into.

Language of economics

Services provided by natural systems are routinely assessed from several points of view. They can be seen as inputs into the energy, food and fibre production, they can be considered an important factor of man's economic well-being,

	Ecosystem services (1994 USD ha-1 year-1)																			
Biome	Area (ha x 106)	1 Gas regulation	2 Climate regulation	3 Disturbance regulation	4 Water regulation	5 Water supply	6 Erosion control	7 Soil formation	8 Nutrient cycling	9 Waste treatment	10 Pollination	11 Biological control	12 Habitat/ refugia	13 Food production	14 Raw materials	15 Genetic resources	16 Recreation	17 Cultural	Total value per ha ($ ha-1yr-1)	Total global flow value ($ yr -1 x 109)
Marine	36,302																		577	20,949
Open ocean	33,200	38							118			5		15	0			76	252	8,381
Coastal	3,102			88					3,677			38	8	93	4		82	62	4,052	12,568
Estuaries	180			567					21,100			78	131	521	25		381	29	22,832	4,110
Seagrass/ algae beds	200								19,002						2				19,004	3,801
Coral reefs	62			2,750						58		5	7	220	27		3,008	1	6,075	375
Shell	2,660								1,431			39		68	2			70	1,610	4,283
Terrestrial	16,323																		804	12,319
Forest	4,855		141	2	2	3	96	10	361	87		2		43	138	16	66	2	969	4,706
Tropical	1,900		223	5	6	8	245	10	922	87				32	315	41	112	2	2,007	3,813
Temperate/boreal	2,955		88		0			10		87		4		50	25		36	2	302	894
Grass/rangelands	3,896	7	0		3		29	1		87	25	23		67		0	2		232	906
Wetlands	330	133		4,539	15	3,800		?		4,777			304	256	106		574	881	14,785	4,879
Tidal marsh/mangroves	165			1,839						6,696			169	456	162		658		9,990	1,648
Swamps/ floodplains	165	265		7,240	30	7,600				1,659			439	47	49		491	1,761	19,580	3,231
Lakes/rivers	200				5,445	2,117				665				41			230		8,498	1,700
Desert	1,925																			
Tundra	743																			
Ice/rock	1,640																			
Cropland	1,400										14	24		54					92	128
Urban	332																			
Total	51,625	1,341	684	1,779	1,115	1,692	576	53	17,075	2,277	117	417	124	1,386	721	79	815	3,015		33,268

and they can also be regarded as phenomena whose value reflects the grandeur of the universe rather than anything linked to human activities. A particular point of view adopted thus implies particular types of values. To ecosystem services, people can attach material, sentimental, religious or other values. Of course, the economic ones are important, but they do not necessarily exhaust what people may have in mind when they care for such services.

Economic values are particularly useful, since they are independent from a specific worldview or a specific set of beliefs. According to a current definition of economics, this is a study of how people make choices when their resources are too scarce to satisfy all the needs[1]. Scarcity and alternative uses are the focal points of economic inquiry. If there were no scarcity, there would have been no economics.

Let us see how the overwhelming scarcity determines our decisions. Time is an example of a scarce resource that all of us have to allocate between alternative uses. Assuming that a person likes both popular and classical music, if one listens to a pop music, one cannot take advantage of a classical recital and vice versa. Hence the necessity to choose. If a hectare of land is devoted to rye cultivation, it cannot be forested. If I spend all my spare money on food, I cannot afford buying a book. And so on, and so forth.

Scarcity affects every society and every man. Even a rich person in a rich country cannot meet the expense of satisfying all the needs that come to his or her mind (although some of these needs may be considered frivolous by somebody else). Thus scarcity forces us to make choices. Poor people make choices as well. Perhaps some of us may think that poor persons, who can hardly make the ends meet, do not really choose anything since they are in fact compelled to get what they need in order to survive. But this is not true. Even the poorest person is free to choose, although the space of his or her choice is indeed constrained severely.

While making choices people trade off one good or service for another one. Somebody may be willing to forego an opportunity to see a theatrical performance in exchange for two kilograms of tomatoes. Somebody else prefers to give up some of her leisure and to work an extra hour in order to earn money to be spent on a charity. A boy may prefer buying a watch over buying a jack-knife as his budget does not allow to have them both.

Trade offs revealed in voluntary decisions inform about the weight people attach to what they prefer and what they do not. For instance, it may turn out that – when given a choice – they are willing to exchange one kilogram of pears for two kilograms of apples; or to swap a one-week holiday at an attractive location for a two-week holiday at a less spectacular place; or they pay money equivalent to a one-day salary for a seat at a rock-concert. In each of the examples above, one can claim that people's choices revealed relative values they attach to certain goods or services. Two kilograms of apples are worth one kilogram of pears; an attractive holiday is worth twice as much as the less attractive alternative; and

[1] L. C. Robbins, *An Essay on Nature and Significance of Economics*, Macmillan, London 1932.

a seat at the rock concert is worth the daily salary. If the choices are repeated many times, typical ratios may emerge.

Experience shows that people tend to be quite coherent in their choices (at least when circumstances do not change), so that a consistent system of ratios emerges. For example, if a typical ratio of pears to apples is two, and if a typical ratio of walnuts to pears is three, then one may expect that if the walnuts are to be swapped for apples, the ratio will be six. It is practical to select one specific good or service as the common reference for these ratios. In some societies this was one ounce of gold, but it can well be a monthly salary of a worker, a litre of petrol, a hectare of an average productive land, or anything else, as long as its characteristics are measurable and well understood. This common reference is called money and values are typically quantified in monetary terms.

It should be stressed that monetary valuation reflects choices of ordinary people, not necessarily of those who are good and clever. This is the key element of economic valuation that is often misunderstood by e.g. environmentalists, or academics. Environmentalists, for instance, expect that the value of a rare species will be high – higher than an average person is willing to pay in order to save it. They argue that the species is important and it will be lost for ever if extinction comes. Likewise, some people may say that an idiotic computer game is absolutely worthless; and yet there are people who are willing to pay for it some money. While it should be acknowledged that education or upbringing may influence the values people attach to goods and services, economics is about actual people's behaviour. If one wishes to change values, one needs to approach educators or politicians rather than economists.

Eighteen and nineteen century economists fought fierce battles over where economic values come from. The number of candidates was, however, small. There were two important hypotheses. According to Francis Quesnay[2], the land (or – in contemporary language – the environment) was the ultimate source of values. Karl Marx[3] was perhaps the best known economist who claimed that the value is determined by the amount of labour necessary to produce a good or a service. Twentieth century economists largely lost interest in such philosophical disputes. Instead, they adopt a view that the values are determined not in the process of production, but in the process of consumption. The values – reflecting choices people make – indicate how a given good or service satisfies human needs directly or indirectly. In the case of consumer goods, the relationship is straightforward. In the case of goods used to produce consumer goods, their values are derived from the latter (using so-called imputation or *Zurechnung* technique developed by Eugene von Böhm-Bawerk[4]). In the case of goods used

[2] F. Quesnay, *Tableau économique,* 1759 (3d ed. reprint. Edited by M. Kuczynski and R. Meek, Macmillan, London 1972).

[3] K. Marx, *Das Kapital. Kritique von Politischen Oekonomie. Erster Band*, Verlag von Otto Meissner, Hamburg 1867, (English on-line translation: http://www.marxists.org/archive/marx/works/1867-c1/index.htm) [Date of entry: 17-07-2009].

[4] E. Böhm-Bawerk, von 1884-89, *Kapital und Kapitalszins*, Innsbruck (Vol. 1-2).

to produce the former ones, economists iterate the same procedure. Ultimately the number of iterations can be high, but the basic principle remains the same: the value reflects the usefulness of a good rather than the amount of effort applied in the course of its production.

Economic valuation – like the contemporary economics itself – is thus anthropocentric. Nevertheless it does not have to be materialistic. Human needs do not confine to food and shelter. Men care not only for the material consumption, but for other things as well. They may derive satisfaction from music, from seeing an animal or sometimes from the mere existence of a species. All their preferences are studied by economics, and the values their choices imply are calculated. Thus economists are ready to calculate the values of goods and services as far from anything material as a song sang by a bird. This does not mean that such values are easy to measure or that they are not controversial, but they are definitely within the domain of economics.

"Greening" the GDP

As mentioned before, GDP measures the value of certain market transactions carried out over a year. Critics say that it counts what does not count, and does not count what counts. Indeed, if there is an environmental improvement such as a more effective enforcement of forest protection, our welfare increases. At the same time, GDP is likely to decrease as a result of less intensive logging. On the contrary, an oil spill decreases welfare. Despite that, it is likely that GDP will go up as a result of increased rescue activities.

Disappointment with GDP has led to the emergence of alternative welfare indicators such as *Human Development Index*, HDI. These do reflect environmental changes, but – unlike GDP – they are entirely arbitrary in picking or ignoring their potential elements and choosing their relative weights. A more promising strategy seems to be that of greening and 'netting' GDP in order to take the environment into account and to subtract replacement values, i.e. expenditures aimed at merely substituting what was consumed or worn out.

A greened and 'netted' GDP is defined as:

Consumption of marketed goods
\+ Public expenditures
– Flow of environmental damages
\+ The value of the net change of real capital
\+ The value of the net change of human capital
\+ The value of the net increase in the environmental resource base (– if the net change is negative).

This definition reflects the assertion adopted by many contemporary economists that the capital, i.e. our base for production, consists of three parts called, respectively: real capital, human capital, and natural capital. The last one does not show in markets and for that reason its value is difficult to assess.

Types of economic values

In modern economics, the *Total Economic Value* (TEV) consists of several elements, some of which may relate to less tangible non-material characteristics that are nevertheless measurable[5]. In broad terms, TEV consists of *Use Value* (UV) and *Non-Use Value* (NUV), the latter being sometimes referred to as „Passive Use Value". *Use Values* are divided into *Direct Use Values* (DUV) and *Indirect Use Values* (IUV). An example of DUV is the value derived from swimming in a lake, while an example of IUV is provided by stabilizing a local water table as a result of protecting the lake. Often DUV is linked to the physical consumption of a good, but – like swimming in a lake – it is not a prerequisite. John Krutilla[6] observed that what people are willing to pay for a good or a service may not be exhausted by UV in any sense. Thus he introduced the concept of NUV as a measure of the residual. The NUV is often divided into *Existence Value* (EV) and *Bequest Value* (BV). The former is linked to what people may attach to the mere existence of a good, while the latter represents the value from handing over the good to next generations.

The formula TEV = UV + NUV = DUV + IUV + EV + BV is not universally accepted. Some economists argue that there are yet additional elements not captured in the list above. An example of such a concept is a *vicarious value* that people attach to goods or services which are meaningless for themselves but may meet some needs of somebody else. For instance, someone may be willing to pay for the protection of a species that is used or appreciated by somebody else. However, other economists argue that vicarious values are already included in NUV, and a new category is unnecessary.

Another example is *Option Value* (OV)[7]. Burton Weisbrod defined it as a value that people attach to something in order to keep future options open. For instance, a future discovery can make a species valuable as a source of a pharmaceutical, even though such benefits are not known today. Consequently the general formula reads TEV = UV+NUV+OV. However, some critics argue that OV does not exist, since its components are included either in UV or NUV, if future (uncertain) benefits are properly accounted for.

Even though the labour theory of value does not belong to modern economics, there are a number of similar approaches that are used in applications. Two of them are particularly popular. These are the energy and land theories of value. The former is based on the assumption that exchange ratios tend to reflect the

[5] D. Dziegielewska, T. Tietenberg, S. Niggol, *Total economic value,* "Encyclopedia of Earth", C. J. Cleveland, Washington D.C. Environmental Information Coalition, National Council for Science and the Environment 2007, http://www.eoearth.org/article/Total_economic_value [Date of entry: 17-07-2009].

[6] J. V. Krutilla, *Conservation Reconsidered*, "The American Economic Review" 1967 Vol. 57, No. 4, p. 777-786.

[7] B. A. Weisbrod, *Collective Consumption Services of Individual Consumption Goods*, "Quarterly Journal of Economics" 1964 Vol. 77, p. 71-77.

amount of energy used – directly and indirectly – to produce a good. The latter posits that the ratios should depend on the amount of land used – directly and indirectly – to produce a good. Values calculated according to the former are denominated in calories or joules, while the values calculated according to the latter are denominated in hectares. Actual choices involve monetary valuations which means that everything should be converted into money. Nevertheless some analysts claim that there are goods which do not allow for monetary valuations.

Statistical life is an example of a good that is thought of by many as impossible to put a price tag on. This, however, depends on how the good is defined. First of all, statistical life has nothing to do the life of a concrete person; for many people this is simply sacred and priceless, and economists do not pretend that they can contribute to a debate on human life. Even though sometimes the life can be exchanged for money (for instance, a murderer kills somebody for a small amount of money, or somebody else rescues a relative from death by paying a large bounty), economists explain that these are not routine transactions reflecting people's preferences. Instead, economists analyze how people choose when they have an opportunity to change (either increase or decrease) a small probability of death. Based on such choices, it is possible to infer about their preferences with respect to saving lives in large populations, reflected in the so-called *Value of Statistical Life* (VSL), which is a finite number. It is then an easy exercise to calculate the so-called *Value of Life Year* (VOLY) gained or lost, for example, as a result of a policy programme.

Nevertheless some analysts insist that even a statistical life cannot be priced. But they admit that a person whose life is saved may not be in perfect health. Hence the concept of *Quality Adjusted Life Years* (QALY) which captures the fact that a life year gained may be perceived as less valuable if the person affected enjoys imperfect health. Advocates of the QALY concept argue that everything that affects humans – be it air pollution, noise, landscape, recreation opportunities etc. – ultimately translates into QALY.

A similar approach can be taken with respect to non-human life. The equivalent of a „person-year" is a „hectare-year". Additionally, if a hectare enjoys natural biological diversity, it is calculated as a full hectare. If, on the contrary, the field is affected by impaired diversity, it is calculated as a fraction of the actual area. Hence the concept of *Biodiversity Adjusted Hectare Years* (BAHY). Its advocates argue that everything that affects non-humans – be it air pollution, noise, climate etc. – ultimately translates into BAHY[8].

Nevertheless, if there is a trade-off between QALY and BAHY, and obviously some programmes are oriented towards human well-being rather than nature, then the question remains how to translate QALYs into BAHYs and *vice versa*. Therefore money equivalents of everything are called for, despite efforts to free environmental improvements from economic values. It is improper to simply multiply physical units – e.g. QALY or BAHY – by fixed „prices" attached to

[8] B. P. Weidema, *Using the budget constraint to monetarise impact assessment results*, "Ecological Economics" 2008 Vol. 68, p. 1591-1598.

these units. Analysts should always strive to understand the trade-offs people actually make when they take decisions.

The approach making a strict difference between humans and nature (not to be valued in money terms), and non-living resources (that can be valued in money terms without much hesitation) is questionable also on theoretical grounds. Changes that affect non-living resources – leading e.g. to cheaper computers – may ultimately save people's lives and hence contribute to QALYs. Attempts to free value assessments from money considerations can never be successful. Economics is about how people make choices which – by their very nature – are complex and multifaceted.

Economic values are thus very diverse and they call for appropriate measurement techniques. In their attempts to capture values implied by people's choices, economists must understand what specific needs are served by what they analyze.

Valuation techniques

Economic values exist whenever people make choices, irrespective of whether they buy and sell in competitive markets. Therefore economic values existed in feudal and in centrally planned economies. In a market economy they are simply more visible and easier to capture, but even there they are not always effortlessly available to a researcher.

Economists distinguish between private and public goods. The former can be easily bought and sold in markets. The latter comply with two principles: non-exclusion and non-rivalry. The first means that if a good is provided, it is impossible to exclude anybody from using it. The second means that if a unit of a good is used by somebody, the same unit can be used by somebody else without adversely affecting the original user. A lighthouse and an air defence system are textbook examples of public goods, but there are more interesting examples studied in environmental management.

Environmental quality is an example of public good. If it is low then everybody is adversely affected, and the gravity of individual damages does not depend on the number of victims. If – on the contrary – one makes an investment to improve it, then everybody will benefit and the level of individual gains will not depend on the number beneficiaries. Also biodiversity possesses characteristics of a public good. Its benefits can be enjoyed by everybody and – at least within certain limits – an additional user does not affect adversely previous ones.

Private goods can be exchanged in markets and their values can be derived from their prices. Public goods are a different story. Market behaviour is distorted as a result of the non-exclusion principle. People understand that if a public good is provided, then nobody can be excluded from using it. Therefore some take advantage of this fact by being 'free-riders', i.e. they use the good while pretending that they do not care for it and consequently they do not finance its

provision. Economists demonstrate that the market supply of a public good is lower than justified by social preferences. An alternative is to supply it through a political process (outside the market), but this requires that public authorities are able to measure how much of the good is demanded by the society. Putting it in economics language, they should know how much are people willing to pay jointly in order to have the good provided.

Until the 1940s there were no methods to valuate public goods. For instance, people felt that a unique landscape might have a value, but thought that this was beyond economics. Harold Hotelling[9] was the first economist to suggest that the value of a scenic site visited by tourists (a public good) can be derived from the cost they incur in order to get to the place (travel is a private good). Robert Davis[10] was the first to demonstrate that if the good is not private (and hence it does not have a market price), its value could be determined by simply asking people how much they are willing to pay in order to use it. These two ideas started a whole new domain of economics devoted to the valuation of non-market goods.

Economic values can be best reflected in competitive market prices. If the market is a non-competitive one, then prices are distorted by strategic behaviour of its agents, and consequently they do not necessarily inform about people's preferences well. However, if there is no market – as in the case of public goods – there are no market prices to rely on at all. Typical environmental goods and services belong in this category.

There are two valuation techniques developed for non-market goods: indirect and direct ones. The former derive economic values from so-called surrogate markets where people buy and sell goods that are complementary to the one in question. The latter refer to a hypothetical market where the good in question could be bought and sold; economists ask people directly how much they would be willing to pay (WTP) for what they do not have, or how much they would be willing to accept (WTA) for being dispossessed of what they have. Of course, both types of questions are hypothetical and there is no guarantee that answers truthfully reveal people's preferences. Nevertheless there were great efforts undertaken (especially over the last two decades) to make the direct methods credible.

Indirect valuation techniques are considered by economists more reliable, since they are based on actually revealed preferences. The prime example of this approach is the Travel Cost Method (TCM) first suggested by Harold Hotelling. The idea is very simple. The more people visit the place, the more valuable it is. Also when they travel longer distances or pay higher costs, the goal of their journey must be more valuable. The idea is quite simple, yet its implementation is not. The same records of visitations can be interpreted in several ways. Even the cost incurred by an individual visitor is problematic. There are no definitive

[9] H. Hotelling, *An Economic Study of the Monetary Valuation of Recreation in the National Parks*, Washington, DC: U.S. Department of the Interior, National Park Service and Recreational Planning Division 1949.

[10] R. K. Davis, *The Value of Outdoor Recreation: An Economic Study of the Maine Woods*, Ph.D. dissertation, Harvard University, Cambridge, USA, 1963.

solutions to how to account for the travel time. Many economists argue that the time spent in travel has its value reflected by earnings lost. But as it is difficult to practically assess these earnings, some researchers simply do not include them in the travel cost. Another unsolved issue is how to allocate the cost of multipurpose trips. Some analysts exclude such trips while others try to allocate the cost according to the weight attached to any of the purposes as declared by visitors themselves. Of course, either way is questionable.

If the costs of individual travels are somehow determined, then it is by far not obvious what conclusions can be drawn from these observations. Economic theory implies that the value people attach to the visit should not be lower than the travel cost. But for some visitors it can be higher. Moreover, the analysis typically captures only a fraction of those who are actually visiting the place. There are very sophisticated econometric techniques to reveal demand functions based on the observed distribution of travel costs. Unfortunately the results are sensitive to assumptions regarding theoretical distributions these observed ones are sampled from.

Despite theoretical problems, TCM proved to be a powerful instrument of environmental protection. Valuable places are sometimes subject to a pressure to destroy them in order to provide some economic benefits. For instance, a canyon can be destroyed by constructing a water retention reservoir to produce hydroelectricity. The benefit from destruction is the net value (i.e. after subtracting production costs) of 'clean' electricity. The alternative use of the canyon is tourist recreation. If TCM demonstrates that this alternative is more valuable than the electricity, then the dam does not make economic sense. Similarly, a wetland can be destroyed by draining it in order to enhance agricultural production. If TCM demonstrates that the wetland provides sufficiently high tourist recreation benefits then its drainage loses its economic justification.

Another example of indirect approach is provided by so-called Hedonic Price Method (HPM). Let us look at the case of silence. This is a typical non-market public good. It can be neither bought nor sold. However, there is a complementary private good, namely real estate. If there are two identical houses, one of which is located in a silent place while the other one in a noisy neighbourhood, it can be expected that the former will get a higher price. If everything else is the same, then the price difference can be attributed to the silence. In other words, the difference indicates how much are people willing to pay for silence. Of course, it would be unrealistic to find two almost identical estates so that the price difference can be attributed to a single cause. In practical applications, researchers analyze a large number of transactions and look for correlations of prices with many attributes that may possibly affect the price. Based on econometric modelling, they can determine to what extent a specific cause – like, for instance, silence – changes the price. The number found can then be interpreted as the value of the attribute that *per se* was not a market good.

There are also other techniques aimed at analyzing people's revealed preferences in order to estimate values of non-market goods. The one that can also be used to estimate e.g. the value of silence is Avertive Behaviour Method (ABM).

Again the intuitive justification is quite straightforward. People are willing to pay for noise-proof windows more than what they pay for 'normal' ones. Therefore the difference can be attributed to how much they value silence. Like before, practical inference is based not on a single comparison, but rather on a large data set where prices of windows are correlated with many attributes, one of which is a window's ability to reduce the noise.

If a surrogate market cannot be easily identified, the value of a non-market good has to be assessed directly, by asking people about their WTP or WTA in a hypothetical market. The first technique developed for this purpose is so-called Contingent Valuation Method (CVM). It owes its name to the fact that a respondent is presented with a hypothetical scenario of the provision of the good in question, and his or her answers are made contingent upon acceptance of this scenario. There are two basic formats of CVM. The WTP/WTA question can be open-ended, OE (e.g. *How much are you willing to pay for ...?*), and respondent are expected to quote a number. Alternatively, respondents can be presented with a number and asked if they were WTP/WTA for the scenario shown. They are supposed to answer *yes* or *no*.

This format is called dichotomous choice (DC), since the choice respondents have – like in a referendum – is a dichotomous one.

Economists debate which of the two formats – OE or DC – is better. In most applications the DC is preferred since it is common for people to look at a price and then to decide (*yes* or *no*) about the transaction. Some analysts apply so-called double-bounded dichotomous choice. It starts with a DC question and then, based on the answer received, it either doubles the bid (if the answer was *yes*) or halves it (if the answer was *no*). The second DC question is followed by the final OE question. Theoretically the series of three answers gives a more accurate description of respondents' preferences. In reality, however, people tend to see the first bid as a 'reference', and their answers to the final OE question are highly correlated with it. In economists' jargon, the first bid 'anchors' respondents' thinking about the problem, so that the seemingly increased accuracy of estimates is disputable.

Initially the development o CVM was rather slow. A radical change was triggered by a massive oil-spill near the coast of Alaska in 1989 (the *Exxon-Valdez* disaster). The catastrophe was unprecedented both in terms of the amount of oil leaked and in terms of damages to the natural environment. All the same, there were apparently no economic losses, since nobody suffered and no property was destroyed (the area was not inhabited). Nevertheless the government of Alaska sued Exxon for 3 billion dollars for damages that American citizens suffered as a result of the catastrophe. The amount of money was determined in a CVM survey where respondents were asked about their WTP for avoiding such a disaster in the future.

Exxon, the world's largest corporation at that time, did not want to pay such a fine and tried to ridicule the CVM as a non-reliable technique. To this end they commissioned three CVM surveys about people's WTP for saving ducks migrating from Alaska to Latin America. In one survey they asked about WTP for

saving 10,000 ducks and the average answer was roughly UDS 20. In the second survey they asked about 100,000 ducks and the average answer was USD 20 again. In the third one they asked about 1,000,000 ducks and the answer was more or less the same. Hence the conclusion was that the method yielded inconsistent results, as the average value of a duck saved was like 100:1, depending on how they phrased the question.

Experts noted, however, that the question was misleading, since a typical respondent thought of saving the seasonal migration process rather than a specific number of birds. Thus the answers were consistent, but it was unjustified to relate them to specific numbers quoted. The Exxon exercise showed that CVM can be abused, but it did not prove that it was not credible. The war over the *Exxon-Valdez* case resulted in establishing by the US President a special panel – co-chaired by two Nobel laureates, Kenneth Arrow and Robert Solow – to determine if the CVM is reliable as a technique of estimating values of non-market goods.

The Arrow-Solow Panel concluded that, if properly designed, the CVM is reliable and it can be used to assess environmental values. The findings of the Panel[11] were published in the *Federal Register* and they have been binding for the American justice system. The Panel developed a protocol that a good CVM survey should follow in order to prevent inconsistent results like in the Exxon study. The protocol is now commonly referred to by researchers whenever they apply CVM. The Panel also indicated WTP rather than WTA, and DC rather than OE as preferred formats of surveys.

The 1993 marked the launch of a new era in the development of CVM. The number of applications became large, and every year economists improve the method by solving problems encountered in earlier cases.

The success of CVM has not stopped the search for alternative methods of soliciting people's preferences for non-market goods. The technique which is now becoming more and more popular is called Choice Experiment (CE). It differs from CVM in that it is not confined to a single WTP/WTA question. Like in CVM, respondents are presented with a scenario of the possible provision of a public good to be evaluated. The good is characterized by several attributes and each of the attributes can be measured at several levels. For instance, there was a CE study carried out in Poland[12] aimed at estimating people's WTP for enhanced biodiversity protection in the Bialowieza Primeval Forest (at the border of Poland and Belarus). Biodiversity was characterized by three attributes such as: (1) natural ecological processes, (2) rare species, and (3) ecosystem components. Each of the attributes was contemplated at three possible levels: (a) *status quo*, i.e. no improvement, (b) partial improvement, and (c) significant improve-

[11] K. J. Arrow et al., *Report of the NOAA Panel on Contingent Valuation*, "Federal Register" 1993 Vol. 58 No. 10, p. 4601-4614.

[12] M. Czajkowski, M. Buszko-Briggs, *Valuing changes in forest biodiversity. The application of a CE approach to Białowieża forest in Poland*, paper presented at the Annual Conference of the *European Association of Environmental and Resource Economists*, Gothenburg 2008, http://www.webmeets.com/files/papers/EAERE/2008/449/Valuing%20Changes%20in%20Forest%20Biodiversity%20-%20blind.pdf [Date of entry: 17-07-2012]

ment. All types of improvements were carefully explained and quantified. The fourth attribute that was presented to respondents was a financial contribution, defined as a tax to be paid for 10 years (also in several variants, including no tax at all – linked to the *status quo* variants). Every respondent was given several options to choose from (hence the name 'choice experiment'). His or her choices were then analyzed in order to determine what was the (implicit) WTP for a specific change in biodiversity. The advantage of CE is that each respondent gives many statistical observations instead of a single one, as in the classical CVM. Consequently, CE surveys lead to better statistical estimates at a fraction of the cost required by CVM ones.

Valuation results

The second half of the 20th century, and especially its last decade brought an eruption of valuation studies relevant for environmental protection and management. Perhaps the best known example is the exercise compiled by Robert Costanza. The numbers aggregated for given ecosystems multiplied by their areas gave the total value of the world's ecosystem services.

As indicated before, there are important reasons to question the correctness of this valuation. First, the studies used by the team could be simply inaccurate. In fact, it would be very strange if all of the studies were error-free. Second, it is likely that the values calculated were not always comparable. The authors admitted that some of them were gross and some were net, even though all of them should have been net ones (the difference between gross and net values is the cost of provision which should be subtracted, if the result is to be comparable with GDP). Third, the numbers were coarse aggregates. For instance, there was only one number used to characterize the value of pollination provided by grasslands, even though there are of course many types of grasslands, and the value of pollination services depends on many aspects that cannot be accounted for in this approach. Finally, most of the entries in the matrix were based on single studies, and it is unlikely that these studies were fully representative for all ecosystems and all services they stood for.

Despite these limitations, the survey of Costanza et al.[13] serves as a useful reference. It would be inappropriate to pick rates from the Costanza matrix and multiply them by the number of hectares in order to establish the value of a given site. However, it is fair to argue that – irrespective of what may possibly come out from specific site surveys – the per hectare value of ecosystem services provided by a wetland is likely to be an order of magnitude higher than the respective value of a forest (the matrix implies the ratio of 49). Looking at the matrix gives a rough approximation of what can be expected from a site-specific survey.

[13] R. Costanza et al., *The value of the world's ecosystem services and natural capital,* "Nature" 1997 No. 387, p. 253-260.

All techniques mentioned in section 5 were tested in Poland. Their review covering the period of 1994-1999 is included in Zylicz[14]. In particular, the book explains how CVM surveys were prepared and carried out according to the Arrow-Solow Panel guidelines. There were several CVM studies performed. WTP for reduced eutrophication of Baltic Sea was the focus of a number of these. Both DC and OE questions, and two main types of interviews – face-to-face and mail – were tested. It should also be noted that for the first time the same survey scenario was implemented in three countries. The same study was simultaneously executed in Lithuania, Poland and Sweden. The results were then used to analyze prospects for establishing a Baltic-wide cooperation programme aimed at cleaning-up the sea[15]. Apart from the Baltic studies, there were CVM surveys of WTP for improved protection of the Biebrza wetland in north-eastern Poland. Indirect valuation techniques were represented in the book by TCM applied in order to estimate the value of clean water that many people in Warsaw acquired from public Oligocene wells (the tap water was of a much lower quality, but it did not require travelling).

After 1999, there were several CVM surveys done. Other methods were tested too. CVM was used in a couple of new applications. Most notably it was used to study people's WTP for time savings[16], reduced health risks from air pollution[17], improved quality of surface water[18], improved medical care[19], as well as for reduced work accident risk[20]. An international study aimed at lake recreation was carried out in Poland, Czech Republic and Norway[21].

An HPM study of housing prices in Warsaw[22] revealed interesting characteristics of real estate market in Poland. For instance, it demonstrated that people are WTP more for less noisy locations (no surprise). At the same time, they are

[14] T. Zylicz, *Costing Nature in a Transition Economy. Case Studies in Poland*, Edward Elgar, Chelthenham 2000.

[15] A. Markowska, T. Zylicz, *Costing an international public good: The case of the Baltic Sea*, "Ecological Economics" 1999 Vol. 30, p. 301-316.

[16] A. Bartczak, *Wartosc czasu podrozy*, "Ekonomia" 2002 No. 7, p. 100-121 [en. The value of travel time].

[17] D. A. Dziegielewska, *Essays on Contingent Valuation and Air Improvement in Poland*, Ph.D. dissertation, Yale University, New Haven 2003.

[18] A. Markowska, *Koszty i korzysci wdrozenia w Polsce Dyrektywy 91/271/EWG w Sprawie Oczyszczania Sciekow Komunalnych*, Ph.D. dissertation, University of Warsaw 2004 [en. Costs and benefits of implementing in Poland the Council Directive 91/271/EEC concerning urban waste-water treatment].

[19] O. Markiewicz, *Analiza oplacalnosci programow ochrony zdrowia na podstawie wyceny statystycznego zycia i wyceny dodatkowego roku przezycia w Polsce*, Ph.D. dissertation, University of Warsaw 2008 [en. Efficiency of health protection programmes in Poland based on the Value of a Statistical Life, and the Value of a Life Year].

[20] M. Giergiczny, *Value of a Statistical Life – the Case of Poland*, "Environmental and Resource Economics" 2008 Vol. 41 No. 2, p. 209-221.

[21] M. Czajkowski et al., *Lake Water Quality Valuation-Benefit Transfer Approach vs. Empirical Evidence* „Ekonomia" 2007 No. 19, p. 156-193.

[22] M. Borkowska, M. Rozwadowska, J. Sleszynski, T. Zylicz, *Environmental Amenities on the Housing Market in Warsaw. Hedonic Price Method Research*, "Ekonomia" 2001 No. 3, p. 70-82.

WTP more for green neighbourhood unless the apartment is in a detached house; in the latter case the neighbourhood of a public park adversely affects the price. Another HPM was carried out in order to check if real estate prices were positively affected by a water retention reservoir on the lower Vistula river; they were not[23]. A variant of HPM – a so-called hedonic wage method (where wage differentials are linked to working conditions) – was performed in order to estimate people's WTP for reduced accident risk[24]. Yielding more consistent results, the study turned out to be much more credible than a simultaneous CVM survey. This confirms economists' conviction that whenever possible, indirect methods based on revealed preferences are preferred to direct methods based on stated preferences.

The recreation value of Polish forests was estimated three times using TCM and other methods. Two of these studies were focused on the Bialowieza Primeval Forest[25]. One covered ten different sites representative for Polish public forests[26]. Contrary to earlier hypotheses[27], they revealed that people's WTP for forest recreation is higher than in Western Europe, and – moreover – it is remarkably higher for the Bialowieza Primeval Forest.

The most recent studies apply the CE technique. As an alternative to CVM, it was used in Markiewicz's and Giergiczny's studies on the VOSL. As well, it was used by Czajkowski and Buszko-Briggs in order to decompose people's WTP for improved protection of the Bialowieza Primeval Forest. The latter research allowed for two important conclusions. First, people in Poland place quite a value on natural ecological processes; contrary to prior expectations, they are WTP more for these than for protecting rare and charismatic species. Second, people in Poland indicate their preference for protection measures carried out within the framework of a national park; protection scenarios that differ only in whether they are undertaken by the park imply different values with a clear preference for activities bearing the stamp of a national park.

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[23] A. Jacewicz, J. Zelazinski, T. Zylicz 2002*, Prawdy i mity o stopniu i zbiorniku wodnym we Wloclawku*, „Gospodarka Wodna" 2002 No. 8, p. 326-329 [en. Truths and myths about the Wloclawek dam].

[24] M. Giergiczny, *Value of a Statistical Life – the Case of Poland*, "Environmental and Resource Economics" 2008 Vol. 41, No. 2, p. 209-221.

[25] M. Buszko-Briggs, M. Giergiczny, J. Ziezio, T. Zylicz, *Wartość ekonomiczna Puszczy Bialowieskiej*, WWF-Polska, Warszawa 2004 [en. Economic value of the Bialowieza primeval forest]; M. Czajkowski, M. Buszko-Briggs, *Valuing changes in forest biodiversity. The application of a CE approach to Białowieża forest in Poland*, paper presented at the Annual Conference of the *European Association of Environmental and Resource Economists*, Gothenburg 2008 [http://www.webmeets.com/files/papers/EAERE/2008/449/Valuing%20 Changes%20in%20Forest%20 Biodiversity%20-%20blind.pdf [Date of entry: 17-07-2012].

[26] A. Bartczak, H. Lindhjem, S. Navrud, M. Zandersen, T. Zylicz, *Valuing forest recreation on the national level in a transition economy: The case of Poland*, "Forest Policy and Economics" 2008 Vol. 10, No. 7-8, p. 467-472.

[27] UNECE/FAO, *European Forest Sector Outlook Study. 1960 – 2000 – 2020*. Main report, Geneva 2005.

Benefit transfer approach

It is excellent if analysts or policy makers can afford an empirical study carried out at the location of interest. Unfortunately in many cases they do not have time or resources to do it. The idea that comes to one's mind is to extrapolate the results from a site where a study of interest was conducted to the site that needs to be analyzed. This is called „benefit transfer".

There are two major approaches to using values or coefficients that do not originate from a study of a particular site. One is based on breaking a good G into components g_1, g_2, ..., g_n, and tries to attach a value from another assessment exercise to each of these. Formally it can be explained by the following formulae:

$$G = (g_1, g_2, ..., g_n), \text{ and } TEV(G) = TEV(g_1) + TEV(g_2) + ... + TEV(g_n), \quad (1)$$

This has been routinely used in assessing gains from projects that provide multiple benefits in terms of avoided externalities. For instance, if switching from a passenger car to a bus reduces air emissions, noise and road accidents, then the overall gain can be decomposed into corresponding elements, each of which is given a value separately, based on earlier assessments. Of course, the lack of exact equivalence between the original circumstances and the project implies possible errors, but these may be considered minor compared to the effort required by a new study (which – by the way – would also be subject to uncertainty). This is how the ExternE[28] base is utilized by the European Commission for assessing benefits from alternative energy scenarios.

The second approach is based on interpreting the results of a benefit study carried out for one site from the point of view of another site. If, for instance, a good G was evaluated at site *s* (the empirical „study" site), and its value was calculated as $TEV_s(G)$, then the question is how to estimate $TEV_p(G)$, the value of the same good at the site *p* (the „policy" site).

The simplest way would be to assume that $TEV_p(G) = TEV_s(G)$. Nevertheless, for most practical purposes, this is not a satisfactory solution, since there are no convincing arguments that the actual value computed at both sites would have been the same. There are two main reasons why the numbers could be different. One reason is that the people whose preferences are to be taken into account have different incomes in both sites. If we further assume that the value they attach to the good depends on their incomes with constant elasticity of ε (i.e. $TEV_p(G)/TEV_s(G) = (Y_p/Y_s)^\varepsilon$), then

$$TEV_p(G) = TEV_s(G)(Y_p/Y_s)^\varepsilon. \quad (2)$$

This is a benefit transfer statement that is, perhaps, the most frequently used one. The elasticity ε has to be determined using some additional information.

[28] European Commission, *ExternE, Externalities of Energy. Methodology 2005 Update*, Brussels 2005: http://www.externe.info/ [Date of entry: 18-07-2012].

Often analysts assume that the elasticity is linked to a specific type of a good. For instance, a „luxury" good has elasticity higher than one ($\varepsilon>1$), while „necessity" goods are characterized by low elasticities ($\varepsilon<1$). There is no consensus on whether, by default, environmental quality is a luxury good or not. If there is no convincing argument about the level of elasticity, analysts may assume that it is equal to one. Then the formula simply reads $TEV_p(G) = TEV_s(G)(Y_p/Y_s)$.

Another way of extrapolation is to observe that not only people's incomes, but also other characteristics observed at site *s* determine $TEV_s(G)$. Analysts assume that $TEV_s(G) = f(x_s, y_s, ..., z_s)$, where $x_s, y_s, ..., z_s$ are variables observed at *s* such that $TEV_s(G)$ depends on them. The function f is called a benefit function. The result of a benefit transfer exercise is then summarized by the formula $TEV_p(G) = f(x_p, y_p, ..., z_p)$. The formula from the previous paragraph turns out to be a special case of the latter, with Y playing the role of the single relevant variable, and f(Y) defined as $TEV_s(G)\ (Y/Y_s)^{\varepsilon}$.

Some researchers assume that the more parameters estimated in the benefit function f the better. Indeed, increasing the number of explanatory variables in the definition of f increases the estimation fit at the site *s*. This does not necessarily imply that the accuracy of the transfer will be better. On the contrary, the more variables are taken into account at the site *s*, the more likely it is that some of them are specific for the data set at *s*, not necessarily for the site *p*. As a result, the benefit transfer using such a complicated function f may result in a higher error than a simple alternative based on e.g. income differentials.

Research experience, as well as theoretical arguments, suggest that benefit transfer functions f should have firm foundations in economic theory. Parsimony is a useful guide for analysts who would like to transfer conclusions from an empirical study to a site possessing apparently similar characteristics. Income is an example of a variable that economic theory heavily relies on, while neither age nor level of education seem to play the same strong role. Consequently, including income in benefit transfer functions is inevitable. At the same time, using functions that include social and demographic characteristics of stakeholders improves statistical fit to the empirical data sets at the site s, but it may prove very misleading when transferred to the site *p*[29].

Extrapolations based on the Costanza's *et al.*[30] matrix, as well as on the QALY/BAHY concept are examples of a benefit transfer method based on the formula (1). They are eagerly used in many applications, since original research would have been costly. Nevertheless one needs to appreciate that the numbers provided by them have to be regarded as first approximations rather than the

[29] I. Bateman, R. Brouwer, S. Ferrini, M. Schaafsma 2009, *Guidelines for Designing and Implementing Transferable Non-market Valuation Studies*, A Multicountry Study of Open Access Water Quality Improvements paper presented at the 17th Annual Conference of EAERE, Amsterdam 2009 http://www.webmeets.com/files/papers/EAERE/2009/945/090201%20-%20Aquamoney%20CDV%20-%20EAERE%20format%20-%20guidelines%20version%20-%20anon.pdf [Date of entry: 18-07-2012].

[30] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260.

values that justify the selection or rejection of a given project. More accurate conclusions need either an original research or at least a benefit transfer exercise involving the formula (2).

Kuik et al.[31] provide an interesting review of wetland valuation studies. The authors, however, do not attempt a benefit transfer. Instead they perform a „meta-analysis" of the existing empirical studies in order to explain the differences in money values by geographical and social circumstances. The difference between a benefit transfer based on formula (2) and meta-analysis is that the former is based on a single site valuation study while the latter estimates a value function based on several site valuation studies. The corresponding regression model reads:

$$TEV(G_s) = f(x_s, y_s, ..., z_s);\ s = 1,...,k. \quad (3)$$

Hence the function f estimated as a result of such an exercise depends not only on a single site, but rather on an array of sites 1,...,*k*, each of which has a different value but also different characteristics.

A practical application

In 2010 the Director of a National Park in Poland realized that market prices do not reflect the value of ecosystem services provided by the land he administers. A commercial enterprise leased a narrow strip of land (to operate a gas pipeline) paying the rental price of 244 EUR/ha per year. The park director requested that the price be increased in order to reflect ecosystem services compromised as a result of the enterprise activities.

Warsaw Ecological Economics Center was asked to assess the value of ecosystem services such as O_2 production, CO_2 sequestration, water retention, protection against erosion, wind etc, provision of natural habitats, and landscape amenity – not included the 244 EUR/ha price. Neither the time suggested, nor the unusual shape of the land (a very narrow strip) allowed for original field studies. Thus the Warsaw University team decided to browse earlier studies in order to recommend per hectare numbers as proxies for the value of ecosystem services lost.

According to a widespread belief, 'forests produce oxygen'. Hence constraints on forestry activities lead to a decrease in O_2 production. This is not correct. Oxygen is produced by a young ecosystem only. A mature forest consumes as much oxygen as it produces, but an old one – where decay processes dominate over photosynthesis – consumes more than produces. Thus – following

[31] O. Kuik et al., *The Value of Wetland Ecosystem Services in Europe: An Application of GIS and Meta-analysis for Value Transfer*, paper presented at the 17th Annual Conference of EAERE, Amsterdam 2009 http://www.webmeets.com/files/papers/EAERE/2009/448/Value_transfer_and_GIS_EAERE.pdf [Date of entry: 18-07-2012].

e.g. Colinvaux[32] – we concluded that O_2 production should not be taken into account.

Carbon sequestration is a different story. As long as the forest exists, it stores carbon. Assuming that a Polish forest grows at the pace of 3 m^3/ha per annum, i.e. roughly 2 tonnes/ha, one can assume that this corresponds to the amount of carbon dioxide not sequestrated if there is no forest. Taking into account the CO_2 to C ratio of 3.67, 1 hectare of forest captures 7.34 tonnes of carbon dioxide per annum. At the European price of 15 EUR/tonne this corresponds to 110 EUR/ha approximately.

An atypical geometry of the land studied suggests that a per hectare value of water retention is simply copied from the literature. Costanza et al[33]. estimate it at 5 USD(1994)/ha. Taking into account inflation and exchange rates, this corresponds to 9 EUR/ha, and this is what was adopted in our assessment.

Protection against erosion, wind etc calls for separate analyses. Again, because of an atypical geometry of the land, its wind protection role is negligible. However, even a very tiny filed may play a role in soil protection and formation. Costanza et al. estimate it at 96+10 USD(1994)/ha per annum. Like before, taking into account inflation and exchange rates this corresponds to 190 EUR/ha.

The last two types of ecosystem services referred to a number of Polish studies. Removing forest cover implies losing natural habitats. Moreover these are habitats protected under a national park regime which adds to their value, as empirical analyses indicate. Recent Polish studies demonstrate that the 'trademark' of a national park increases the value people attach to a natural habitat[34]. In a separate study[35] the total value of forest habitats was estimated at 570-970 EUR(2005)/ha. This, however, covers two elements of the Total Economic Value of a forested hectare, i.e. natural habitats and recreational (landscape) amenity. It was based on a national survey which includes both frequently visited forests and areas considered less attractive as tourist destinations but of a high natural importance. Taking into account the specific geographical location of the park, we made an arbitrary assumption to understand 50% of the lower bound as a proxy for the first element and 50% of the higher bound as a proxy for the second one. Allowing for inflation, this implies 310 EUR/ha for the former and 528 EUR/ha for the latter.

As before, let us compare these numbers with entries in Costanza et al. The is no equivalent of the 'value of natural habitats' there. A similar scope is cover by two entries: nutrient cycling (361 USD(1994)/ha), and genetic resources (16 USD (1994)/ha), 367 in total. Allowing for inflation and using appropriate exchange

[32] P. A. Colinvaux, *Why big fierce animals are rare: an ecologist's perspective*, Princeton University Press 1979.

[33] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260.

[34] M. Czajkowski, M. Buszko-Briggs, N. Hanley, *Valuing Changes in Forest Biodiversity*, "Ecological Economics" 2009 Vol. 68, p. 2910-2917.

[35] A. Bartczak, H. Lindhjem, S. Navrud, M. Zandersen, T. Zylicz, *Valuing forest recreation on the national level in a transition economy: The case of Poland*, "Forest Policy and Economics" 2008 Vol. 10 No. 7-8, p. 467-472.

rates, this is more than a double of what we estimated. Our much lower estimate results perhaps from the fact that Costanza's number reflects mainly tropical forests whose habitats are much more valuable than those located in boreal ones. In contrast, the number adopted by us for recreational (landscape) amenities is much higher than the mere 38 USD(1994)/ha used by Costanza et al. (1997). Two factors could have caused this difference. Firstly, as demonstrated by Bartczak et al. (2008), the demand for forest recreation in Poland is much higher than in Western Europe and USA where numbers adopted by Costanza's team came from. Secondly, the demand for recreation in our site – a national park – comes from wealthy urban agglomerations which adds to whatever an 'average' level may be.

These analyses can be summarized as follows:

- O_2 produced 0,
- CO_2 sequestrated 110,
- Water retention 9,
- Protection against erosion, wind etc 190,
- Provision of natural habitats 310,
- Landscape amenity 528.

This makes the total of 1147 EUR/ha (per year), i.e. much higher than the price 244 EUR/ha (which reflects 'private' benefits only). A new rental price negotiated between the park director and the enterprise takes into account ecosystem services lost.

Summary

Ecosystem services can be evaluated in economic terms. The fact that they are not included in market transactions makes the exercise more difficult, but not impossible. The number of studies is very high and still increasing. Thus there is a sufficient empirical base for decision and policy makers to take into account the economic value of nature. Owners and guardians of ecosystems seem to be gradually more aware of their assets' values. In Poland there are precedents of taking these into account in practical applications.

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ECOSYSTEM SERVICES AS PART OF THE GROSS DOMESTIC PRODUCT ACCOUNT

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ŚWIADCZENIA EKOSYSTEMÓW W RACHUNKU PRODUKTU KRAJOWEGO BRUTTO

STRESZCZENIE: Celem opracowania jest próba zdefiniowania świadczeń ekosystemów i ich właściwości, wskazanie możliwości oraz warunków uwzględniania ich w wartości produkcji globalnej, w zużyciu pośrednim, w konsumpcji i inwestycjach, jako elementach rachunku PKB. Autorka jest przekonana, że taka integracja kategorii świadczeń ekosystemów i wartości wytworzonych w społeczeństwie w ciągu roku jest niezbędna. Analiza teoretyczna postawionego zadania wskazuje jednak na liczne ograniczenia i brak podstaw takiego rozwiązania, a nawet na podważenie zasadności stawiania takiego celu badawczego. Zarówno rozwijanie postawionej tezy, jak i jej podważenie wymaga dalszych analiz teoretycznych.

SŁOWA KLUCZOWE: ekosystem, usługi (świadczenia) ekosystemu, produkt globalny, zużycie pośrednie, produkt krajowy brutto, spożycie, akumulacja, korzyści ekosystemów

Introduction

Increasing interest in ecosystem services initiates new research fields and applicatory studies. One such issue pertains to the link between ecosystem services (benefits, ecosystem functions)[1] and the GDP account. In this particular case the GDP account constitutes a measure of goods and services generated by the economy in a designated amount of time. The GDP definition emphasizes the fact that the aforementioned measure expresses the value of all goods and services, and since ecosystems also provide service on account of production and consumption therefore they should be treated as a subject of the GDP account. The author of this paper intends to treat ecosystem benefits as a factor that is productive, can be purchased and may be utilized in the processes of production, consumption and investment.

This paper attempts to define ecosystem benefits and their properties and tries to point out the possibility and conditioning of incorporating them in the global production scheme. This pertains to indirect utilization, consumption and investments, which are treated as individual components of the GDP account. The author is convinced that such integration of ecosystem benefit categories as well as values that have been generated during one year within the community is essential. Theoretical analysis of tasks posed indicates numerous constraints, lack of principles of such a solution, and in extreme cases attempt to undermine this particular issue. It should be noted that thesis presented herein and its possible invalidation requires further theoretical analyses. This paper indicates both the scope and topics that are discussed.

Specificity of ecosystem services and the search for economic value

Ecosystem – a random fragment of the environment in which a group of organisms accomplishes production and decomposition processes, in another words the transfer of chemical bonds according to the laws of thermodynamics, albeit in partially enclosed matter cycle and energy flow, with the usage of information, which flows through this system[2]. The subject of economics and the economic account may not be regarded as simply the ecosystem itself, nor its economic value (it does not exist anyway), but as benefits (services) of the ecosystem. A question arises, whether economic value of such benefits does exist? In this aspect there certainly is a tremendous need for usage of such value in

[1] *Scaling up ecosystem benefits – A contriubtionto The Economics of Ecosystemsand Biodiversity (TEEB) study*, Environmental, European Agency, 2010, No. 4, p. 13.

[2] A. Michałowski, *Działalność gospodarcza a procesy przyrodnicze*, Wyższa Szkoła Administracji Publicznej ,Białystok 2009, p. 82.

many social sciences, and not just economics. For example we can mention biology and many disciplines that are related to biology.

Ecosystem benefits (functions, services) can be classified in many ways, but for the purpose of economics it is useful to classify them as follows[3]:

- resource,
- regulatory,
- cultural,
- supportive.

In a different approach we can subdivide ecosystem benefits (functions, services) into[4]:

- resource, production, transformation,
- regulatory and utilization,
- creation of space for human utilization,
- information.

Environmental services are also interpreted as material and intangible benefits (outcomes) achieved by the community from ecosystem metabolism[5]. It should be noted nevertheless, that ecosystem services are not constrained to just benefits; they are treated as natural processes in natural ecosystems. We can distinguish the following processes of ecosystem benefits (functions)[6]:

- conversion of matter,
- conversion of energy,
- transmission of information,
- conversion of space,
- stabilizing role – by maintaining the dynamic equilibrium of ecological condition to transfer matter, energy, information and space they integrate all other ecosystem servicing processes.

Functions that pertain to energy conversion, information and space may be (at least partially) included in the account of indirect costs and global production. This may be incorporated in a situation when the market prices are established at the level of indispensable costs (price of energy i.e. renewable, assessment labor price, prices for utilization of protected areas, climate taxes etc.).

It appears that stabilization services are rarely defined in scientific literature and hence they are by no means measurable in terms of economic standards (they're simply priceless). Stability determines rigidity and resistance of environmental systems in terms of any type of interaction. Stability can be characterized

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[3] The Millenium Ecosystem Assessment, *Ecosystems and Human Well-being: Synthesis*, Island Press, Washington 2005.

[4] E. Kośmicki, *Zrównoważony rozwój w warunkach globalnych zagrożeń i integracji europejskiej*, in: *Zrównoważony rozwój – doświadczenia polskie i europejskie*, ed. S. Czaja, Wydawnictwo I-BiS, Wrocław 2005, p. 227-248.

[5] A. Mizgajski, M. Stępniewska, *Koncepcja świadczeń ekosystemów a wdrażanie zrównoważonego rozwoju*, in: *Ekologiczne problemy zrównoważonego rozwoju*, ed. D. Kiełczowski, B. Dobrzańska, Wydawnictwo Wyższej Szkoły Ekonomicznej, Białystok, 2009, p. 12-16.

[6] A. Michałowski, *Stabilizacyjne usługi środowiska w świetle założeń ekonomii zrównoważonego rozwoju*, "Ekonomia i Środowisko" 2012 No. 1, p. 36.

by many properties but the most important are: equi-finality, permanence, inertia, resistance and flexibility. Equi-finality can be defined as the ability to achieve identical final state in development processes under different starting conditions and by employing quite different means. Stability is considered to be a system invariable in a given time frame. Environmental system maintains stability throughout the years and even millennia, although it is possible that they undergo evolutional and successive change. Inertia may be defined as a phenomenon that is observed after a certain amount of time of durability of external factors which disturb their nature. It constitutes a type of delay which may be elucidated by compensation and stabilization mechanisms. System resistance is associated with the occurrence of threshold values of system ambience parameters, in which case no change exists, or the changes are reversible after the occurrence of disturbances. Finally, flexibility is defined as the rate, level and the means of reflecting system properties after recession of disturbances[7].

Changes of environmental system states should be observed and described by employing the following processes or features: biomass production, number of species, inorganic nitrogen content, CO_2 combustion rate. This may be accomplished by constructing and studying models (theoretical analysis) and through experimental observation. The aforementioned models are greatly simplified and such experiments are very sophisticated. One indirect approach that may be used in the attempt to describe the scale and intensity of stabilization processes is energy usage. Energy initiates all stabilization processes and ensures endurance of macro-system life such as community-economy-environment[8]. Experts recommend to perform an analysis of environment service stabilization processes. This analysis should be carried out in terms of two aspects in particular – observation of geo-chemical cycles that were either forced by live organisms, or through the presence of mechanisms and successive processes. In this particular case we are dealing with a strong coupling of biological, geochemical and climate processes[9].

The usage of energy to measure stabilization processes and other ecosystem functions may be inscribed into the energy value theory, which was consequently derived from the entropy law. According to entropy law in natural processes there is a tendency to pass from lower to higher state of probability of energy, particle and atom distribution. In reference to social-economic development theory (which should be measured via GDP) this constitutes a recognition that survival of civilization is coupled with rational investment in low entropy resource (principally from the inner earth deposits and thermal energy of the sun). Introduction of the ever growing number of pollutants into the natural environment means increase in the entropy of social-economic systems. The negative consequences of this process are constrained by stabilization properties of eco-

[7] Ibidem.
[8] J. Weiner, *Życie i ewolucja biosfery. Podręcznik ekologii ogólnej*, PWE, Warszawa 2005, p. 265-282, quatation: ibidem, p. 38-39.
[9] A. Michałowski, *Stabilizacyjne usługi...,* op. cit., p. 39.

systems, under the condition that the level of pollutants does not exceed their threshold capabilities.

Law of entropy[10] enables to express social-economic processes (i.e. environmental damages) through the energy category, which is subsequently expressed by the primary load of sun energy by converting it to the unit of energy that has been utilized in the ecosystem. Energy allows us to estimate how distant are energy media that are used in many households from solar energy. For example if the energy use is identical, then higher energy means that entropy will increase. The ratio of energy to GDP[11] (so-called mono-energy) manifests the level of savings (wastefulness) in terms of natural resource investment (especially in energy) and expresses the level of energy conversion in reference to original solar energy. In addition it also informs us about actual need for energy including the one that is materialized in case of its import. When we consider traditional research of energy absorbency we can see that it does not overload in any way the GDP. The increase of energy in the national income indicates clear wastefulness of energy economy and at the same time indicates the decrease of social benefits (welfare) on account of utilization of energy resources[12].

The description and assessment of ecosystems, ecosystem benefits, ecosystem services and measurement of their economic value must come from other science disciplines. Economics should identify productive, energy, material and intangible content of ecosystem benefits and should attempt to estimate them both in terms of quantity as well as quality. It should be pointed out herein that one such measure is the GDP account.

Recent concepts pertaining to pricing of ecosystem services and its usefulness in the aspect of GDP

The search for an existing link between ecosystem services and GDP can be achieved by expressing these benefits in economic values. The Total Economic Value (TEV) comprises of the following values (T. Żylicz)[13]:

- Use Value (UV), which is subdivided into Direct Use Value (DUV) and Indirect Use Value (IUV);
- Non Use Value (NUV) which is also referred to as Passive Use Value (PUV).

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[10] T. Żylicz, *Ekonomia wobec problemów środowiska przyrodniczego*, PWN, Warszawa, 1989, p. 63; St. Czaja, B. Fiedor, Z. Jakubczyk, *Ekologiczne uwarunkowania wzrostu gospodarczego w ujęciu współczesnej teorii ekonomii*, Wydawnictwo Ekonomia i Środowisko, Białystok-Kraków, 1993, p. 84-119.

[11] D. Begg, S. Fischer, R. Dornbusch, *Ekonomia*, PWE, Warszawa 1993, p. 36.

[12] J. Famielec, *Straty i korzyści ekologiczne w gospodarce narodowej*, Wydawnictwo Naukowe PWN, Warszawa-Kraków 1999, p. 112-131.

[13] T. Żylicz, *Wycena usług ekosystemów. Przegląd wyników badań światowych*, „Ekonomia i Środowisko 2010, No. 1, p. 31-46.

A good example of Direct Use Value is swimming in a lake, and Indirect Use Value is the stability of the local water table as a result of lake protection. However both of these values cannot be interpreted in a comprehensive way and directly linked to the GDP account. In addition these values do not express the value of ecosystem benefits (functions). If the value of swimming in a lake can be measured by a specific fee to swim in this lake, then even in case when this price is dependent on the lake quality we will still have to deal with other costs (i.e. lake maintenance) which are the result of other economic activity and cannot be taken into account in this particular case.

In the second example – lake protection is considered a cost (investment) to maintain the quality of water ecosystem, but what is important it does not signify benefits from this system nor its costs. Furthermore to include swimming in lake within the GDP account we would have to carry out market transactions (act of purchase/sale of services provided by the lake). If this particular condition is met we are able to include these market transactions into the global production scheme, which consequently becomes the starting value in the GDP account. Swimming in lake is inevitably a form of ecosystem consumption and as such should be recognized as its benefit. However, there is no basis to include this type of consumption into the GDP value (swimming as public good, free of charge or one that is subsidized by the state) when we consider the process of establishment, division in the light of obligatory principles of managing such an account.

If somehow we are able to verify a translation of ecosystem services into the GDP value then it has to be performed in terms of usefulness category. Usefulness is the fundamental category of welfare theory, which was destined to substitute the value theory based on labor[1413]. The usefulness theory is defined as an ensemble of mental pleasures which are sensed by a person on account of purchasing, gathering and consuming a particular good. The founders of the usefulness theory (H.H Gossen) assumed that this category is measurable. Co-authors of this theory (i.a. L. Walras) assumed that a rational consumer makes adequate economic choices and therefore should possess the opportunity to identify usefulness and be able to measure this value. At that time scholars believed that usefulness does exist and that people are able to recognize the usefulness of individual extreme goods albeit the measurable category was not the same. Scholars devised models (neutrality curves) and performed sophisticated mathematical interpretations. In such a model a usability index is attributed to each basket of goods. The function of usefulness describes subjects' behavior within the economy that operates according to specific regulations. Such economy is targeted to maximizing the goods of individual citizens.

Traditional usefulness function may be expressed by an equation below[15]:

$$Ui = Ui(xi1,xi2,...,xin) \quad (1)$$

where xij(i = 1, ... i = m; j = 1,..n) signifies quantity j-of good, purchased by i-consumer.

[14] A. Becla, S. Czaja, A. Zielińska, *Analiza kosztów –korzyści w wycenie środowiska przyrodniczego*, Difin, Warszawa 2012, p. 28.

[15] H. R. Varian, *Mikroekonomia*, Wydawnictwo Naukowe PWN, Warszawa 1997, pp. 84.

It is assumed that the usefulness function is continuous and possesses continuous partial derivatives of first and second order. This enables to determine formal conditions which are essential so that the consumer selects a basket of goods that maximizes usefulness and its value is equal to its income. A characteristic usefulness entry comprises of ranking baskets of goods. Values of the usefulness functions are important due to the fact that they categorize various consumption baskets. The magnitude of the usefulness difference between two given consumption baskets is in this particular case immaterial. This particular type of usefulness is referred to as ordinal usefulness[16].

Without further explanation of these difficult issues pertaining to the usefulness function (this needs to be pursued by the developing science called mathematical economics) it is recommended that marginal utility should be employed for analysis of ecosystem benefits (functions). Marginal utility enables to assess the change in consumer's usefulness if he obtains more of accessible good. This "more of accessible good" may signify more energy used for this particular good, which is expressed in the value of ecosystem function. For instance this may include a house in a pristine environment, production of electronic subparts in pure environment etc.

It should be pointed out that usefulness has never been described or measured in scientific aspects. This applies to the Victorian era when usefulness was treated as a numerical measure of human happiness and in contemporary times when it is expressed in categories of consumers' preferences. Scholars have managed to construct usefulness functions (Cobb-Douglas) however their usability does not exceed past theoretical analysis of consumer behavior, even when we take into account a number of principles that simplify reality.

The principal criterion of the assessment of consumers' behavior is reaction to changes in price of goods and the assumption of consumer's rationality. Basically this means that the consumer always chooses best items that he can afford. However the consumer or other person which is perceived a potential consumer does not always behave according to the established economic model. This type of situation may be verified for ex post scenario but there is no rational background to project preference functions ex ante.

The application of usefulness function and welfare theory to describe and assess ecosystem benefits (functions) is conditioned by numerous factors, and the most important ones (according to the author) are presented below:

- identification of ecosystem basket;
- comprehension of consumption process pertaining to these benefits and their measurement;
- existence of economic market and market prices of such benefits.

Identification of potential ecosystem benefits (functions) is presently making considerable progress but selection of comprehensive basket of goods and ecosystem services may not be possible for some time without more profound integration of biology, chemistry and physics with social sciences. A group of scholars

[16] Ibidem.

led by Constanzy has identified 18 ecosystem types such as: boreal forest, marshy land and others as well as 17 key services such as climate regulation, pollination and recreation. Each ecosystem can supply any type of service mentioned above but their scale is diversified. Subsequently we obtain a 18×17 matrix (another words 306 components) and each of them may contain the value of a specified service that is provided per one acre of the ecosystem. Most of these components are empty because there are no proper estimates for individual issues. It should be noted that estimates which have been performed using this matrix calculated a sum of 33 billion USD (in 1994), which consequently was greater than the value of global GDP.

It should be emphasized at this point that this value may be only compared with the GDP but cannot be assessed based on the GDP. "*There is absolutely no reason to think that ecosystem services are part of market transactions and their value should be linked with the GDP*[17]". This remark undermines the legitimacy of the approach assumed by the author of this paper. We can concur with such an assumption if we take into account the procedure and principles of these estimates. This is also strongly supported by numerous reservations in terms of reliability and credibility of these estimates. However it is difficult to undermine the assumption that ecosystem benefits category should not be a component of the GDP value. This is justified by the fact that there exists a common agreement that ecosystem benefits constitute welfare value and in addition the GDP is so far the only applicable measure of such welfare in all possible social-economic systems.

In the years 2001-2004 the General Secretary of the United Nation has devised a concept of economic assessment pertaining to changes of ecosystem services. This concept focuses on the changes in ecosystem services in the light of human welfare. In this project 37 different categories of ecosystem services have been distinguished, and subsequently they were subdivided into four groups[18]:

- fundamental, which condition life on earth (i.e. photosynthesis capability, primary production, natural cycle of important radicals and substances such as carbon, oxygen and water;
- supportive, such as food, water, wood, fiber, biofuels;
- regulatory; such as absorbance of pollutants, climate conditioning, mitigation of flood crest, effect on soil erosion, pollination;
- cultural such as esthetical, recreational, religious.

Over 1300 scientists from all over the world managed to achieve qualitative assessment of the direction of changes of benefits magnitude, which has taken place in the second half of the twentieth century. Research methodology and interest of various scientific disciplines concerning ecosystem services has been viewed upon as added value. It should be noted however, that no numerical es-

[17] T. Żylicz, *Wycena usług ...,* op. cit., p. 39.

[18] A. Mizgajski, *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne*, „Ekonomia i Środowisko" 2010, No. 1, p. 14-15.

timates have been elaborated and translation to the measure of welfare has not been accomplished (including the GDP).

The author would like to mention the initiatives implemented by the International Science Society regarding the issues of ecosystem benefits (functions). The author believes they are quite useful in discussing the nature of ecosystem benefits. These initiatives attempted to define the payment model of ecosystem benefits, which is consequently an indispensable condition in acknowledging the subject of market transaction and its further incorporation into the production, consumption, cost, and investment account (within the GDP account). The author proposes to define payment for receiving ecosystem benefits by employing the following set of criteria:

- Transaction is voluntary,
- Ecosystem benefits (or ones that ensure land use) are precisely structured,
- There is at least one benefit buyer,
- Benefits may be ensured by the provider of services.

As previously emphasized the definition and precision of ecosystem benefits (functions) has many restrictions. Both the buyer and the seller exist in conditions of intelligent and highly skilled market of goods and ecosystem services.

According to T. Żylicz typical goods and ecosystem services are ones for which "the market does not exist, no market prices exist for which a consumer could resist[19]". For the aforementioned reasons environmental goods and services can be treated according to the so-called market conditions.

Conditional market includes pure good, the institutional context of its provision and means of financing transactions. What is important, is the fact that in reality goods and services are not provided. A hypothetical situation is created in which the respondent (potential purchaser, investor) behaves as if he was functioning on a real market[20]. The value of potential transaction and the magnitude of market price is estimated on the basis of the following components: by studying the declared preferences of the consumer and his willingness to pay (WTP) for a given service, status of the environment and willingness to accept compensation for losing either the good or services (WTA). The above mentioned methods as well as others, which pertain to pricing of non-market goods, are accepted by the economists because they reveal preferences. This point is crucial when it comes to transactions and purchasing a product.

They are thoroughly elaborated and are applied more often. This new technique referred to as the Choice Experiment was applied for example to assess the value of possible public goods provision in case of the Bialowieski Virgin Forest. This research project involved the estimate of the tendency of paying for greater biodiversity. For example the residents have been asked wheer they are inclined to pay taxes (10-year period) on the account of specific environmental

[19] T. Żylicz, *Wycena usług ...,* op. cit., p. 35.

[20] J. Famielec, *Straty i korzyści ekologiczne w gospodarce narodowej,* Wydawnictwo Naukowe PWN Warszawa-Kraków 1999, p. 112 oraz 154-155.

attributes. Such studies are estimated as credible and they develop the knowledge pertaining to economic parameters of potential transactions on the service market and maintain biodiversity[21].

The above-mentioned methods of assessment of environment economic value are not sufficient in terms of the application to the ecosystem benefits (functions) in the GDP account. We would need to construct many conditional markets of ecosystem benefits but currently the major obstacle is that we are not familiar with the principles of service consumption in this matter. These services are usually consumed indirectly in the production of goods and services, in the material realm (i.e. manufacturing high-class electronic equipment in pure environment) and intangible realm (curing of rashes after surgical operations, which require pure air, or functioning in spas that are located in protected areas).

So far it is possible to use estimations of certain damages and environmental benefits by applying the aforementioned methods of estimates. Scientists attempt to include and distinguish this methodology in the GDP account (table 1). In this case the subject of pricing are resources and the process of their utilization. Ecosystem benefits are only one possible component associated with atmosphere and hydrology services.

This concept assumes that utilization of environment resources provides certain benefits (income, receipts) but it also requires certain costs and expenses which may be included in the global production account. In addition it needs to take into account indirect costs, but only in such cases where they constitute independent components (i.e. water treatment) or they are fully integrated with production processes (i.e. filters in the power plants). Subsequently results of the aforementioned processes constitute the subject for market transactions and they may be assessed in terms of market prices.

A separate problem is the access to natural resources and their property as well as political situation. As example we can mention the current Israel – Palestine conflict regarding water issues. In that region water is present in sufficient amounts but it is not accessible for many Palestine residential areas, due to legal and political restrictions imposed by Israel. Such complications prevent the assessment of the value of benefits on account of water resources. On one hand the irrigated deserts are "green" and provide a wide variety of products, which can be estimated using an economic approach. On the other hand the absence of water access in this area (Palestine case) suggests lack of benefits in this matter. What is vital is that unfortunately there is no background for voluntary transactions and adjusting market price for water.

The concept of benefits and losses is useful but not sufficient to solve the problem of including ecosystem benefits (functions) in the GDP account[22]. Environmental losses and benefits are defined as decreased benefits (incurred losses), wasted benefits (lost opportunities), and benefits acquired which are strictly as-

[21] T. Żylicz, *Wycena usług ...* op.cit., p. 38-39.

[22] J. Famielec, *Korzyści i straty ekologiczne w ekonomii sektora publicznego*, „Ekonomia i Środowisko" 2010, No. 1, p. 46-63.

Table 1.
Selected natural environment resources as part of the GDP account

Resource type	Included components	Excluded components
geological • minerals • soil • water resevoir	• income and costs of private and public resource yield • income from cultivation, cultivation production costs • investing expenses and costs due to water consumption	• depreciation of resources • depreciation of soil quality • depreciation of water reserves • free of charge water consumption
biological • forests • shoal of fish • wild life	• costs and revenue from timber acquisition • revenue and costs of fish catch • recreation expenses	• depreciation of a given resource • non-market benefits • expenditure for one's own usage • non-consumption benefits on account of wild life
biosphere • atmosphere • hydrosphere	• environment protection expenditure • health costs	• ecosystem depreciation • value of ecosystem services

Source: Author's elaboration based on: J. Famielec, *Straty i korzyści ekologiczne w gospodarce narodowej*, Wydawnictwo Naukowe PWN, Warszawa-Kraków 1999, p. 58.

sociated with the environment. They can comprise production value, their small component (included in the market price) or they can be a part of the component of production cost (included in the GDP account).

Table 1 indicates that there are many examples of costs and environmental costs not included in the GDP account because they are not estimated and they do not have a direct character of production or indirect costs. Only some of the losses and benefits may express the value of ecosystem benefits (i.e. revenue from timber acquisition). It should be noted that costs and environmental costs comprise the results obtained or incurred by the producer, investor and consumer on the account of environment utilization. Meanwhile ecosystem (functions) should express the results of environment services because in this case they will be perceived as expenditure (cost) for its purchase, or a revenue that is obtained from sales. Cost of treatment is not a value of ecosystem benefit. It is perceived as an indirect measure of environmental losses.

Opportunities of incorporating ecosystem benefits into the GDP account

Construction and utilization of the GDP analyzed by the Principle Statistical Bureau (current market price) can be expressed with the following equations:

$$\text{GDP} = \text{Global Production} - \text{indirect utilization} + \text{+taxes derived from products} - \text{subsidized products.}$$

$$\text{GDP} = \text{consumption} + \text{accumulation} + \text{balance of products exchange abroad.}$$

The GDP comprises the following components[23]:

- value of all goods and services generated in specific time period in the territory of a given country,
- flow measurement of current production,
- value of investments goods including consumption goods.

We could include the value of ecosystem benefits (functions)in the aforementioned equation on condition that they be expressed in currency and designated on the basis of the market price scale system. Prices are the only necessary tool used in aggregation of various components of the GDP.

The GDP account has many constraints in general, but if we take into account the possible value of ecosystem benefits there are particular constraints. A list of these constraints is presented below[24]:

- summing up values that pertain only to goods, which are aimed for direct consumption and subsequently which are used in the investment process. We can mention here environmental services which do not possess the character of direct consumption goods, or investments; they merely create conditions for stabilizing life processes. Also we can mention human functioning and the course of economic processes, which are not the subject of accounting and statistical documentations, and consequently the cannot be aggregated into the flow of GDP account;
- omission of the value of indirect goods that have been utilized by the producers of finished goods (i.e. semi-products, energy, resources) – environmental goods possess this character
- does not reflect the values of goods and services, which are not the subject of market transactions (i.e. household activity) – ecosystem services are neither the subject of market transactions nor they constitute basis for calculating prices in market transactions – the reason is that majority of these services cannot be identified and they are treated as voluntary goods, which are utilized or consumed free of charge. Also the property status of these benefits are not regulated, which is indispensible to carry out any market transaction (this is referred to as the necessity to hand over property right for these goods),
- does not include purely fiscal transactions (such as state transfer, non-returnable payment transfers), which are so far the only means of fiscal flows that can be measured (i.e. environmental taxes, public aid for environment protection, budget expense for maintaining research institutions and protection of biodiversity etc,

[23] L. Zienkowski, *Co to jest PKB? Jego rola w analizach ekonomicznych i prognozowaniu*, Dom Wydawniczy „ELIPSA", Warszawa 2001, p. 85 and following.

[24] M.G. Woźniak, *Wzrost gospodarczy. Podstawy teoretyczne*, Wydawnictwo Uniwersytetu Ekonomicznego, Kraków 2008, p. 13-14.

- value of benefits/services is calculated on the basis of production costs (benefit costs) with the exclusion of indirect taxes. It should be noted that ecosystem services do not constitute the subject of market pricing and therefore they do not have a price.

The GDP account may be calculated using three different methods:

- summing up the added value generated in all enterprises of state economy,
- measurement of the flow of expenditures allocated for goods and services,
- measurement of income from productions factors

The inclusion of ecosystem benefits value into the GDP account would be possible if we employ the method which measures the revenue of investment participants on account of the involvement of production factors. This is conditioned by one important fact, the prices for labor, rent of space, interests and profits would have to be „sensible" to both quantity and quality of ecosystem services and we could devise a way to internalize benefits and costs of utilization of ecosystem benefits for market transaction pricing. So far the only existing market instrument associated with environment protection features trade of rights to emit pollutants. However it does not fulfill its role due to its free of charge character, public aid etc. The second possible instrument features environment taxation (they do not exist in Poland). *„Market mechanisms can play a crucial role in improving change, for example in constructing a new „green" economy. To be honest even a simple change (warranty) that prices properly effect the state of natural resource depletion in the long run would create a significant headway"*[25].

If we assume further progress in identification of ecosystem benefits by natural sciences as well as the possibility to assess its participation in production and consumption processes (cause-effect functions) the economists could perform the following tasks in terms of linking ecosystem benefits with the GDP account:

- keeping pro forma accounts of ecosystem benefits values – advantages and costs for production and consumption processes in the economy,
- Identifying values and components of generation price factors in the current balance of income, costs, investments and consumption of the organism production value. The purpose of these tasks would be to designate a generative factor, which has not been established thus far. This factor would be much broader than land and would constitute ecosystem services.

At the same time it is vital to seek new measures of welfare – the current GDP index causes many damages in terms of the evaluation of economic growth and development as well as aims and priorities for future generations. It is also necessary to make economics more "environmental" including the GDP account.

25 J.E. Stiglitz, *Freefall. Jazda bez trzymanki*, PTE, Warszawa 2010, p. 229.

Summary

Social-economic development and its assessment is often times the background for making political, financial, investment and consumer-related decisions. The most common category of measures employed are the GDP and economic growth. It should be noted that economic growth refers to the real sphere of economy, which subsequently comprises material production base including natural resources, population, and changes in its structure as well as production and consumption that are generated[26].

The above-mentioned natural resources do not include ecosystem benefits (functions) and free of charge goods. The GDP account only expresses the growth of generated goods and services (related to consumption and production) or in another words only selected means of satisfying human needs. The GDP measure does not fulfill its role in measuring the effects of the real economic sphere, because it omits the value of goods and services that are not the subject of market transactions. It also omits purely fiscal transactions. It should be pointed out that the GDP measures the scale of production in a given time period – not the welfare[27] or usability. The latter features are sought after in order to include the values of ecosystem benefits, or at least basic attributes of environmental development (social-economic and environmental order).

It is possible to propose such an order[28], formulated on the basis of the Ordoliberal theory (Walter Eucken et all) and the policy of accomplishing such an order in the form of social market economy[29] (Ludwig Erhard, the author of the concept and subsequent policy „German economic miracle"). The above-mentioned issues are to extensive to be included in this elaboration. It is worth mentioning though that the author proposes a very bold thesis – welfare for everyone. Unfortunately this type of welfare will not generate growth[30]. Maybe if we take into account this approach we would have more room for incorporating the values of ecosystem services as ecosystem benefits?

[26] M.G. Woźniak, op. cit., p. 9 and following.
[27] L. Zienkowski, op. cit., p. 85 and following.
[28] Wskazuje na taką potrzebę i szansę: B. Fiedor, *Trwały rozwój a koncepcja społecznej gospodarki rynkowej*, in: *Kształtowanie zrównoważonego rozwoju w reakcji na kryzysy globalny*, ed. A Graczyk, Wydawnictwo Uniwersytetu Ekonomicznego, Wrocław 2011, p. 13-29.
[29] T.T. Kaczmarek, P. Pysz, *Ludwig Erhard i społeczna gospodarka rynkowa*, Instytut Studiów Politycznych PAN, Warszawa 2004.
30 T. van Treeck, *„Wohlstand ohne Wachstum" braucht gleichmäßige Einkommensverteilung*, „APuZ aktuell" 2012, No. 27-28, p. 32-51.

POLITYKA EKOLOGICZNA I ZARZĄDZANIE ŚRODOWISKIEM

ECOLOGICAL POLICY AND ENVIRONMENTAL MANAGEMENT

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ECOSYSTEM SERVICES ASSESSMENT FOR POLAND – CHALLENGES AND POSSIBLE SOLUTIONS

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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.

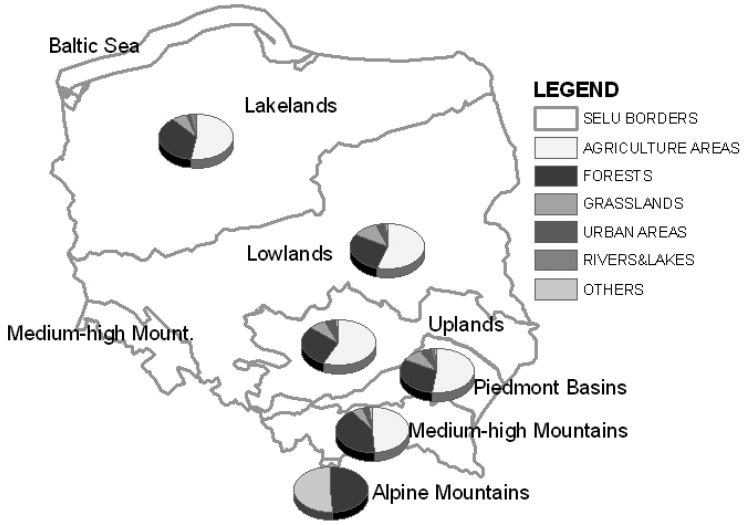
Spatial framework for Ecosystem Services Evaluation for Poland

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.

Arnold Bernaciak

THE ROLE OF LOCAL AUTHORITIES IN THE MANAGEMENT AND PROTECTION OF ECOSYSTEM SERVICES

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ROLA WŁADZ LOKALNYCH W ZARZĄDZANIU I OCHRONIE ŚWIADCZEŃ EKOSYSTEMÓW

STRESZCZENIE: Władze lokalne odgrywają ważną rolę w ochronie ekosystemów i ich struktury, zachodzących w nich procesów i pełnionych funkcji. Jednakże ich wpływ na ekosystemy, a w szczególności na dostarczane przez nie świadczenia jest ograniczony. Zależy od takich czynników, jak: potrzeby (popyt) społeczności lokalnej, dostęp do źródła świadczenia, możliwości techniczne oraz przyzwolenie prawne. W konsekwencji możliwości wpływu władz lokalnych na świadczenia ekosystemów są zróżnicowane. Część z nich, w szczególności świadczenia zasobowe, stosunkowo łatwo poddają się wpływowi władz. Inne, przede wszystkim świadczenia wspierające i regulujące, praktycznie nie poddają się temu wpływowi. Możliwość ingerencji władz na poszczególne świadczenia dostarczane przez ekosystemy zróżnicowana jest również w czasie i przestrzeni.

SŁOWA KLUCZOWE: świadczenia ekosystemów, władze lokalne, wpływ na środowisko

Introduction

The intervention possibilities taken in order to raise the level of services' usage, as well as the possibility of applying safety precautions are varied and depend on several factors. The level of importance presented by a given service for the socio-economic system, and the consequent demand is the first essential factor. In practical terms, a low level of demand causes the influence on a given service to be lower, than when it comes to high-demand services.

The second factor is the location of the source of a given service (structure, process) with respect to the area of the service. The source area, and the area where the service occurs, may be located on the same territorial unit, which gives the authorities a greater chance to intervene. The water cycle services are most commonly located to a very small extent in the area of their occurrence. The range of the water cycle goes far beyond the local authorities area. The third factor is the nature of a service, which is decisive when it comes to the technological possibilities of the socio-economic system influence. The impact of the authorities regarding storing genetic resources is much smaller than on supplying the citizens or the local industry with water. The fourth factor is the law conditions and their consequences on a given area. The intervention of the socio-economic system on the ecosystem is possible only when the law regulations allow for such an activity

The aim of the article is to identify possibilities of managing and protecting ecosystems along with their functions, which are the source of ecosystem services, by the local authorities. An attempt is made to categorize services in order to manage them properly.

The results of analyses present the real impact of the local authorities, when it comes to ecosystem services, and allow for the creation of the typology of services. In practical terms analyses make it possible to find any law imperfections concerning ecosystem services, which may be the guideline for implementing further changes.

Socio-economic system and ecosystem services

The important role of ecosystem services for socio-economic development has been shown by numerous studies. Research has been done on global, regional and local scale. It is worth mentioning G.C. Daily, who presented social dimensions of the functioning of the natural environment, or R. Costanza, along with his breakthrough research from the 90s, concerning the global value of ecosystem services[1]. Projects such as Millennium Ecosystem Assessment (MEA)

[1] G.C. Daily, (ed.), *Nature's Services: Societal Dependence on Natural Ecosystems*, Island Press, Washington DC. 1997; G.C. Daily, *What are Ecosystem Services?* in: *Nature's Services: Social*;

and The Economics of Ecosystems of Biodiversity (TEEB) have also played an important role in popularizing the knowledge about ecosystem services[2]. All the studies and analyses underline the important role of ecosystem services for the management processes, and point to their crucial role in creating the standard of living.

A vast amount of studies concerning the role of ecosystem services for the local and global development has been done. Scholars such as MJ. Metzger et al. and R.S de Groot et al. present the negative influence of soil exploitation change on the ecosystem services[3]. The ground policy's support possibilities using the estimation of a value is presented by E.V. Viglizzo et al.[4]. The guidelines for the government concerning the ecosystem services' management are shown by B. Fisher et al. and GC. Daily[5]. Two reports created for the aforementioned TEEB project, were devoted to issues which are crucial for the local and regional politics.[6] Publications point out to the possibilities to support development, by conscious and balanced usage of ecosystem services.

A plethora of publications and documents pertaining to the ecosystem services' management on the regional and local level, underline the important role of the local authorities. What may optimize the socio-economic development and the growth of the prosperity is the proper attitude of local government concerning the management of ecosystems. The lack of knowledge about ecosystem services, as well as the lack of management skills, may negatively affect developmental processes.

Dependence on Natural Ecosystems, G.C. Daily (ed.), Island Press, Washington 1997; R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997, Vol. 387.

[2] *The Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Synthesis*, Island Press, Washington 2005, The Economics of Ecosystem and Biodiversity, European Communities 2008.

[3] M.J. Metzger et al., *The vulnerability of ecosystem services to land change*, "Agriculture, Ecosystems and Environment" 2006 Vol. 114; R.S. de Groot at all, *Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making*, "*Ecological Complexity*" 2010 Vol. 7.

[4] E.F. Viglizzo et al., *Ecosystem services evaluation to support land-use policy*, "*Agriculture, Ecosystems and Environment*" 2012 Vol. 154.

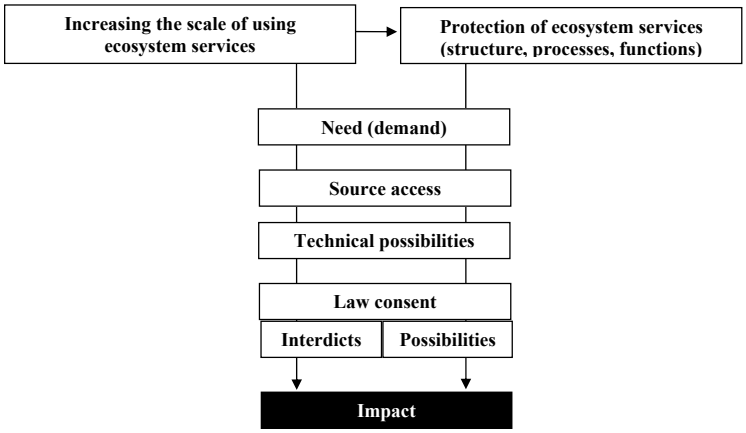
[5] B. Fisher, R.K. Turner, P. Morling, *Defining and classifying ecosystem Services for decision making, "*Ecological Economics" 2009 Vol. 68; Management objectives for the protection of ecosystem services, "Environmental Science & Policy" 2000 Vol. 3.

[6] *The Economics of Ecosystem and Biodiversity. TEBB for Local and Regional Policy Makers*, 2010; H. Wittmer, H. Gundimeda (eds.), *The Economics of Ecosystem and Biodiversity in Local and Regional Policy and Management*, Earthscan, London 2011.

Necessities and possibilities of the intervention of the socio-economic system in the ecosystem services

The reasoning behind the intervention of the socio-economic system, especially local authorities, in the functioning of the ecosystem may be double-sided. On one hand, the source may be the need to increase the usage of ecosystem services, on the other hand – the will to protect them. There is a relation between these two – the need to protect ecosystems and their functions, and as a consequence – ecosystem services may be the result of their previous exploitation (Figure 1).

Figure 1.
The mechanism of socio-economic system impact on ecosystems



Source: Own elaboration.

In order for the socio-economic system to show interest in the intervention in an ecosystem and its functions, there is a need for an appearance of positive circumstances. Among such circumstances are the need of intervention, access to the source of service, technical possibilities of an intervention, and law consent.

Each of the elements stimulating the intervention in ecosystems and its services is of different nature. The need to intervene in the service or a process of ecosystem is based on the demand for a given service. The greater the social demand is, the greater the scale of an intervention. The need characterizes the side of the demand: it occurs within the socio-economic system, so the authorities along with their voters. It must be observed, however, that not each and every demand may be fulfilled. Each ecosystem has a given capacity to create a service. In economic terms, it is about its entire productivity and capability.

The extreme productive possibilities of an ecosystem are determined by various factors. For example, for an ecosystem of a river, categories such as, the river bed, the flow, or the species living there, determine the maximum amount of services which may also, to certain degree, be increased by a specific human activity. The range of services may be increased by both protective measures (limiting the biogenic inflow, in order to increase self-cleaning abilities) or degrading the ecosystem (regulation of the river bed)[7].

The second factor influencing the possibility to control the ecosystem services is the access to the source. An ecosystem service is usually its structure (e.g. a water tank as a water reserve), or a process taking place within the system (e.g. cellular respiration being the source of oxygen). The place where the service occurs may be remote from the place where it is created. From the point of view of the local authorities the service in this context may be divided into:

- both the source and occurrence in one area, e.g. recreational services of water tanks,
- source in a given area, but the occurrence out of it e.g. the production of oxygen by a big forest ecosystems located in a given area,
- source out of a given area, but the occurrence in the area e.g. oxygen incoming to an highly urbanized area,
- both the source and occurrence out of the area, e.g. water self-cleaning service in case of an area without any water tanks.

From the point of view of a territorial unit, and its management, services from the first category are the most important. Services from the second and third category have limited importance, whereas the fourth category have no practical meaning for the authorities.

The technical possibilities of intervention depend on the current level of technological development. It is an external feature, independent from the authorities. Internalizing such factors is possible when there are technical possibilities of intervention, but due to various reasons (e.g. financial) they are not available for each and every unit.

Law regulations, which determine the possibility and the range of intervention, may be classified as both external and internal features, depending on the unit's competences to create regulations in a given environment-economics area (The European Council, The European Commission, national parliament, the authorities of a territorial unit). There are two contexts in which legal consent for intervention in ecosystems may be interpreted: bans protecting the environment and incentives to take protective actions.

Each of the aforementioned factors is an essential condition which need to be fulfilled. The need, source access, technical possibilities and law consent must all occur at the same time. The lack of any of them makes it impossible, completely or partially, to influence the ecosystem and its services.

[7] The issue is illustrated by Siebert's ecological utilization space: H. Siebert, *Nature as a life support system: renewable resources and environmental disruption*, "Journal of Economics" 1982 Vol. 42.

Possibilities for the local authorities to manage ecosystem services – results of research

Bearing in mind the aforementioned factors, each service has been rated according to the possibility for the local authorities to intervene in their structure and processes, and to manage the services of the ecosystem. The typology of the Millennium Ecosystem Assessment was assumed. Each of the services has been rated according to four factors: the need, source access, technical possibilities and law consent. The 0-2 scale was taken, adequately to growing possibility of intervention (Table 1). As a result each service is characterized by four figures. The greater the value for a given service is, the greater the possibility to intervene.

Table 1.
Assesement criteria

Level	Need (demand)	Source access	Technical possibilities	Law consent
0	No need for the socio-economic intervention; service does not affect the life of humans or is perceived as not affecting it.	The source is impossible to establish, dispersed or located out of the subject's range.	The nature of service cannot be affected by human; a technology allowing for such process does not exist.	The law forbids socio-economic intervention.
1	Little need for the socio-economic intervention in the service; service affects the life of humans to a limited extent or is perceived as affecting it to limited extent.	The access is limited; either partial or limited in time.	The nature of service shows a large resistance to human intervention; existing technologies allow only for a partial intervention.	Partial consent for an socio-economic intervention.
2	An essential need for socio-economic intervention in the service, service affects the life of humans to a large extent.	Full access; source is easy to identify, possible to locate in the subject's range.	The nature of service shows great susceptibility to human intervention.	Law does not limit the intervention in any way.

Source: Own elaboration.

In the next stage the results obtained by each of the services were multiplied. The result is a coefficient of a service showing the susceptibility of service to the intervention of the local authorities. Such calculations allow to obtain six different values of coefficients: 0, 1, 2, 4, 8 and 16. The higher the value is, the easier for the authorities to affect structures, processes and services of an ecosystem. On such a basis, adequately to the coefficient, it is possible to distinguish between six different categories of ecosystems as for the intervention possibility: 0 – lack of possibility, 1 – small possibility 3 – small+ possibility 4 – medium probability 8 – great probability 16 – certainty. It must be noted, that the aforementioned condition of necessity for each of analyzed factors, causes that obtaining value 0 in any of the criterion, makes the final factor value 0. Such dependency was obtained through multiplying values obtained in each criteria.

The results of the analyses show the limited possibility for the local authorities to intervene in structures and processes which take place in the natural environment, and as a consequence in ecosystem services. Among 37 services listed in the Millennium Ecosystem Assessment typology, only nine obtained value equal, or higher than 4. Only three of them were listed in the 'certainty' category, having obtained the result of 16 – plant production, water supply and tourism. There were seven services which do not undergo any intervention at all. Four of them are supporting services, two are regulating services and one is a cultural service (Table 2).

Table 2.
Ecosystem services categorization according to the management possibility

Lp.	16 points services	8 points services	4 points services	2 points services	1 point service	0 point services
1	PS – Crops	PS – Livestock	PS – Aquaculture	PS – Wood fuel	PS – Wild plant and animal products	RS –Climate regulation (global)
2	PS – Fresh water	PS – Capture fisheries	PS – Timber	PS – Biochemical, natural medicines and pharmaceuticals	PS – Genetic resources	RS – Polination
3	CS – Recration an ecoturism	PS – Cotton, hemp, silk	CS – Educational values	PS – Ornamenatal resources	RS –Climate regulation (regional and local)	CS – Cultural haritage values
4				RS – Air quality regulation	RS – Water regulation	SS – Soil formation
5				RS – Natural hazard regulation	RS – Erosion regulation	SS – Photosynthesisi
6				CS – Cultural and religious values	RS – Water purification and waste treatment	SS – Primary production
7				CS – Knowlege systems	RS – Diesese regulation	SS – Nutrient cycling
8				CS – Inspisration	RS – Pest regulation	
9				CS – Aesthetic values	CS – Cultural diversity	
10				CS – Social relations	SS – Water cycling	
11				CS – Sense of place		

PS – provisioning services, RS – regulating services, CS – cultural services, SS – supporting services

Source: Own elaboration.

Table 3.
Factor value for the possibility of intervention in service categories

Category of services	The sum of the products (ratio) in the category	Number of services	No. of points in one service
Provisioning services	72	12	6
Regulating services	11	10	1,1
Cultural services	32	10	3,2
Supporting services	1	5	0,2

Source: Own elaboration.

Provisioning services are the dominant group among the service which easily undergo the intervention of the local authorities. The sum of values for them is 72. There are 12 services in the category, which means that the average factor value for the entire category is 6. Cultural services have relatively high value as well – 3,2. Regulating and supportive services are characterized by low values. For the former it is 1,1, and for the latter only 0,2 (Table 3).

Relations between local authorities and ecosystem services – conclusions

The possibilities for the local authorities to intervene in ecosystems, and as a consequence in their services are varied. Some of the services, especially the provisioning services, are relatively easy to intervene in. The need, easy access to the source, lack of necessity to use advanced technologies, and law regulations which do not limit the possibility of intervention, or limit it to a little extent, are the factors which are supportive for the local authorities to manage such services. However, there are several services, especially in the supporting and regulating category, which are practically impossible to be managed by the local authorities. The most common causes are lack of the source access, and limited technological possibilities. What is more, there is no sufficient demand for many services of these categories. However important may the service be for the socio-economic development, inhabitants may be unaware of its importance and impact on their lives (e.g. pollinating, soil formation process, cycle of substances).

The spatial differences concerning the intervention possibility must be noted. All the factors, presented in the study as necessary factors, show such a difference. The needs of local communities vary in different areas. The diversity may be seen both regionally and locally, and on the higher, global level. The source access is, by definition, dependent on the location of two subjects: source, and the subject trying to obtain the access to it. Technical possibilities may depend

on the innovativeness of the country or region. The financial aspect may also limit the access to proper technologies.

The intervention possibilities may also differ in time. The technological development and legislative changes are both very dynamic areas. However, the former factor usually makes it possible for a wider intervention possibilities, whereas the latter depends on the intention of the legislator and the point of regulation – it may both limit or enhance the existing possibilities. Demand is also a subject to change, depending on the presence of natural threats. The occurrence of such threats is a factor creating higher demand, whereas their lack means no demand for the self regulation of ecosystems.

Ecosystem services management and their protection are characteristic for a given territorial unit at a given time. Services undergo constant evolution, adequately to factors allowing for an intervention, which are constantly undergoing changes as well.

In practical terms, an emphasis must be placed on services which are essential for the socio-economic development, and the standard of living. However, the local authorities do not usually have any chance of intervention. If such an activity would prove essential in order to keep ecosystems and support proper standard of living, the issue of ecological politics shall be defined and fulfilled by the regional or central authorities.

The research which was carried out, pertains to environmental, economic, technological and law determinants functioning in Poland in the year of research (2012). Carrying out similar research under different circumstances (e.g. the countries of the EU), would prove to be an interesting comparative study. Repeating the study after several years would show the direction of changes in the matter. Such research would also analyse the relation between the intervention possibilities and factors such as GDP, investment level or innovativeness.

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ECOSYSTEM SERVICES PERCEPTION. THE EXAMPLE OF LOCAL GOVERNMENTS REPRESENTATIVES IN MAŁOPOLSKA VOIVODSHIP

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POSTRZEGANIE USŁUG EKOSYSTEMÓW. PRZYKŁAD PRZEDSTAWICIELI SAMORZĄDU LOKALNEGO W WOJEWÓDZTWIE MAŁOPOLSKIM

STRESZCZENIE: Koncepcja usług ekosystemów w ostatnich latach zyskuje na znaczeniu i popularności zarówno w kontekście badań naukowych, jak i w działaniach praktycznych. W Polsce wciąż jednak nie jest powszechnie znana i jest rzadko uwzględniana w debacie publicznej dotyczącej polityk środowiskowych. W niniejszym artykule zaprezentowano wyniki badań dotyczących systemu ochrony przyrody, w tym wybranych aspektów usług ekosystemów, przeprowadzonych wśród przedstawicieli samorządów lokalnych województwa małopolskiego. Wskazano czynniki różnicujące postawy i poziom świadomości względem usług ekosystemów, jak też rekomendowano, jak wyniki niniejszych badań mogą być pomocne w działaniach praktycznych.

SŁOWA KLUCZOWE: usługi ekosystemów, samorząd lokalny, opinie, postawy, ochrona przyrody

Introduction

The concept of ecosystem services has been given more and more attention both in academia[1] and in practical actions[2]. In Poland, this scientific approach received some interest among scientists[3] and non-governmental organizations[4] but still is not widely used neither in policy-making, nor in public debate on environmental governance. Yet, ecosystem services concept delivers a clear and systematic theoretical framework for analyzing, assessing and valuating benefits from nature to human kind and societies as well as for decision making processes. So far, the research and actions taken in the field of ecosystem services have faced several main constraints, one of the major is – continuously questioned – grounds for economic and monetary valuation of non-market goods. Monetary valuation of cultural, spiritual, aesthetic or religious values is particularly undermined and it is confronted with a lot of methodological challenges. Majority of valuation techniques of ecosystem services is based on people's choices – either directly (by asking people about their willingness to pay) or indirectly (by observing and estimating prices of complementary goods)[5]. Another sort of techniques that have been developed are so-called noneconomic social valuations, that are claimed to have been included in the decision making processes[6]. Social valuation can be based on traditional social science methodology (individual in-depth interviews, questionnaires, focus groups interviews) or on more transdisciplinary techniques such as those based on GIS, e. g. Social Values for Ecosystem Services (SolVES) or Public Participation GIS (PP GIS)[7].

In the following paper we present the data collected among representatives of local level authorities using internet, mail or face-to-face questionnaires (mix mode approach). The main aim of the manuscript is to discuss factors that might differentiate the level of awareness of or attitudes towards some ecosystem services on the example of local authorities representatives in Małopolska voivodship.

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[1] e.g.: Constanza et al. *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 253-260; B. Fisher, R.K. Turner, P. Morling *Defining and classifying ecosystem services for decision making*, "Ecological Economics" 2009 No. 68, p. 643-653; R. B. Norgaard *Ecosystem services: From eye-opening metaphor to complexity blinder*, "Ecological Economics" 2010 No. 69, p. 1219-1227.

[2] e.g.: TEEB activities, UNEP-WCMC reports and actions.

[3] e.g.: A. Graczyk *Świadczenia ekosystemów jako dobra ekonomiczne* „Ekonomia i Środowisko" 2010 No. 1(37) p. 64; A. Mizgajski *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne,* „Ekonomia i Środowisko" 2010 nr 1(37) p. 10.

[4] e.g. project and portal uslugiekosystemow.pl by Sendzimir Foundation.

[5] T. Żylicz *Wycena usług ekosystemów. Przegląd wyników badań światowych* "Ekonomia i Środowisko" 2010 No. 1(37) p. 31.

6 G. Brown, J.M. Montag, K. Lyon, *Public Participation GIS: A Method for Identifying Ecosystem Services,* "Society and Natural Resources" 2011, p. 633-651.

[7] G. Brown and D. Weber *Public Participation GIS: A new method for national park planning* "Landscape and Urban Planning" 2011 No. 102, p. 1-15; B.C. Sherrouse, J.M. Clement, D.J. Semmens *A GIS application for assessing, mapping, and quantifying the social values of ecosystem services,* "Applied Geography" 2011 No. 31, p. 748-760.

Methods

We conducted a study among local governments' representatives from Małopolska voivodship. The questionnaire was sent to all (182) municipalities of Małopolska voivodship and addressed to both officials responsible for environmental issues in the municipality and local politicians (mayors or local government representatives). In total, 144 questionnaires from 108 communities were filled in and sent back (response rate by municipality: 59%). The research questions considered among all the performance of nature conservation system, the role of various institutions and actors and the relations between ecological and administrative scale. Although the perception and level of awareness of ecosystem services were not the main area of interest, there are some crucial outcomes that contribute to a discussion on noneconomic social valuation of ecosystem services. Due to the research goals, majority of analysis relates to nature conservation system and its performance at the local level.

Statistical analysis included frequency analysis and Principal Component Analysis (PCA). PCA was conducted using Varimax rotation with Kaiser normalization; the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was checked to be greater than 0,5.

Results

Local level representatives recognize – to a wide extent – the impact of nature conservation system on various aspects of community life. The impact on tourism and recreation, education and forestry is assessed to be positive by majority of respondents (accordingly: 82%, 68% and 60%). The highest proportion of both negative and no impact of nature conservation is seen in relation to labor market and development of small and medium enterprises (SME) sector. Interestingly, the impact on agriculture and life conditions in the neighborhood is also seen differently – the share of 'no impact' is significantly high (50% and 32%), (Figure 1).

The results of PCA enabled to distinguish three independent components that explained 80% of the total variation among the original variables. KMO measure of sampling adequacy was 0,657. Three principal components were named: (1) Nature conservation system is effective, (2) Nature attracts tourists and increases recreational values of the neighborhood and (3) Due to nature conservation the water and air are clean. The second and third relate to perception of ecosystem services such as recreational values and touristic opportunities provided by nature (cultural services) or water and air purification (regulatory services). The components' loads and questions included into each component are shown in Table 1.

Figure 1.
Responses to the question: "*How do you assess the impact of nature conservation system on functioning of other aspects of community life?*"

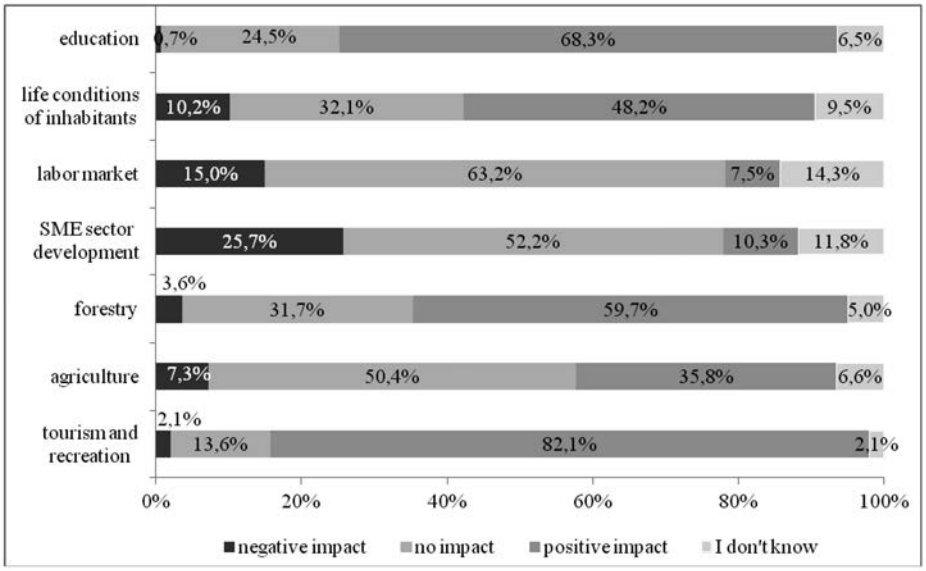
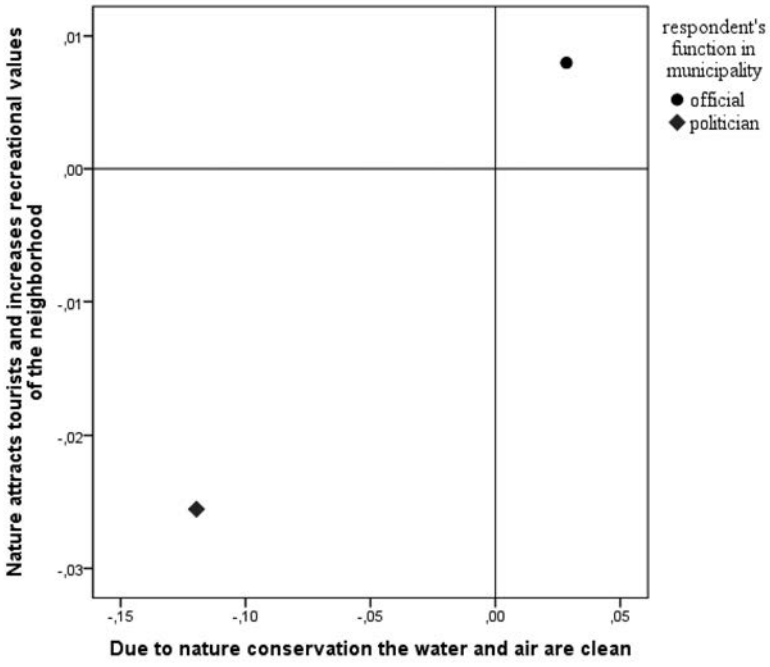


Table 1.
Questions analyzed in PCA. Loadings of less than 0,3 were excluded from the table

	1	2	3
Nature conservation system in my municipality protects wildlife effectively	0,937		
Nature conservation system in Malopolska protects wildlife effectively	0,908		
Nature conservation system in Poland protects wildlife effectively	0,839		
Local government in my municipality copes well with making decisions relating to nature conservation that is within its responsibilities	0,725		
The surrounding nature makes the municipality a better-known place		0,920	
Nature in the municipality and the surrounding area attracts tourists		0,913	
Nature conservation in the municipality increases the recreational value the neighborhood		0,764	
Due to nature conservation there is clean air in the neighborhood			0,944
Due to nature conservation there is clean water in the neighborhood			0,917
variation explained	33%	26%	20%

We analyzed whether respondents with different characteristics (such as a professional or social role in municipality or view on nature conservation influence on local development) or from different municipalities (with or without Natura 2000 site(s)) differ also in support or opposition towards second and third component. In most analysis the differences are visible but not fundamen-

Figure 2.
Scatter plot of respondents' support for two components in relation to respondents' function in municipality.



tal. For instance, local politicians (mayors or other representatives of local governments) less clearly recognize both cultural and regulatory services then local officials responsible for environmental issues (Figure 2).

In municipalities where Natura 2000 sites are designated, both politicians and officials claim clearly that nature conservation attracts tourists and substantially increases recreational values of the neighborhood (cultural services) while in municipalities without Natura 2000 sites respondents do not recognized those services but they appreciate more regulatory services (water and air purification due to nature conservation), (Figure 3).

Neither officials nor politicians appreciate any of the ecosystem services, if they claim that nature conservation hinders local development (Figure 4). Those who disagree with the limitation of local development tend to notice cultural as well as regulatory services. The tendency to see touristic and recreational values by people from the municipalities with Natura 2000 sites is also visible in Figure 5. Irrespective of Natura 2000, those who agree that nature conservation hinders local development do not recognize any of described ecosystem services (Figure 5). Finally, respondents who assess that nature in their municipality is unique clearly tend to perceive both cultural and regulatory ecosystem services (Figure 6).

Figure 3.
Scatter plot of respondents' support for two components in relation to respondents' function in municipality and the fact of having Natura 2000 sites within municipality

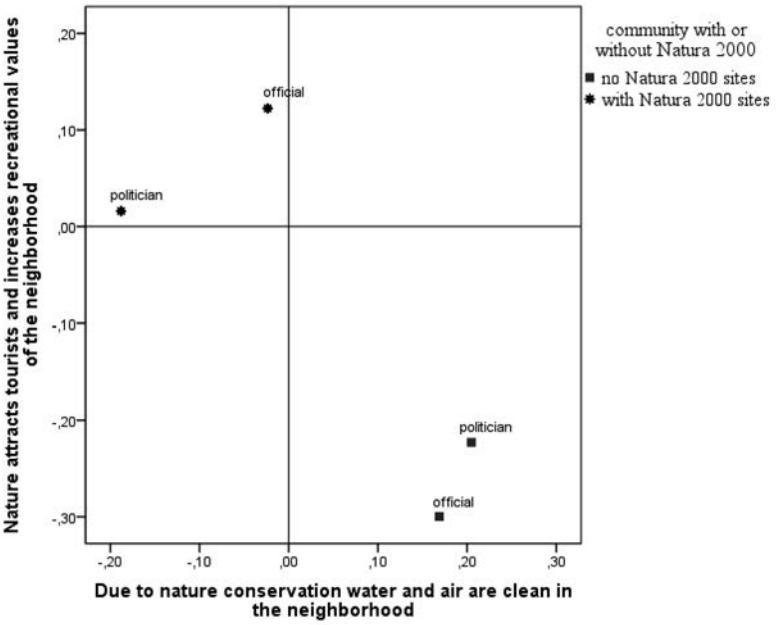


Figure 4.
Scatter plot of respondents' support for two components in relation to respondents' function in municipality and the attitude toward the statement "*Nature conservation hinders municipality development*"

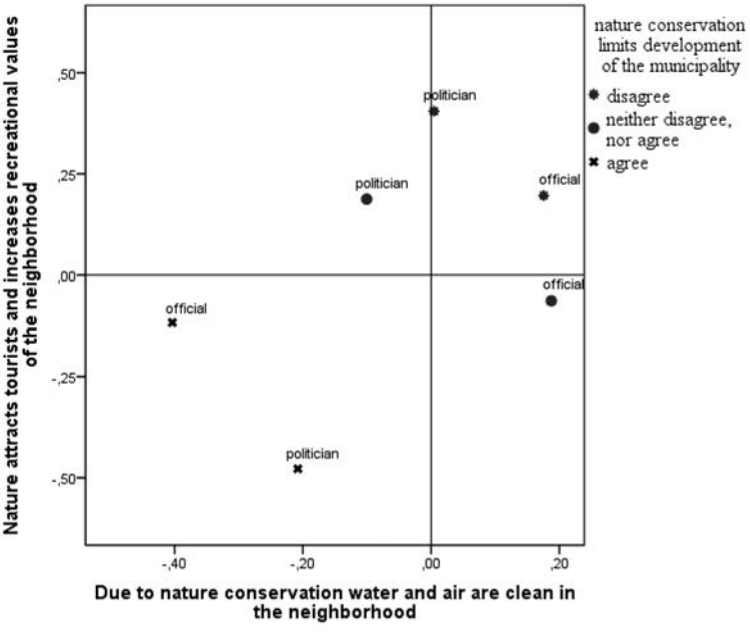


Figure 5.

Scatter plot of respondents' support for two components in relation to respondents' attitude toward the statement "*Nature conservation hinders municipality development*" and Natura 2000 presence in the municipality

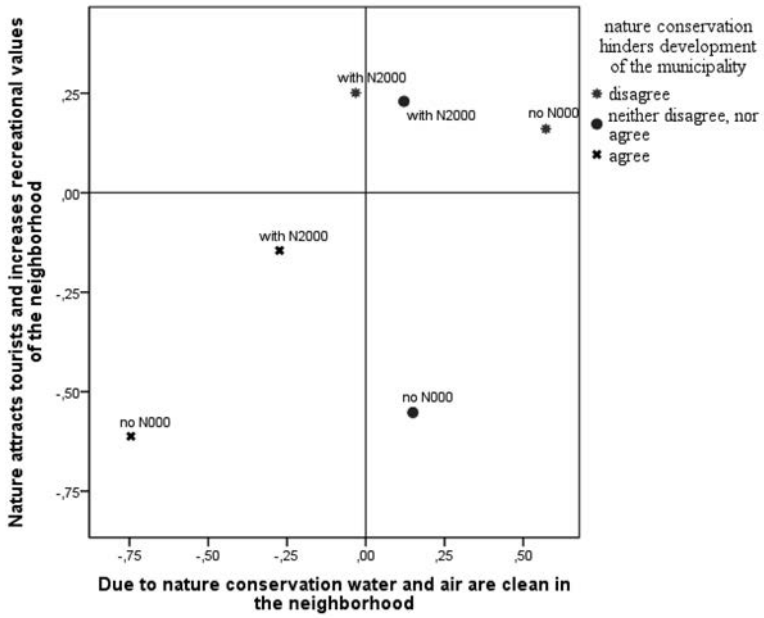
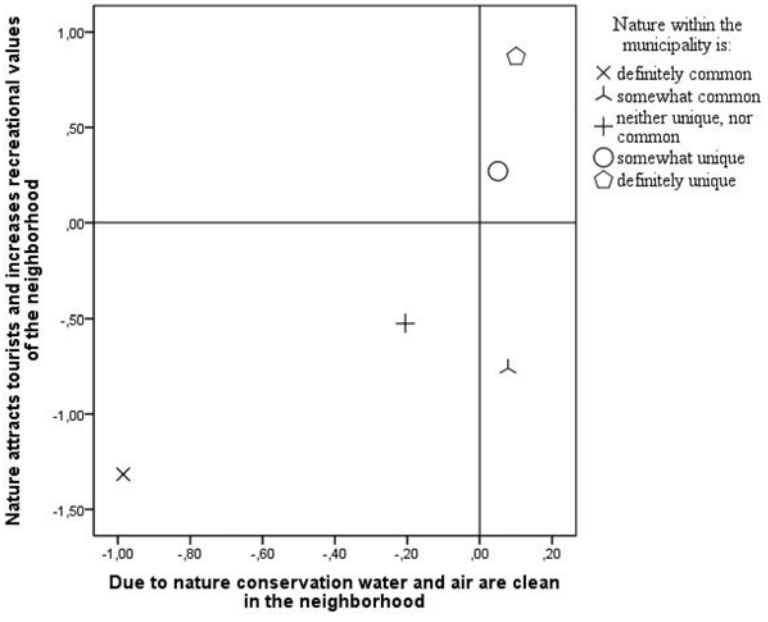


Figure 6.

Scatter plot of respondents' support for two components in relation to respondents' assessment of uniqueness of nature in the municipality.



Discussion

Nature conservation management has been and still is mainly based on biophysical and economic values whereas social aspects are often left behind. Both scientific and local communities started to recognize and thus actively expect a broader perspective to be used while conservation policy development. This particularly comprises local and economic values originating from relations between culture and nature and people and the place they identify themselves with. Although ecosystem services issues are still novel in Poland, investigated respondents had some knowledge and recognition on them. The relations between personal characteristics or local factors and recognition of chosen ecosystem services are not linear and unambiguous. In case of the study presented herein, services are perceived differently depending on local circumstances (e.g. protected areas) as well as on individual characteristics (a professional/social role in the municipality, experience with and opinion on nature conservation system etc.). Undoubtedly these are not the only factors affecting ecosystem services perception. E.g. the question on causality still remains – whether people were aware of touristic and recreational values before or after Natura 2000 sites had been designated in their place of living? There is no straightforward and correct answer – it has been already found that local circumstances and differences often require broad and multifactor analysis and interpretation at the local level[89]. Although a number of public participatory approaches to decision making within nature conservation sector has been proposed, a further research on priorities for identification and valuation of ecosystem services among local communities available at their localities should be undertaken. Such noneconomic valuation would firstly help when we try to assess those values that fall outside of the sphere of markets and secondly mitigate an potential conflicts. Knowing a perspective of various actors, it would be easier to negotiate an eventual environmental policy for a particular locality.

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[8] A. Pietrzyk-Kaszyńska, J. Cent, M. Grodzińska-Jurczak, M. Szymańska *Factors influencing perception of protected areas – The case of Natura 2000 in Polish Carpathian communities,* "Journal for Nature Conservation" 2012 No. 20, p. 284-292.

[9] C.M. Raymond, B. A. Bryan, D. H. MacDonald, A. Cast, S. Strathearn, A. Grandgirard, T. Kalivas *Mapping community values for natural capital and ecosystem services*, "Ecological Economics" 2009 No. 68, p. 1301-1315.

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THE MANAGEMENT OF ECOSYSTEM SERVICES VERSUS TIME IN ECOSYSTEMS

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ZARZĄDZANIE USŁUGAMI ŚRODOWISKA, A WYMIAR CZASU W EKOSYSTEMACH

STRESZCZENIE: Makrosystem społeczeństwo-gospodarka-środowisko funkcjonuje i rozwija się z wykorzystaniem zasobów naturalnych usług środowiska przyrodniczego.
W teorii ekonomii przede wszystkim analizowano zasoby naturalne, a usługi środowiska są stosunkowo nową kategorią ekonomiczną, szczególnie w aspekcie wymiaru czasu. Teoria ekonomii powinna szerzej uwzględniać założenia ekonomii ewolucyjnej oraz różne interpretacje czasu i korzystać z nich w analizach zjawisk ekonomicznych, w tym związanych z gospodarowaniem usługami środowiska. Celem pracy jest analiza roli czasu w ekosystemach w zrównoważonym gospodarowaniu usługami środowiska przyrodniczego – ze szczególnym uwzględnieniem badań polskich przedstawicieli ekonomii ekologicznej i zrównoważonego rozwoju. Czas w ekosystemach jest nierozerwalnym elementem oddziaływującym na zjawiska i procesy gospodarowania w postaci czwartego wymiaru czasoprzestrzeni lub logicznego następstwa zdarzeń. Problemy badawcze nie powinny koncentrować się na pytaniu, czy uwzględnić jego rolę w procesach gospodarowania, szczególnie w odniesieniu do zrównoważonego gospodarowania usługami środowiska, tylko na pytaniu, jak ten czas rozumieć i w jaki sposób wprowadzić go do teorii ekonomii i praktyki gospodarczej.

SŁOWA KLUCZOWE: ekosystem, ekonomia ekologiczna, ekonomia ewolucyjna, ekonomia zrównoważonego rozwoju, usługi środowiska, gospodarka oparta na wiedzy, czas w ekosystemach

Introduction

Society-economy-environment macrosystem functions and develops with the use of natural resources and ecosystem services. The theory of economics has primarily analysed natural resources, while ecosystem services, particularly in temporal aspect, are a relatively new economic category. Time is present in every activity of a contemporary man, both scientific and non-scientific, including philosophy, religion, life sciences, history and psychology. Time, as a form of matter, energy and information existence, is a universal manifestation of economic activities and functioning of the economic system.[1]

The theory of economy should consider the assumptions of evolutionary economics and various time interpretations more thoroughly and use them in analysing economic phenomena, including the ones concerning ecosystem services. In fact, real economic systems without the supporting role of ecosystem services do not exist. The management of ecosystem services is based on their conscious and unconscious use. Knowledge-based economy should be aimed at fully conscious management of ecosystem services, which takes account of time in ecosystems. The aim of the present paper is to analyse the role of time in ecosystems in sustainable management of ecosystem services – with particular attention to the researches by Polish representatives of ecological economics and sustainable development. The introduction of this topic to the theory of economics is to increase the effectiveness and efficiency of economizing processes and the implementation of sustainable development in society-economy-environment macrosystem.

Economic category of ecosystem services

The concept development of ecosystem services has been clearly noticeable since 18th century.[2] The economic category of ecosystem services appeared in 1981.[3] The article of 1997 is a significant publication concerning the issue of ecosystem services. It presents 17 global scale functions of natural environment, attributed with material and non-material services. Their value was estimated at over 33 bln USD.[4] The beginning of 21 century brought a number of reports providing classification systems, evaluations and assessments of ecosystem ser-

[1] S. Czaja, *Czas w ekonomii*, Wydawnictwo Uniwersytetu Ekonomicznego, Wroclaw 2011; *see Time in Economic Theory*, ed. S. Zamagni, E. Agliardi, Edward Elgar Publishing, New York 2005.
[2] E. Gómez-Baggethun, R. de Groot, P.L. Lomas, C. Montes, *The history of ecosystem services in economic theory and practice: from early notions to markets and payments schemes*, „Ecological Economics" 2010 No. (69)6, p. 1209-1218.
[3] H.A. Mooney, P.R. Ehrlich, *Ecosystem services: A fragmentary History*, in: *Nature's Services: Societal Dependence on Natural Ecosystems*, ed. G.C. Daily, Island Press, Washington 1997, p. 11-22.
[4] R. Costanza et. al., *The value of the world's ecosystem services and natural capital*, „Nature" 1997 No. 387, p. 253-260.

vices. The reports include: Ecosystems and Human Well-being: Synthesis in 2005, The Economics of Ecosystems and Biodiversity in 2008, The Economics of Ecosystems and Biodiversity. Mainstreaming the Economics of Nature: A synthesis of the approach, conclusions and recommendations of TEEB in 2010. Polish authors have also reviewed international and Polish researches on ecosystem services, which were the main topic of the first issue of *Ekonomia i Srodowisko* (*Economics and Environment*) in 2010.[5]

The most popular system of ecosystem services classification was presented in the report Ecosystems and Human Well-being. It distinguishes four groups of ecosystem services:

- provisioning services – include medicinal plants, genetic resources, ornamental resources,
- regulating services – refer to the benefits from regulatory properties of ecosystems, e.g. climate and air quality regulation, water purification, waste utilization,
- cultural services – non-material benefits from the functioning of ecosystems, e.g. natural and cultural heritage, leisure and recreation, creative inspiration, ecological education,
- supporting services – a group of services that are necessary for rendering other services, e.g. soil formation, water circulation, nutrient cycling, photosynthesis.[6]

Polish literature on the subject uses the classification by Kosmicki. It also distinguishes four groups of ecosystem services:

- raw material, production and transformation services – oxygen production, water circulation and purification, food production, gene pool as a reserve for the future, medical resources, material production for clothes and household industries, materials for construction and other branches of economy, biochemical production, fuel and energy production, fodder and fertilizers production,
- regulating and utilizing services – protection against harmful background radiation, regulating local and global energy balances, regulating chemical composition of the atmosphere and oceans, water flow man-

[5] e.g. A. Mizgajski, *Świadczenia ekosystemów jako rozwijające sie pole badawcze i aplikacyjne*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 10-19; B. Poskrobko, *Usługi środowiska jako kategoria ekonomii zrownoważonego rozwoju*, „Ekonomia i Srodowisko" 2010 No. 1(37), p. 20-30; T. Żylicz, *Wycena uslug ekosystemow. Przeglad wynikow badan swiatowych*, „Ekonomia i Srodowisko" 2010 No. 1(37), p. 31-45; J. Famielec, *Korzysci i straty ekologiczne w ekonomii sektora publicznego*, „Ekonomia i Srodowisko" 2010 No. (1)37, p. 46-63; A. Graczyk, *Świadczenia ekosystemow jako dobra ekonomiczne*, „Ekonomia i Srodowisko" 2010 No. (1)37, p. 64-76; A. Michałowski, *Ocena działań na rzecz zachowania świadczeń ekosystemów na etapie programowania rozwoju jednostek organizacyjnych*, „Ekonomia i Środowisko" 2010 No. (1)37, p. 98-113; see R. Costanza, I. Kubiszewski, *The authorship structure of „ecosystem services" as a transdisciplinary field of scholarship*, „Ecosystem Services" 2012 No. 1(1), p. 16-25.

[6] *The Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Synthesis*, Island Press, Washington 2005.

agement, flood prevention, water retention, underground water supply, prevention of soil deterioration, humus formation and fertility maintenance, solar energy absorption and biomass production, recycling of organic matter and nutrients, accumulation and recycling of anthropogenic waste, regulation of biological control mechanisms, life space maintenance for the purpose of reproduction, socialization and mobility, biodiversity maintenance, stabilization of ecosystems,

- services of space preparation for the anthropogenic use – settling, cultivation, energy use, leisure and tourism,
- information services – aestheticism of nature, stimulation and reward patterns in society, sense and socialization patterns, gene pool for agriculture and medicine, historical information, cognition patterns.[7]

Constant development of environment economy and economic research on sustainable development[8] forces modification and supplementation of different economic categories, including ecosystem services[9]. Graczyk emphasizes the fact that in order to define ecosystem services, one has to adopt the point of view of a microeconomic entity that makes choices in their economic activities. Such entities include companies and households (consumers). Environment functions that are significant from their perspective might be limited to the following three dimensions:

- environment as a supplier of production factors – it is a function of supplying production factors as primary goods (e.g. raw materials, fish) and the goods that result from intended actions of men (e.g. cultivated plants),
- environment as a service – environment is a system that facilitates the transfer of costs and benefits by the collection of wastes and pollutants and by generating direct benefits,

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[7] E. Kośmicki, *Globalne zagrozenia bioroznorodnosci a problem swiatowego kierowania*, in: *Teoretyczne aspekty ekonomii zrownowazonego rozwoju*, ed. B. Poskrobko, Wydawnictwo Wyższej Szkoly Ekonomicznej, Bialystok 2011, p. 34-58.

[8] e.g. H. Rogall, *Nachhaltige Okonomie. Okonomische Theorie und Praxis einer Nachhaltigen Entwicklung*, Metropolis Verlag, Marburg 2009; *Ekonomia zrównoważonego rozwoju. Zarys problemów badawczych i dydaktyki*, ed. B. Poskrobko, Wydawnictwo Wyższej Szkoly Ekonomicznej, Białystok 2010.

[9] e.g. R. Muradian, E. Corbera, U. Pascual, N. Kosoy, P.H. May, *Reconciling theory and practice: An alternative conceptual framework for understanding payments for environmental services*, „Ecological Economics" 2010 No. (69)6, p. 1202-1208; R.B. Norgaard, *Ecosystem services: From eye-opening metaphor to complexity blinder*, „Ecological Economics" 2010 No. (69)6, p. 1219-1227; I.J. Bateman, G.M. Mace, C. Fezzi, G. Atkinson, K. Turner, *Economic Analysis for Ecosystem Service Assessments*, „Environmental and Resource Economics" 2010 No. 48, p. 177-218; A. Balmford, B. Fisher, R.E. Green, R. Naidoo, B. Strassburg, R.K. Turner, A.S.L. Rodrigues, *Bringing Ecosystem Services into the Real World: An Operational Framework for Assessing the Economic Consequences of Losing Wild Nature*, „Environmental and Resource Economics" 2010 No. 48, p. 161-175; B. Fisher, S. Polasky, T. Sterner, *Conservation and Human Welfare: Economic Analysis of Ecosystem Services*, „Environmental and Resource Economics" 2010 No. 48, p. 151-159; A. Michałowski, *Przestrzenne usługi środowiska w świetle założeń ekonomii zrównoważonego rozwoju*, „Problemy Ekorozwoju"/"Problems of Sustainable Development" 2011 No. 6(2), p. 117-126.

- environment as a state – this perspective considers environment as a generator of conditions that are necessary to perform actions, i.e. a possibility to do activities that contribute to better prosperity.[10]

The above perspectives correspond to conscious and unconscious requirements of different subjects and consumers. Meeting those requirements by the environment generates benefits, while ecosystem devastation results in obtaining insufficient profits. Therefore, the entities that plan to undertake their activities should consider changes in the intended features of natural environment which form the intended functions of their economic objectives. From the economic point of view, ecosystem services may be defined as performing service functions (transferring costs and benefits) and the functions of state (generating conditions for activities) by the ecosystems.

Poskrobko notices that ecosystem services may be interpreted from two perspectives: bio-ecological and socio-economic.[11] The former considers ecosystem services as all natural processes that form a developmental niche for a man and ensure evolution-driven quality of life basis. The latter approach interprets ecosystem services as those ecosystem processes that have significant impact on economic activities, e.g. the functioning of nutrient circulation or plant pollination. According to this view, services should be regarded as values, powers and natural processes, along with their effects which generate non-resource economic values, necessary for the development of society-economy-environment macrosystem and the functioning of production processes. Anthropogenic infringement upon ecosystem services forces incorporation of ecosystem services into economic analyses, as it deteriorates natural foundations of human life and increases the manufacturing costs. The problem of understanding and defining ecosystem services needs to be discussed more deeply.

Considering the foundations of contemporary ecology and the results of the quoted researches and reports as well as their discussions, ecosystem services – according to the author – may be defined in the following way: ecosystem services include all the processes in ecosystems supplied by living organisms and geophysical powers which process the matter, energy and information in a positive manner from the perspective of socio-economic processes and the development of society-economy-environment macrosystem. On the basis of the above definition, the author distinguishes the following main streams of ecosystem services:

- material – as temporary economic effects of processing matter in the society-economy-environment macrosystem, e.g. biomass production, waste decomposition,

[10] A. Graczyk, *Swiadczenia ekosystemów jako dobra ekonomiczne*, „Ekonomia i Środowisko" 2010 No. (1)37, p. 64-76.

[11] B. Poskrobko, *Kategorie: gospodarowanie, bogactwo i kapital w ekonomii zrownowazonego rozwoju*, in: *Ekologiczne uwarunkowania rozwoju gospodarki oraz przedsiebiorstw*, ed. J. Famielec, Uniwersytet Ekonomiczny, Kraków 2011, p. 21-40.

- energetic – as temporary economic effects of processing energy in the society-economy-environment macrosystem, e.g. solar energy accumulation in living organisms' tissues, transferring energy from the Earth's interior,
- information – as temporary economic effects of processing information in the society-economy-environment macrosystem, e.g. scientific and artistic inspiration, beauty of the nature, genetic information.

The function of total stream of ecosystem services can be expressed in the following formula: $ES(t) = F[ES_M(t), ES_E(t), ES_I(t)]$, where $ES(t)$ – total stream of ecosystem services, $ES_M(t)$ – stream of material ecosystem services, $ES_E(t)$ – stream of energetic ecosystem services, $ES_I(t)$ – stream of information ecosystem services. The analysis of constant time, provides a possibility to define the density of total stream. It is a derivative of a given function, under condition that the function is constant and differentiable. The density of stream at t point is defined with the following formula: $ES'(t) = F'(t)/dt$. Different types of ecosystem services can be distinguished in different groups of streams. Their further classification entails further theoretical work and empirical experiments on ecological economics and sustainable development with consideration to time in ecosystems. All ecosystem services have their spatial dimension.[12]

The proper interpretation of ecosystem services requires the researcher to employ the perspective of analyzing natural environment as a basis of all nations' wealth. From the most general perspective, wealth is a factor satisfying needs and wants. It is differently perceived by people in different social situations. In the mainstream theory of economics, wealth does not have a status of an economic category. Instead, the terms capital and added value are used and the wealth of a nation is measured in its domestic product. It seems that the largest mistake of classical economics was regarding natural resources as free goods which gained value only when acquired. Such an approach has led to colonization of the nature as purposeful interaction of a man with ecosystems and their processes regardless of the outcomes. Colonization of the environment brought significant changes in the circulation of matter, energy flows and information transfer in ecosystems. The present generation lives and develops at the cost of the coming generations. The economy of environment and sustainable development should lead to decolonization of natural environment, what requires new rules of functioning for the economic system and measuring the effects of developmental activities. Considering natural environment as a basic component of nations' (countries') wealth should become a key assumption.[13]

The author believes that ecosystem services should be analysed and researched in dynamic perspective with an account of temporal category. Special

[12] see A. Michałowski, *Przestrzenne usługi środowiska...*, op. cit.; A. Michałowski, *Ekonomiczne podstawy usług srodowiska*, „Optimum. Studia Ekonomiczne" 2011 No. 6.

[13] B. Poskrobko, *Filary ekonomii zrównoważonego rozwoju,* in: *Ekonomia zrownowazonego rozwoju. Materiały do studiowania*, ed. B. Poskrobko, Wydawnictwo Wyzszej Szkoly Ekonomicznej, Bialystok 2010, p. 132-160; see e.g. E. Kośmicki, *Główne zagadnienia ekologizacji społeczeństwa i gospodarki*, Agencja Wydawnicza Ekopress, Bialystok 2009.

attention must be paid to economic consequences of the manifestations of time in ecosystems. Full understanding of the role of time in ecosystems is possible by comprehending the dynamics of species that take part in the process. Changeability of stand composition is an important feature of secondary succession. It results from regression of certain species and progression of others. These mechanisms are of strictly demographic character. Dynamic analysis of ecosystem phenomena cannot neglect the role of distribution and relocation of specimens in space. In succession processes the relations of a population to space change, especially the frequency of occurrence and the means of filling the space. They can have different character – certain species increase their frequency in time and space, others appear exclusively in selected places. The time and means of filling the space by a given species can influence significantly the organization and dynamics of ecosystem and the quality of ecosystem services streams.

The conditioning of time in ecosystems

In the theory of ecosystem service management temporal conditions refer primarily to the problem of natural resource exploitation, especially to renewable resources. They encompass those which can be reused after procession and use. From the perspective of human life in a sense of real time, renewable resources can be reused without any temporal limitations. The theory of economics offers a number of analytical approaches to temporal aspects of renewable and non-renewable natural resource management. One of the solutions is basing natural resource management on classical optimization harvesting, and particularly on the concept of Maximum Sustainable Yield (MSY). It offers a formal model that clearly explains the relations in renewable resources exploitation. However, it has a disadvantage related to the fact that renewable resource exploitation rarely means harvesting only one species. This brings the problem of weight definition, which is crucial in estimating the significance of other variables in the model. Another disadvantage of the concept is model sustainability which is exceptionally rare in real natural systems. Gordon's theory of rent-seeking is closer to reality. According to the theory, the balance between the industry and renewable resources will take place at the moment of equating streams of incomes with the level of costs. At the moment when income increases, the exploitation of outsiders starts, whereas in reverse situation there is a flow of capital to other branches of production. Moreover, the concept epitomizes the possibility of total exploitation of resources. The use of both concepts gives foundations to modeling the methods of natural resource preservation in a form of public goods, e.g. biodiversity or species population. The concepts can also be used with regards to ecosystem services.[14]

[14] see S. Czaja, *Czas w ekonomii...*, op. cit.

Temporal aspects of non-renewable resource management also generate significant problems related to the time range of their exploitation and allocation. From an economic point of view, Malthus's and Ricardo's paradigms influence the solution of these problems to largest extend. According to the former, there is an absolute limitation of resources, while in the latter there is no absolute exhaust of resources but the increase of exploitation costs resulting from the decrease of income. Malthus's approach does not account for the shift of temporal limitation of resources in the processes of new discoveries, technological development and changes of resource consumption. Ricardo's approach allows overcoming the limitations of Malthus's paradigm. Additionally, it is more flexible in analysing time range of non-renewable resource exploitation. Other problems arise with regards to non-renewable resource exploitation. They derive from the approach proposed by Hotelling. While traditional approach assumes the criterion of economic surplus maximization in microeconomic calculations, Hotelling's model makes assumption that the owner of natural resource deposits is the price taker and aims at maximization of the current value that is understood as the sum of discounted allowances from the resource exploitation. The allowance is a difference between what the purchasers want to pay for a unit of the resource and what the seller has to charge for delivering the unit to the market. Contemporarily, Hotelling's rule accounts for a few additional elements, including technological advancement, discovering new resource deposits and external costs in the light of preserving optimization conditions. Another problem is the inter-period allocation of resources. The problem appeared in the theory of economics with the publication by Ramsey[15] who rejected the idea of time discounting as unethical. Other opponent of discounting such as Arrow, Solow, Rawls and Sena also refer to Ramsey's point of view. Supporters of discounting emphasise, among other arguments, the consequences for man's survival and life opportunities for the future generations. As far as natural environment is concerned, the problems of discounting and monetary evaluation refer to legitimacy of the valuation of biotic and abiotic elements of ecosystems and the advisability of protection policy. Binding the issues of ethical with temporal reference facilitated the search for appropriate means of natural resource exploitation, on the other hand, it complicated the problem, particularly with reference to sustainable development and fighting with global ecological problems, including the decrease of ecosystem service quality.[16]

One of the most vital problems of sustainable development and ecosystem service management is to clearly understand the range and time frame of developmental processes. All dynamic phenomena, including sustainable development, function in cyclic systems. The most broadly discussed cycles in economics include civilization cycle, Kondratiev cycle, and business cycle. Society-economy-environment macrosystem is at different phases of known and unknown developmental cycles at a given moment. Each of the systems in society,

[15] F. Ramsey, *A Mathematical Theory of Savings*, „The Economic Journal" 1928 No. 38, p. 543-559.
[16] S. Czaja, *Czas w ekonomii*..., op. cit.

economy and environment changes in a specific developmental cycle.[17] Economic system develops at a very fast rate. Environmental system is based on differentiated natural cycles, which are very difficult to control. The development of the society is a resultant of changes in economy and in the society. Consequently, the macrosystem that is not in the dynamic equilibrium can be on the way to it. Therefore, the evaluation of the level of sustainable development implementation can be performed in suitably long time perspective. With regards to ecosystem service management the evaluation should consider the range of time in ecosystems.

Borys identifies boundary conditions for the economics of sustainable development. They have the characteristics of time in ecosystems. They should also constitute a basis for the sustainable ecosystem service management in dynamic approach to ecological processes, as they reflect the developmental properties of ecosystems. The most important temporal ranges of boundary conditions in society-economy-environment macrosystem should include the rules of development durability, rules of development sustainability, rules of development maintenance, integrated order and the rule of responsibility.[18]

Durability rules correspond to its specific variants and are assigned to defined ethical areas. They reflect different levels of social, economic and ecological reference and the existing conflict between conservative and expansive ways of management. Durability is graded according to restrictiveness of natural capital retention rules, which reflect the transition from ideal capital substitution to their increasing complementarity and domination of nature capital. The development that executes weak rule of durability (based on ideal capital substitution) means preserving the whole capital, regardless of its structure – nature capital, anthropogenic capital, human capital. Such a development is typically conventional and considers the most obvious requirements concerning resource management and ecosystem services. The development based on sensible and moderate rule of durability require the preservation of total capital with defined values of its individual elements. The development that executes strong rule of durability requires the preservation of each component of capital separately, because nature capital, anthropologic capital and human capital do not substitute one another. It has particular significance with relation to ecosystem services. From this perspective, maintaining nature capital and high level of ecosystem service quality are the key conditions of development. The development can be based on even more restrictive rule of durability that prohibits any exploitation of non-renewable resources, while renewable resources can be used to such a degree that allows for their renovation in the subsequent periods.

[17] B. Poskrobko, *Cykliczność, trwałość i równoważenie rozwoju*, in: *Zrównoważony rozwój. Wybrane problemy teoretyczne i implementacyjne w świetle dokumentów Unii Europejskiej*, ed. B. Poskrobko, S. Kozłowski, Wydawnictwo Wyższej Szkoły Ekonomicznej, Bialystok 2005, p. 19-36.

[18] T. Borys, *„Warunki brzegowe" ekonomii zrównoważonego rozwoju*, in: *Ekonomia zrównoważonego rozwoju w świetle kanonów nauki*, ed. B. Poskrobko, Wydawnictwo Wyższej Szkoły Ekonomicznej, Bialystok 2011, p. 51-68.

The rules of sustainability bring balance to preservation of anthropogenic, human and natural environments. The emphasis the necessity to improve life quality of the present and future generations by shaping proper proportions between different components of the total capital, including ecosystem services.

The rules of development self-maintenance emphasise inter-generation and intra-generation justice. Their manifestation is related to the drive to satisfy the needs of the present and future generations and to improve broadly understood life quality as a supreme objective. Positive evaluation from at least anthropocentric system of values is a significant feature of development self-maintenance.

Integrated order is a positive ultimate objective of temporal developmental changes. It is a landmark for the changes characterised by the strong rules of durability, sustainability and self-maintenance. It means coherent and simultaneous formation of social, economic and environmental order. There are two approaches to integrated order: hierarchical and the one that does not differentiate the importance of each order. The former is characteristic for traditional developmental paradigms, while the latter – for the new paradigm of sustainable development. Hierarchical approach puts emphasis on the superiority of environmental order over economic or social one.

The rule of responsibility is one of the central categories of general ethics and axiology. Responsibility forms the basis of man's genuine identity and his/her awareness of the role they play in the economy. It can be referred to all activities in institutions and organizations, including entities of the economy, business and its sectors, the country and politics. In socio-economic practice, there are three approaches to responsibility, which also have time in ecosystems dimension. The first two approaches are characteristic for old economic paradigms, while the third one is an axiological boundary condition for sustainable economy. According to this condition, a man is good by nature; however, in the moments of weaknesses he rejects his nature as a result of mistakes in his upbringing or the pressure from his environment. Responsibility is represented in a number of dimensions: legal, economical and financial, social and ecological. In ecosystem service management these dimensions must be analysed in the perspective of time in ecosystems.

Czaja emphasises two basic interpretations of temporal dimension with relation to sustainable development strategy – epistemological and implementational.[19] Both of them are significant in sustainable ecosystem service management with regards to time in ecosystems. The former interpretation concerns abstract time, while the latter adopts real, astronomical or calendar dimension. In epistemological interpretation time is related to the essence of sustainable development and its attributes, considering time as a limited dimension and the evolution of sustainable development objectives. The use of implenetational interpretation is concerned with the possibility to control the pace of processes in time, their temporal coordination and time range of sustainable development strategy. The issues get even more complicated when dynamic ecosystem processes in

[19] S. Czaja, *Czas w ekonomii...*, op. cit.

ecosystem services are taken into account. Vast majority of them is of chaotic character, their trajectories and paces change in a completely different manner than on the basis of simplified models of traditional economics. Therefore, a system of gathering, processing and utilizing information on dynamic ecosystem processes should be constructed. With regards to research, it is necessary to broaden their scope by randomness – risks and uncertainty in the scale of time in ecosystems and changes in pace.

Sustainable ecosystem service management requires considering broader range of information about dynamic processes in ecosystems. It is in line with the foundations of sustainable economy and knowledge-based economy. The processes of ecosystem service management occur in the circumstances of increasing ecosystem complication in time during primary succession (which takes place in primary ecosystems) and secondary succession (in devastated ecosystems). The continuity of fauna and flora in a given ecosystem leads to qualitative and quantitative biodiversity, whose condition corresponds to a given set of ecosystem service streams and their density – expressed in natural or monetary units.

The main disorders of relations in ecosystems trigger succession, which is a form of their regeneration. Along with succession, the reconstruction of biocenoses occurs, including animal and plant species. The theory of ecology proves that such process does not equal the return to the conditions from before the devastation. This results from the decrease of species diversity and reconstruction of food chains that is based on their shortening. The share of smaller organisms with short life cycles and quick metabolism increases. The share of big organisms characterised with slow development decreases. Succession processes can be quickly broken by environment management. One of the examples is cultivation of annual plants. Succession may also proceed uninterrupted, as it is in case of forest planting and agricultural cultivation with limited ploughing. Succession changes in individual groups of organisms have different speed and pace. The development of flora is long if compared with the speed of changes that take place in organisms whose life is measured in days or hours. These differences clearly explain the lack of concordance between the diversity of autotrophic and heterotrophic organisms. For instance, the research conducted in prairie for many years showed the contradiction between the world of animals and plants. In the period of decreased plant diversity during the development of high prairie and the increase of plant biomass, a reverse tendency was observed in the group of invertebrates. In the grazing prairies as little as half of the number of arachnids were found, in comparison with non-grazing prairies. Similar results were obtained in research on prairie insects and mammals, which obviously prefer high trees to grazing low-prairie communities. Birds, however, behave in an opposite way to the rest of animals. They favour open plant communities in low grazing prairies, where they find better conditions for nesting and gathering food. The presented contradiction in the development of biodiversity constitutes a significant obstacle in ecosystem service management as far as the choice of priorities and streams is concerned.

Sustainable environment service management with regards to time in ecosystems includes interaction with succession processes. The theory of biodiversity exposes practical problem of ecosystem management that concerns the appearance of new species in the time space. It can be analysed in three dimensions:

- the appearance of new species which can settle ecological niches – this is a natural phenomenon of biodiversity change and increase in time,
- reintroduction of species which disappeared for various reasons – it allows to accelerate succession or facilitate the appearance of new species which are suppressed by natural ecological barriers; it leads to changes in the increase of biodiversity,
- the appearance of species that are stranger to their native habitat, e.g. from other areas of Europe and the continents – it is related to introduction and bringing in alien species, what can cause the displacement of native species from the ecosystems; alien species usually demolish existing relations and facilitate the introduction of other new species into ecosystems.

Disturbances and regressions of ecosystems lead to regeneration of the state similar to the previous or the formation of the system with different biodiversity, which conditions ecosystem service streams. In the first stage of succession this can refer to regeneration of natural processes of ecosystem services, e.g. energetic, which are based on a simplified internal structure. However, previous elements or even redundant structures that extensively secure the same processes may not regenerate. In sustainable ecosystem service management it is indispensible to maintain the critical structures that secure certain sets of streams. Maintaining all redundant structures generates the increase of costs. The objectives of ecosystem service management should be based on scientifically proven social, economic and ecological justification with regards to biodiversity and its changes in different scales of time in ecosystems and various ecosystems. The need to optimize the stability in local and global service management should be accepted. Their maintenance may be self-excluding in the static approach, however, in the dynamic analysis of time in ecosystems, the set of service streams may be evaluated and valued (including monetary valuing) in a given time frame, e.g. 100 years. The selection of management methods becomes more flexible with the adoption of time in ecosystems in sustainable environment service management. However, such a process entails providing significant amount of information and basing all the environment management processes, including those unregistered by the market, on knowledge.

The problem of time in ecosystems in ecosystem service management is closely related to changes in biodiversity. According to Odum[20] and Margalef's[21]

[20] E.P. Odum, *The strategy of ecosystem development*, „Science" 1969 No. 164, p. 262-270; see e.g. F.E. Clements, *Plant succession and Indicators*, H.W. Wilson, New York 1928; H.R. Delcourt, P.A. Delcourt, *Quaternary landscape ecology: Relevant scales in space and time*, „Landscape ecology" 1988 No. 2(1), p. 23-44; K. Falinska, *Ekologia roslin*, PWN, Warszawa 2004.

[21] R. Margalef, *Perspectives in Ecological Theory*, University of Chicago Press, Chicago 1968.

theory, the biodiversity indicators increase from initial stages of succession to the final ones. More detailed elaborations on selected groups show that the increase of biodiversity is not monotonous because the indicators can reach higher values also in transitory stages. The relation between qualitative and quantitative states of biodiversity with ecosystem stability is one of the controversial issues. It is not clear whether biodiversity leads to the stability or if it is the other way round.[22] One should, however, notice that in more diverse ecosystems there are more alternative elements that process matter, energy and information, what ensures the maintenance of ecosystem services with lower risks and uncertainty.

Keeping appropriate set of ecosystem service streams is an important problem in environment management. They are results of ecosystem processes performed by species diversity. Ecologists proved that certain moderate ecosystem disorders change and increase biodiversity. Numerous disturbing agents are also neutral, e.g. appearance of herbivores, natural gaps in the forests, fires, fallen trees, boar rooting, cracking. There is a model in the theory of ecology in which ecosystem diversity is closely related to environmental stress – mowing, grazing, water and food availability.[23] According to this model, ecosystems with very low and very high stress are the habitat of very few species, while moderately stressed areas are biologically more diversified. Appropriate timing of mowing, grazing or removing fallen trees can maintain proper biodiversity from the point of view of a selected set of ecosystem service streams. It is achieved by suppression of more vigorous species i.e. potential dominators, and generating opportunities for other species. Properly selected environment management processes can lead to the preservation of service stream's data at a given spatial-temporal section. One should remember that ecosystem management at early stages of succession allows for easier and more profitable generation of particular streams of ecosystem services. All of the analysed problems of time in ecosystems require incorporating knowledge-based economy, the theory of ecological economy and sustainable development, especially with regards to the category of ecosystem services.

Final remarks

Time in ecosystems is an inseparable element influencing the phenomena and management processes in a form of a fourth dimension of the space-time or a logical consequence of events. The research problems should not focus on questioning whether to consider the role of time in ecosystems in management processes, especially with reference to sustainable management of ecosystem

[22] *Rożnorodność biologiczna: pojęcia, oceny, zagadnienia ochrony i kształtowania*, ed. R. Andrzejewski, R.J. Wiśniewski, Komitet Naukowy przy Prezydium PAN Człowiek i Środowisko, Zeszyty Naukowe No. 15, Instytut Ekologii PAN, Oficyna Wydawnicza, Dziekanów Leśny 1996; see A. Richling, J. Solon, *Ekologia krajobrazu*, PWN, Warszawa 2002.

[23] e.g. *Uwarunkowania ochrony rożnorodności biologicznej i krajobrazowej*, ed. L. Ryszkowski, S. Balazy, Zakład Badań Środowiska Rolniczego i Leśnego PAN, Poznan 1999.

services, but on the defining how the time must be understood and how to incorporate it to the theory of economics and economic practices.

In dynamic and mathematical approach, ecosystem can be defined as a deterministic mathematical formula which defines its evolution in the function of time. Time can be a constant or discrete variable expressed in integral values. In case of constant time, it can be expressed with a vectorial formula: $dE(t)/dt = F[E(t)]$, where E is a n-dimensional vector, dynamic ecosystem because for an initial state E(0) there is a possibility to solve the equation, with the aim to obtain future states of ecosystem E(t) for $t > 0$. In order to make this vectorial (differential) equation describe dynamic ecosystem additional assumptions need to be taken for the existence and explicitness of Couchy's equation for $t \in [0, \infty]$[24]. The path of ecosystem evolution is its trajectory. Such dynamic models can be used to research three interesting economical problems: model stability (ecosystem), connection link between the states of dynamic equilibrium and comparative dynamics. They should be related to the practical problem of the optimization of ecosystem service streams in society-economy-environment macrosystem in the light of the properties of time in ecosystems. Sustainable ecosystem service management must be based on dynamic economical and ecological models. Designing them is a challenge in terms of theory and implementation in ecological and sustainable economy.

[24] S. Czaja, *Czas w ekonomii*, op. cit.

STUDIA I MATERIAŁY

STUDIES AND RESEARCH WORK

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OVERCOMING BARRIERS TO THE USE OF ECOSYSTEM SERVICES FOR SUSTAINABLE DEVELOPMENT OF CITIES IN POLAND

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POKONYWANIE BARIER W WYKORZYSTYWANIU USŁUG EKOSYSTEMÓW NA RZECZ ZRÓWNOWAŻONEGO ROZWOJU MIAST W POLSCE

STRESZCZENIE: Miasta zależą od usług świadczonych przez ekosystemy miejskie i pozamiejskie. Jednak świadomość tego faktu jest relatywnie niska, co prowadzi do degradacji ekosystemów i – w konsekwencji – utraty możliwości korzystania z dostarczanych przez nie usług. Jak wynika z badania przeprowadzonego przez Fundację Sendzimira, problem ten jest w Polsce szczególnie widoczny. W badaniu zwrócono uwagę na instytucjonalne (administracyjne i społeczne) bariery ochrony miejskich ekosystemów. Uzyskano 103 odpowiedzi od ekspertów zajmujących się od strony badawczej i praktycznej zarządzaniem przyrodą w polskich miastach. Najistotniejsze wyłonione w badaniu bariery wiążą się z niedostatecznymi środkami finansowymi i niedostatecznym poziomem świadomości na temat znaczenia ekosystemów i świadczonych przez nie usług. Aby przeciwdziałać tym problemom, Fundacja Sendzimira zrealizowała kampanię promującą koncepcję usług ekosystemów wśród osób odpowiadających za zarządzanie przyrodą w polskich miastach.

SŁOWA KLUCZOWE: usługi ekosystemów, świadczenia ekosystemów, ekologia miasta, edukacja dla zrównoważonego rozwoju, TEEB Polska, ekonomia ekosystemów i bioróżnorodności

Introduction

The concept of ecosystem services appears more and more frequently in scientific publications and reports aimed at aiding the political decision making process. Two large international undertakings: the Millennium Ecosystem Assessment and The Economics of Ecosystems and Biodiversity (TEEB) have greatly contributed to the popularity of this concept. Similar initiatives have been undertaken in individual countries, towns and other administrative units around the world. The most ambitious of these projects was the UK's National Ecosystem Assessment.[1] One of the main conclusions of research carried out so far is that if people were better informed on the benefits derived from nature, social support for environmental protection would be greater, warranting the support of decision makers.

Experts began to address urban nature in the context of ecosystem services in the 1990s.[2] Separate chapters were dedicated to this topic in all major publications in the field of ecosystem services.[3] Each of these publications emphasised that the quality of life in a city depends not only on urban ecosystems, but also ecosystems surrounding the city which provide food and water, purify the air, create recreational opportunities, etc. Five of the most important issues which typically preoccupy urban decision makers and which illustrate the link between the state of nature and the potential of ecosystems to provide services are: the influence of the environment on health (a basic category of the quality of life); role of urban greenery in spatial planning; mitigating the negative effects of transportation; building social capital; and improving city image.[4]

Although the importance of nature has long been acknowledged also by researchers in Poland,[5] the framework of ecosystem services has not been explored

[1] UK NEA, *The UK National Ecosystem Assessment: Synthesis of key findings*, UNEP-WCMC, Cambridge 2011.

[2] P. Bolund & S. Hunhammar, *Ecosystem services in urban areas*, "Ecological Economics" 1999 No. 29(2), p. 293-301.

[3] G. McGranahan et al., *Urban systems*, in: *Ecosystems and human well-being: current state and trends (Millennium Ecosystem Assessment,* Vol. 1*)*, ed. R. Hassan, R. Scholes & N. Ash, Island Press, Washington, D.C. 2005, p. 795-825; H. Robrecht et al., *Ecosystem services in cities and public management*, in: *The Economics of Ecosystems and Biodiversity for local and regional policy makers*, ed. H. Wittmer & H. Gundimeda, TEEB, Leipzig 2010, p. 65-80; L. Davies et al., *Urban*, in: *UK National Ecosystem Assessment: Technical Report*, UNEP-WCMC, Cambridge 2011, p. 361-410.

[4] J. Kronenberg, *Urban ecosystem services*, "Sustainable Development Applications" 2012 No. 3, p. 14-28.

[5] C.f. A. Ptaszycka, *Przestrzenie zielone w miastach*, Ludowa Spółdzielnia Wydawnicza, Warszawa 1950; H.B. Szczepanowska, *Drzewa w mieście*, Hortpress, Warszawa 2001; A. Zachariasz, *Zieleń jako współczesny czynnik miastotwórczy ze szczególnym uwzględnieniem roli parków publicznych*, Wydawnictwo Politechniki Krakowskiej, Kraków 2006.

in this context. However, as the concept of ecosystem services is expected to contribute to better management of economy–society–environment interactions, it is worth exploring also in the Polish context. The Sendzimir Foundation carried out a research project on the barriers to the use of ecosystem services concept in Polish cities, the results of which are briefly reported in the following section. In response to the identified barriers, and in particular in an attempt to enhance the understanding and uptake of the concept in Poland, the Sendzimir Foundation carried out a number of activities, listed in section 3. These complemented other activities carried out with regard to urban ecosystem services in Poland so far. As suggested in the concluding section 4, further activities can be built on those that have been undertaken so far but cooperation is necessary to achieve more significant results.

Barriers to the use of ecosystem services in Polish cities[6]

In order to learn about the barriers to realising the potential of ecosystem services for urban sustainable development, the Sendzimir Foundation conducted a study on the barriers to preserving city trees. Trees are a particularly common element of urban ecosystems and the benefits that they convey to people are relatively well known.[7] Long-term urban tree maintenance is an obvious prerequisite for sustainable development because it provides an opportunity for future generations to benefit from their services. Therefore, the problems related to preserving urban trees and those hindering the use of urban ecosystem services should have a common origin. The focus of the study was on trees growing along streets, within housing estates and next to buildings since these are the most visible elements of urban ecosystems, and at the same time the most exposed and least protected from the negative impacts of urban activity. The study concentrated on large cities, with a population exceeding 100,000 residents, but also encompassed towns of 50,000 – 100,000 residents.

Most debates concerning urban tree-related issues refer to the phenomena hindering tree growth which are related to transport and infrastructure development (e.g. soil salinity and hardening, air pollution, lack of space for root systems).[8] Our study sought to understand where these problems originate. Why is it that nature's potential to support urban development and increase quality of life is not exploited? Aiming to answer such questions, this study began by iden-

[6] For a more detailed overview of the study, see: J. Kronenberg, *Barriers to preserving urban trees and ways of overcoming them*, "Sustainable Development Applications" 2012 No. 3, p. 31-49.

[7] Nevertheless, we keep being surprised by the positive impacts of trees. A recent study discovered that urban greenery absorbs 8 times more pollutants than previously thought: T.A.M. Pugh et al., *Effectiveness of Green Infrastructure for Improvement of Air Quality in Urban Street Canyons*, "Environmental Science & Technology" 2012 No. 46(14), p. 7692-7699.

[8] C.f. H.B. Szczepanowska, op. cit.

tifying the institutional (both administrative and social) barriers to preserving or increasing the number of trees in the centres of Polish cities. The study also attempted to find ways of removing these barriers so that trees can begin to be more consciously used for the benefit of sustainable urban development in Poland.

The notion of institutional barriers has been taken from institutional economics.[9] Administrative limitations encompass a lack of appropriate policies, strategies or other actions that could solve a given problem; problems with actions that have been undertaken (e.g. inappropriate goals or tools); and problems with policy implementation due to inappropriate actions on the part of public officials. In short, these limitations stem from a lack of appropriate administrative actions, which in turn may result from a lack of appropriate knowledge or institutional possibilities. Social limitations are associated with a lack of social mobilization or empowerment to act, in other words the failure to include society in decision making (aka social participation).

The survey was carried out in 2011. It was based on individual questionnaires and respondents were experts in issues related to urban trees in Poland. The sample was chosen deliberately so as to include individuals who actively take part in debates in this field. Of 103 complete responses, 59 came from local administration officers, 37 from researchers, 5 from private sector employees, and 2 from other experts. Notably, the average number of years of experience in the field of urban greenery among participants was 13.5.

The number one administrative barrier is insufficient funds for the maintenance of green areas (Figure 1). Another obvious barrier to preserving trees and nature in cities is the low prevalence of localised spatial management plans in most large cities in Poland, which means that decisions on urban development are based on subjective criteria. Half of the six most important barriers were associated with inappropriately carried out tree and shrub maintenance activities. Other barriers were associated with unclear policy: regulations that downplay the significance of greenery or limit the possibilities for taking action to protect it in cases of conflict with other interests (e.g. infrastructure development). A clear preference for other interests in major legal documents unrelated to environmental protection limits public officials' action in protecting nature. Many of the identified barriers linked directly to poor understanding of ecosystem services. A prominent example was the perceived lack of economic interest associated with urban tree protection, which reflects the dominant way of thinking about city trees among the Polish decision makers. This was linked with two other barriers: neglect for the benefits (services) provided by trees in towns' and cities' economic accounts, and a lack of awareness of the importance of trees among decision makers. Furthermore, the lack of incentives which could encour-

[9] J.B. Opschoor, *Institutional change and development towards sustainability*, in: *Getting Down to Earth: Practical Applications of Ecological Economics*, eds. R. Costanza, O. Segura & J. Martínez-Alier, Island Press, Washington, D.C. 1996, p. 327-350; *Challenges of Sustainable Development in Poland*, eds. J. Kronenberg & T. Bergier, Sendzimir Foundation, Krakow 2010, p. 23-25, www.sendzimir.org.pl/textbook [Date of entry: 10-09-2012].

age appropriate behaviour, including regulations to support the development of greenery in Polish cities, was also highlighted.

Among social barriers, the most important one was that society perceives other issues, such as parking spaces and new buildings, as more pressing than preserving trees (Figure 2). According to respondents, the second most important barrier was residents perceiving trees as a problem, which in particular refers to shade, allergies and the cleaning up of leaves. The third most significant barrier was a lack of awareness of the importance of trees for quality of life. Whilst there are both supporters and opponents of trees, the arguments of opponents are often more persuasive in society. This relates to neglect for public space in Poland and more importantly a lack of awareness that things could look different. The fourth most important barrier – individuals' bad habits – refers mainly to unprofessional tree maintenance by private individuals whose actions are often unauthorised, as is typically the case with tree topping. However, people who wish to protect trees from these and other types of pressure are often not familiar with the possibilities and methods of counteracting damage done to trees in their neighbourhood. Residents usually do not know where to report such cases, and the institutions that they turn to are often unwilling to assist, which quickly discourages them from taking further action. The "trees have always been and always will be" type of thinking, which ranked sixth, assumes that no matter what people do, trees will remain a permanent element of the landscape. The fact that town residents fail to notice trees is associated with the relatively high prevalence of trees, but also most likely a lack of interest in nature. It is not surprising then that households do not include tree services in efficiency analysis (such as reduced energy consumption due to trees protecting sites from wind or sunlight or the positive influence of trees on real estate value).

Proposed routes for action correspond to the identified barriers. Respondents chose guaranteeing higher funds for urban greenery maintenance as their number one solution (Figure 3), which corresponds to the financial barrier identified as the main administrative barrier. Effective law enforcement and execution of properly carried out work match the other respective administrative barriers. Respondents also found clearing up legal acts necessary, such as removing incoherent provisions and clarifying imprecise phrases. A thorough review of relevant legislature is needed that takes into account new knowledge on ecosystem services and their significance in sustainable development of towns and cities and the country as a whole. The achievement of these goals requires social support. The key issue is raising awareness among residents and explaining to them why these actions are so important, so that they become the allies, instead of the opponents of urban nature protection. Information and education are therefore essential to put pressure on politicians to make the relevant legislation more effective. These two issues, closely related to preserving trees in cities, are also key to increasing the involvement of individuals in nature protection and care for public space. Given the commonly perceived lack of economic justification for urban tree protection, popularisation of the ecosystem services concept could play a crucial role. The benefits conveyed by nature do have an

Figure 1.
The number of indications of different institutional barriers to preserving urban trees according to their ranking (N = 293, respondents were asked to identify the 3 most important barriers)

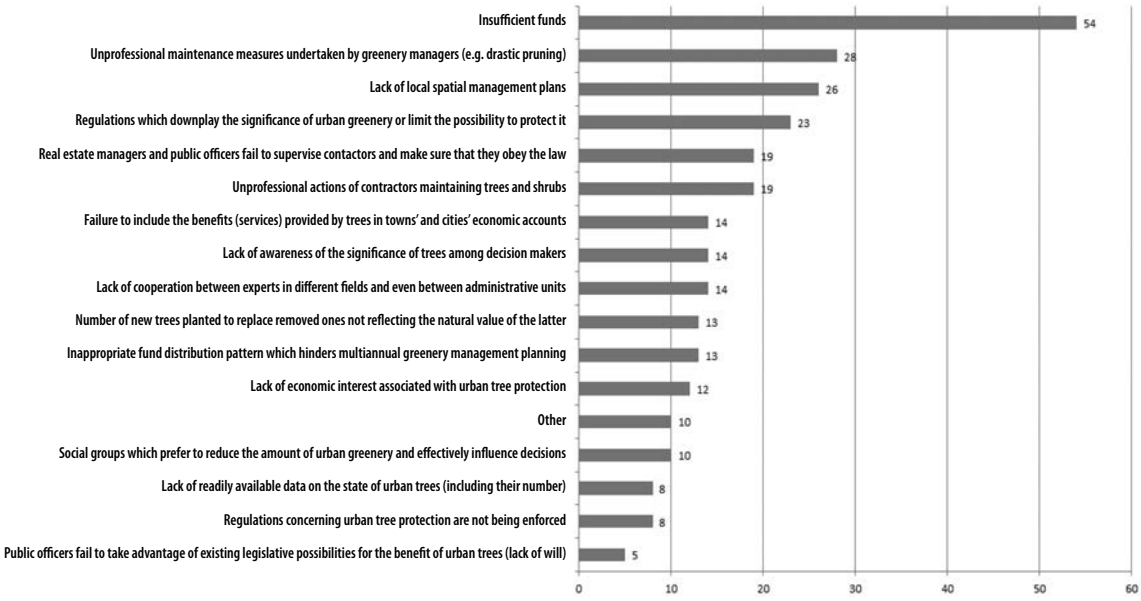


Figure 2.
The number of indications of different social barriers to preserving urban trees according to their ranking (N = 285, respondents were asked to indicate the 3 most significant barriers)

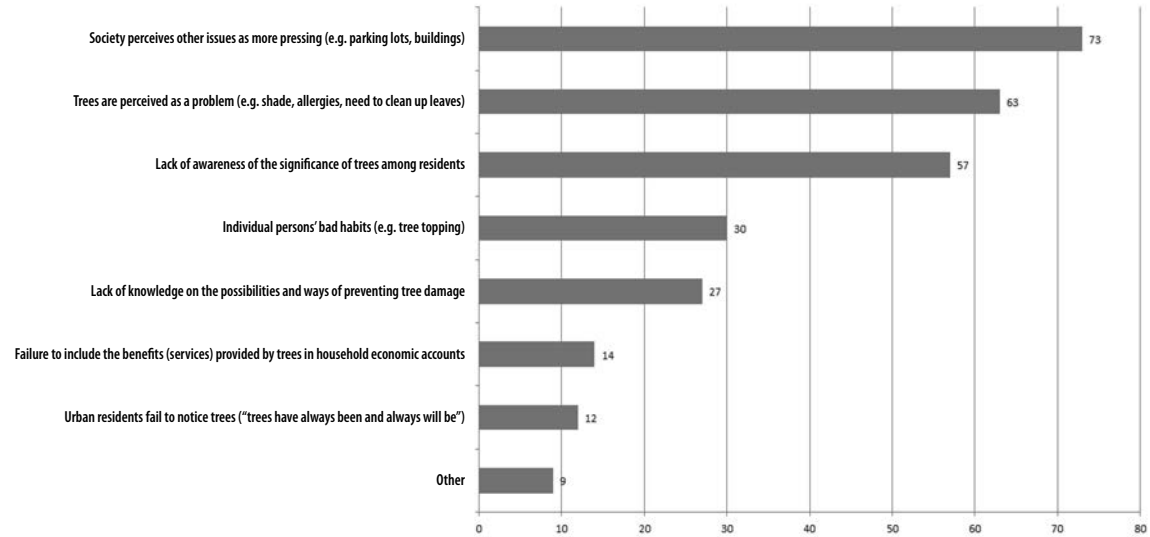
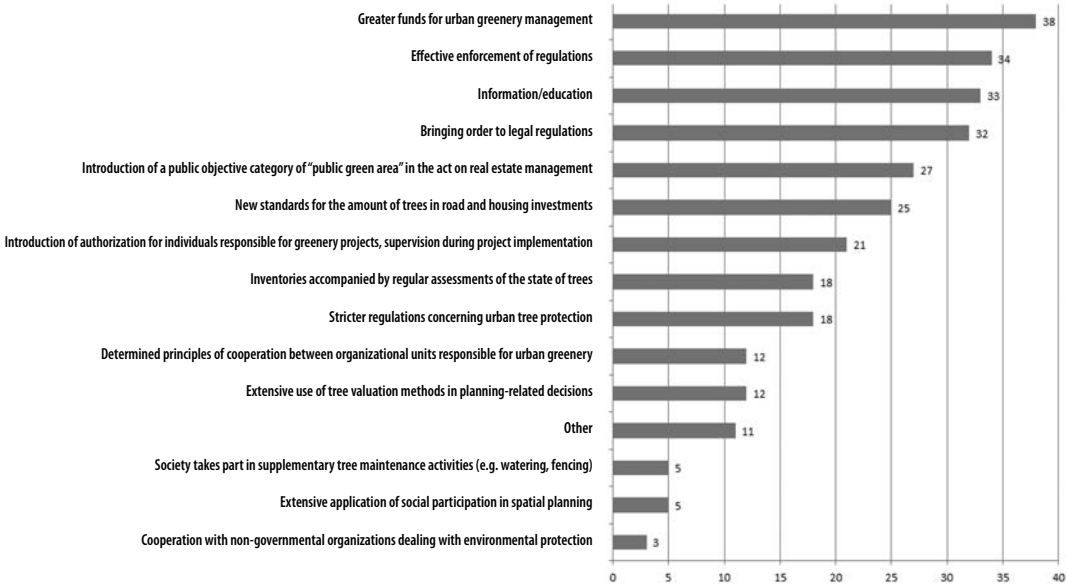


Figure 3.
The number of indications of different ways of overcoming barriers to preserving urban trees according to ranking (N = 300, respondents were asked to indicate the 3 most significant ways of overcoming barriers)



economic dimension and can be compared favourably with the costs of protection. Nature degradation and the associated loss of its services presents an opportunity cost which must be included in financial feasibility analyses of specific actions.

The above findings clearly indicate a need for awareness raising activities to be carried out by various stakeholders, including the government, local and regional authorities, NGOs, research institutions, individuals and international organisations. It is within this framework that the Sendzimir Foundation carried out the project entitled "Ecosystem services for sustainable development of cities".

"Ecosystem Services for Sustainable Development of Cities" project

The Sendzimir Foundation's project "Ecosystem Services for Sustainable Development of Cities" was carried out in the years 2011 and 2012. It included a number of activities aimed at promoting the concept of urban ecosystem services in Poland, the most important of which are briefly described below. Thus, project activities focused on alleviating the above identified barriers linked directly to poor understanding of ecosystem services. The project was carried out with formal endorsement of ICLEI – Local Governments for Sustainability, an international association of local authorities, as well as the Ministry of Environ-

ment, the Union of Polish Metropolises, and the Mayor of Lodz and the Marshal of Lodz Region.

Several of our activities concentrated in Lodz. This city is a particularly interesting case because it developed rapidly in the 19th century as the most important centre of the Polish textile industry and one of the largest textile manufacturers in Europe. One of the main reasons for the development of the city was a network of rivers and streams and wood resources that provided both water and energy required by the industry. However, although the city grew because of ecosystem services, today ecosystem services seem not to be a priority for city authorities and inhabitants. And Lodz is widely perceived as neglected, unattractive and unhealthy. Yet, Lodz was a candidate city for the 2012 and 2013 European Green Capital Awards and the fact that local and regional authorities agreed to endorse the Sendzimir Foundation's project provides an important political signal that the issues related to ecosystem services become important and that it will be possible to consider the findings of our project in local decisions and to build general awareness.

International conference at the University of Lodz

In July 2011, the Sendzimir Foundation, together with the University of Lodz, organised an international scientific conference on the value of urban ecosystem services. The conference was attended by participants from 20 countries, including globally recognised researchers. Keynote presentations were given by professors Jürgen Breuste, Dagmar Haase, and Åsa Jansson. Although the main objective of the conference was to exchange information and ideas and thus contribute to building the body of knowledge on urban ecosystem services, an important side objective was to promote the concept of ecosystem services in Poland and in particular in the host city of Lodz. For the latter reason, representatives of city authorities and other local stakeholders were invited to take part in the conference. A special local case study session was organised to seek advice from external experts on how to improve the management of ecosystem services in Lodz and to use a case study of Lodz to debate the problems of urban ecosystem services.

The discussions focused on ecosystem services at different levels penetrating the urban content: inner city, greater city and city–region interactions. The presentations linked to services provided by allotment gardens, urban parks, the sea, green roofs and other elements of urban nature. They referred to indicators, valuation and governance issues. Selected papers have been published in the special issue of *Landscape and Urban Planning*.[10]

[10] K. Hubacek, J. Kronenberg, *Synthesizing different perspectives on the value of urban ecosystem services*, "Landscape and Urban Planning" 2013 No. 109(1), p. 1-6.

The conference included a field trip presenting the concept of the Blue–Green Network that is being promoted in Lodz by the European Regional Centre for Ecohydrology.[11] Interestingly, the Blue–Green Network incited significant interest among the participants, providing yet another argument for local authorities to appreciate the economic and social potential of good management of ecosystem services.[12]

Workshops in Lodz and report for the city

In 2011, the Sendzimir Foundation organised its international Summer Academy "Challenges of Sustainable Development" in Lodz. One of the two elements of the Academy is the practical Local Sustainable Development Project within which participants work on a selected problem, based on real-life experience and meetings with local stakeholders.[13] In 2011, the Local Project focused on to how to employ the concept of urban ecosystem services to enforce sustainable development of Lodz. In a mutually supportive process, a series of workshops was organised within which the Academy participants assisted local stakeholders in solving the related problems, and the local stakeholders supported the participants in their work.

The participatory workshops were organised in cooperation with the Lodz City Office and referred to the importance of green areas in Lodz. The numerous and diverse group of stakeholders, together with the Academy participants, analysed the potential of Lodz to receive the title of the European Green Capital, as well as methods and activities to increase this potential by 2020. Indeed, Lodz had already applied for this title in 2010 but the application was unsuccessful. The outcomes of the workshops and other findings of the Local Project were described in the report, prepared by the Academy participants, which was presented to the Lodz City Office and is available in Polish and English at the Sendzimir Foundations' website. [14]

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[11] C.f. I. Wagner & M. Zalewski, *Ecohydrology as a basis for the sustainable city strategic planning: focus on Lodz, Poland*, "Reviews in Environmental Science and Bio/Technology" 2009 No. 8(3), p. 209-217.

[12] More information, along with presentations from the conference, can be found at: http://www.sendzimir.org.pl/seminar2011 [Date of entry: 10-09-2012].

[13] T. Bergier, J. Kronenberg, K. Maliszewska, *Szkoła letnia „Wyzwania zrównoważonego rozwoju w Polsce" – dwanaście lat doświadczeń*, in: *Edukacja dla zrównoważonego rozwoju: Główne problemy*, ed. T. Borys, Wydawnictwo Ekonomia i Środowisko, Białystok–Wrocław 2010, p. 393-405.

[14] O. Baltina et al., *Lodz as European Green Capital by 2020*, Sendzimir Foundation, Lodz 2011, http://www.sendzimir.org.pl/sites/default/files/Report%20Lodz%20as%20European%20Green%20Capital%20by%202020.pdf [Date of entry: 10-09-2012].

Coalition for Sustainable Development of Lodz

As a follow up to the above activities, the Sendzimir Foundation has initiated the Coalition for Sustainable Development of Lodz. The Coalition is meant to comprise organisations, companies and institutions which represent the three socio-economic sectors and are interested in collaborative action on the city's sustainable development. The idea is based on similar coalitions operating in other cities, such as Brighton and Hove City Sustainability Partnership, San Diego Regional Sustainability Partnership, or Dearborn Sustainability Coalition.

Towards the end of 2011, the newly created Coalition took active part in public consultations of the development strategy of Lodz. The draft "Integrated Development Strategy Lodz 2020+" that had been presented by city authorities did not include any reference to environmental protection. As a result of several discussions held by the Coalition's members, a statement was prepared commenting on the shortcomings of the municipal document. One of the ideas highlighted in that statement concerned the need to refer to ecosystem services, along with explanations why the Coalition's members considered this necessary.

The statement was then circulated among other stakeholders and presented during a conference organised before the beginning of public consultations. The ideas from the statement permeated through the society and surfaced in almost all of the six groups working independently during public consultations organised by the city office. Eventually, the whole structure of the strategy was changed and ecosystem services have been included into the final document adopted in June 2012.

Active involvement of city inhabitants proved crucial in highlighting the importance of ecosystem services to city authorities, illustrating how barriers related to regulations that downplay the importance of urban greenery can be overcome. Indeed, the subsequent "Municipal and Environmental Protection Policy", presented by the city office later in 2012, made very important references to ecosystem services and attempted to put many other environmental issues in order.

"Nature in the City" – Polish TEEB guide for cities

The guide "Nature in the City",[15] published as the third volume of "Sustainable Development Applications" journal, focuses on the application of ecosystem services for the benefit of urban sustainable development. It is aimed primarily at local government representatives responsible for spatial planning, infrastructure, transport, strategic planning and of course development, and indeed anyone else whose decisions will have a bearing on urban ecosystems.

[15] *Nature in the city. Ecosystem services – untapped potential of cities. Polish TEEB Guide for Cities*, "Sustainable Development Applications" 2012 No. 3, ed. T. Bergier, J. Kronenberg, http://www.sendzimir.org.pl/en/journal3 [Date of entry: 10-09-2012].

The first article concerns the basics of urban ecosystem service management, its main goal is to raise awareness of the subject, especially by presenting why it is worthwhile to deal with urban nature and what kind of benefits it provides. The second article presents the results of research on barriers, briefly reported above, in section 2. The third article deals with the issue of public participation in decision making on urban nature, and includes advice on how to prepare and carry out an efficient participatory process. The fourth article refers to the methods of assessing the value of urban nature, and includes the results of a valuation study carried out in Lodz. Within a choice experiment, the residents of stated how much they would be willing to pay for increasing the number of trees in the city centre. The fifth article concerns urban water ecosystems and their services, such as flood protection, recreation, microclimate and space aesthetics. All articles in the guide are accompanied with the numerous examples from Poland and abroad, and there is an additional section featuring 12 best practice case studies of urban ecosystem services management. This section presents how cities can take advantage of the potential of ecosystem services, what kinds of economic and legal mechanisms can be used for this purpose, and what is the role of non-governmental organisations and other stakeholders in this respect.

The guide was inspired by activities carried out within the international TEEB project (The Economics of Ecosystems and Biodiversity). The Sendzimir Foundation received official approval from the TEEB project coordinators for this initiative, and consent for this guide to be called the first TEEB initiative in Poland, hence the title "Polish TEEB for Cities" and the unique Polish TEEB logo (Figure 4).

Figure 4.
Logo created for the "Polish TEEB Guide for Cities"

"TEEB Manual for Cities" in Polish

The Sendzimir Foundation published a Polish translation of the "TEEB Manual for Cities", comprising the main conclusions of the TEEB project from the perspective of applying ecosystem services concept in urban management. The "TEEB Manual for Cities" had been produced within the international TEEB project and it synthesised the findings of the larger "TEEB for Local and Regional Policy Makers" report published in 2010. Using examples from across the world, the manual presents a 6-stage approach which makes it possible to include ecosystem services in the policies and decision making processes in city planning. The six steps include:[16]

1. specification and agreement on the problem or policy issue with stakeholders;
2. identification the most relevant ecosystem services that can help to solve the problem or policy issue;
3. determining what information is needed and selecting assessment methods;
4. assessment of future changes in ecosystem services;
5. identification and comparison of management/policy options;
6. assessment of the impacts of the policy options on the range of stakeholders.

The manual puts much emphasis on economic valuation of urban ecosystem services and presents numerous case studies where different valuation methods were used to support urban management. Interestingly, many case studies originate from developing countries, where projects related to urban ecosystem services were often carried out with foreign aid. These undertakings were successful enough for cities in other countries to be able to learn from them. From the Polish perspective it is particularly important that the concept of ecosystem services is used both in developing and developed countries, demonstrating that ecosystem services are equally important in all contexts. Thus, the publication of this manual in Polish is meant not only to increase awareness of ecosystem services in our country, but also to undermine the current preference for other interests, apparent in both legal documents and social attitudes.

Discussion and conclusions

The activities presented here were undertaken in response to the findings of the study on the barriers to the use of the concept of ecosystem services in Polish towns and cities. They were meant to serve as an inspiration for further activities to be undertaken by other stakeholders and eventually to contribute to better

[16] TEEB, *Poradnik TEEB dla miast: usługi ekosystemów w gospodarce miejskiej,* wydanie polskie, Sendzimir Foundation, Kraków 2011.

management of urban nature in Poland. At the same time, the Sendzimir Foundation discussed the issue of urban ecosystem services at the European Union level, taking part in an international network of non-governmental organisations committed to making European cities greener. Lobbying is necessary, along with joint efforts of various stakeholders. All of these activities focused primarily on increasing awareness of the concept of ecosystem services among various stakeholders involved in urban management in Poland. To broaden the outreach of these activities, both guides ("Nature in the City" and the "TEEB Manual for Cities") are available free of charge from the Sendzimir Foundation's website.

These publications add to a number of other books and articles on urban nature published in Poland so far. With regard to popularising the concept of ecosystem services, one of the most important initiatives was a special issue of "Ekonomia i Środowisko" focused entirely on this topic.[17] However, with the exception of one article,[18] the special issue neglected the urban or peri-urban context. Similarly, out of several other Polish publications on ecosystem services,[19] few referred to cities. Szumacher[20] discussed relationships between ecosystem functions and services in cities. Kostecka[21] focused on the potential of ecosystem services concept to help protect birds in cities. Bernaciak[22] looked at the importance of ecosystem services for quality of life in cities and the challenges that it poses for spatial planning. Nevertheless, most of the publications on ecosystem services available in Poland so far remain rather academic. To increase the impact of such research, more popular publications are necessary, along with those that link researchers with decision makers and thus facilitate the diffusion of new ideas among practitioners.

Experience gained in discussing urban nature from a more general perspective within a series of conferences organised by the Polish Association of Sanitary Engineers and Technicians, and attended by both researchers and practitioners provides a good example. The title of this series indicates that urban greenery is the wealth of a city ("Zieleń miejska – naturalne bogactwo miasta"), obviously

[17] C.f. A. Mizgajski, Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne, "Ekonomia i Środowisko" 2010 No. 37, p. 10-19.

[18] D. Łowicki, *Wartość krajobrazu w świetle cen terenów pod zabudowę w latach 1995-2000*, "Ekonomia i Środowisko" 2010 No. 37, p. 147-156.

[19] E.g. J. Solon, *Koncepcja „Ecosystem Services" i jej zastosowanie w badaniach ekologiczno-krajobrazowych*, "Problemy Ekologii Krajobrazu" 2008 No. 21, p. 25-44; Z.M. Rosin et al., *Koncepcja świadczeń ekosystemowych i jej znaczenie w ochronie przyrody krajobrazu rolniczego*, "Chrońmy Przyrodę Ojczystą" 2011 No. 67(1), p. 3-20; A. Michałowski, *Ecosystem Services in the Light of a Sustainable Knowledge-Based Economy*, "Problemy Ekorozwoju – Problems of Sustainable Development" 2012 No. 7(2), p. 97-106.

[20] I. Szumacher, *Funkcje terenów zieleni miejskiej a świadczenia ekosystemów*, "Prace i Studia Geograficzne" 2011 No. 46, p. 169-176.

[21] J. Kostecka, *Edukacyjne znaczenie pojęcia świadczenie ekosystemów dla ochrony awifauny miast*, "Inżynieria Ekologiczna" 2010 No. 22, p. 34-42.

[22] A. Bernaciak, Środowiskowe uwarunkowania polityki przestrzennej, in: *Zarządzanie przestrzenią miasta*, ed. M.J. Nowak, T. Skotarczak, CeDeWu, Warszawa 2012.

highlighting the importance of nature and the benefits that it provides.[23] Such a forum of exchange of opinions and good practices offers an opportunity to discuss new solutions in a realistic manner, taking into account the barriers related to the functioning of public institutions.

Nevertheless, the state of urban greenery in Poland has been deemed as bad already for a long time. More than six decades ago, Ptaszycka[24] wrote that the state of greenery in post-war Polish towns and cities was by far unsatisfactory, pointing to the lack of funds, and the shortcomings of relevant legal acts and local regulations as well as their interpretation. She also noted "the appreciation of urban greenery rousing too slowly in society in a sea of other worries and the hardships of everyday life, accompanied by a lack of need for order and aesthetics in the immediate surroundings of town residents". At the time, solutions similar to the ones mentioned in this article were also proposed. However, long-term persistence of barriers has contributed to a constant decline in tree numbers in the centres of Polish cities, limiting the possibilities for their sustainable development. Therefore, urgent actions are needed by public administration officials (who should have greater knowledge than the rest of society) in collaboration with scientific bodies, non-governmental organisations and other stakeholders.

The international conference, workshops in Lodz and the Coalition for Sustainable Development of Lodz, mentioned in section 3, facilitated direct involvement of public administration officials and other stakeholders. These activities raised significant interest and suggest that such cooperation is possible and may bring good results. Another important example of such an activity in Lodz was the 5th SWITCH project conference "Sustainable Water management Improves Tomorrow's Cities' Health" organised in October 2010. Lodz was one of the case study cities within the EU-funded SWITCH project that focused on sustainable integrated urban water management in the "City of the Future". The conference was held at Lodz City Office which increased the rank of this event and facilitated the spread of ideas among practitioners.

In the future, other – more diverse and complex – activities need to be carried out to promote better management of urban nature in Poland, including research projects combined with practical solutions; down-to-earth activities, such as tree planting; educational and awareness-raising activities; cooperation with international stakeholders, such as ICLEI; and many others. Above all, to increase their impact, these activities need to be taken in a more coordinated way, as joint projects involving more partners coming from different backgrounds. A common platform for undertaking, presenting and discussing such activities is necessary, and one more effect of the Sendzimir Foundation's activity – the website on ecosystem services: www.uslugiekosystemow.pl provides a potential tool to facilitate such exchange.

[23] See e.g. *Zieleń miejska – naturalne bogactwo miasta: lasy w miastach Unii Europejskiej – zasady gospodarowania i ochrona*, eds. E. Oleksiejuk & A. Jankowska, Polskie Zrzeszenie Inżynierów i Techników Sanitarnych, Toruń 2007.

[24] A. Ptaszycka, op. cit., p. 50-53.

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ASSESSMENT OF NON-MARKET ENVIRONMENTAL SERVICES IN AGRICULTURAL PRODUCTION

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OCENA POZARYNKOWYCH USŁUG ŚRODOWISKA W PRODUKCJI ROLNICZEJ

STRESZCZENIE: Z punktu widzenia termodynamiki wartość dobra i usługi w ekonomii zależy od jakości energii bezpośrednio i pośrednio wykorzystanej do ich wytworzenia. Ponieważ rynek nie jest doskonały, obliczenia energii zawartej w materii powinny precyzować wartości rynkowych i nierynkowych dóbr i usług.
Metoda oparta na emergii została zastosowana do oceny zarówno wykorzystania strumieni energii, masy oraz nakładów finansowych (azotu, dwutlenku węgla, wody, materii organicznej gleby, nasion, nawozów, środków ochrony roślin, paliw, towarów i usług), jak również produktywności oraz zrównoważenia w typowych uprawach prowadzonych w Wielkopolsce w latach 2006-2008. Obliczono i porównano takie wskaźniki emergetyczne, jak: współczynnik wydajności (EYR), współczynnik obciążenia środowiska (ELR), indeks zrównoważenia (EIS) stopień wymiany (EER) oraz udział inwestycji (EIR) dla upraw pszenicy, rzepaku i buraków cukrowych. Największa wartość EIS występuje w uprawie pszenicy, a uprawa rzepaku charakteryzuje się największa wartością EYR. Wartości nierynkowych usług środowiska w tworzeniu zysku z upraw pszenicy, rzepaku i buraków wynoszą odpowiednio 53%, 60% i 48%. Chociaż uprawa buraków charakteryzuje się największą wartością ELR głównie z powodu degradacji materii organicznej gleby, to równocześnie dostarcza znacznej usługi w procesie stabilizacji klimatu dzięki absorpcji dwutlenku węgla. W ogólności jednostka powierzchni uprawy pszenicy absorbuje taką ilość dwutlenku węgla, jaką dwóch statystycznych obywateli Polski emituje w ciągu roku. Jednostka powierzchni uprawy buraków kompensuje emisje dwutlenku węgla 2,4, a rzepaku 1,5 rocznej emisji *per capita*. Dokonano porównania cen rynkowych (PLN) użytych zasobów z cenami skalowanymi na podstawie obliczeń metodą emergetyczną (EmPLN). Okazało się, ze ceny rynkowe nasion, pracy i paliw są zawyżone PLN>EmPLN, a nawozów są porównywalne PLN » EmPLN.

SŁOWA KLUCZOWE: emergia, seJ, emergetyczny indeks zrównoważenia, emisja dwutlenku węgla *per capita*

Introduction

In order to sustain life and maintain existing social, economic and cultural arrangements the fundamental human activity is focused on the competition in the free energy distribution. There is a close relationship between the value of money and the value of energy. That is because money is used to buy goods and services, of necessity derived from energy. Because energy is the source of economic value wherever a money flow existed in economy there was a requirement for an energy flow in the opposite direction. The driving force of economical growth is the cooperation of energy flow from non-renewable resources controlled by people with the flow of energy from renewable resources of biosphere.

However the large natural energy flows of solar radiation, wind and water have no associated monetary flows. The costs of using these energy flows do not enter into economic transactions directly, often leading to their misuse or the mismanagement of life-sustaining environmental services. Generally money circulates in closed loop, whereas low-entropy energy moves in from the outside, is used for economic tasks, and then leaves the economic system as degraded heat[1].

There is an obvious contradiction with monetary system of values currently existing in the economy, based on the assumption that the measure of the goods and services value is equal to the money that people are willing to pay for them. As a result, the activity of large social groups focuses on the circulation of money that does not have any physical equivalent in the form of streams of matter or energy. It leads to such phenomena as crisis and social inequality which, from the point of view of second law of thermodynamic, are a manifestation of entropy accumulation in the global system.

Moreover, due to existing monetary system of values, goods and environmental services are not taken into consideration because that people are paid for their services but money do not constitute the payment for environmental services. As a result, there is a commonly observed decline of low entropy ecosystem resources, environment pollution with high entropy substances and overall processes of the biodiversity damaging[2].

Threats to economic and civilizational development resulting from the intensive biosphere exploitation can be limited if the principle of sustainable use of resources on the global, national and regional scale is obeyed[3].

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[1] C.J. Cleveland, *Biophysical Economics: From Physiocracy to Ecological Economics and Industrial Ecology*, in: *Bioeconomics and Sustainability*, eds. J. Gowy and K. Mayum, E.E. Publishing, England 1999, p. 125-154; M. Ruth, *Insights from thermodynamics for the analysis of economic processes*, in: *Non-equilibrium thermodynamics and the production of entropy*, eds. A. Kleidon, R.D. Lorenz, Springer-Verlag Germany, Berlin 2005, p. 243-251.

[2] M. Carley, P. Spapens, *Dzielenie się światem,* Instytut na rzecz Ekorozwoju, Wydawnictwo Ekonomia i Środowisko, Białystok-Warszawa 2000.

[3] M.T. Brown, S. Ulgiati, *Emergy-based indices and rations to evaluate sustainability: monitoring economies and technology toward environmentally sound innovation*, 1997 Vol. 9, p. 31-69; M.A. Brown, B.K. Sovacool, *Developing an Energy Sustainability Index to evaluate energy policy*, "Interdisciplinary Science Review" 2007 No. 32, p. 335-349; J.R. Siche, E. Ortega, A. Romeiro,

From the point of view of thermodynamics, the value of a good or a service depends on the quality of energy directly or indirectly used for their production. Since the market is not perfect, the calculations of the energy contained in the matter should specify the value of market and non-market goods and services. It requires the development of holistic measures based on thermodynamics and their application to the control of technological and agrotechnical processes efficiency, together with usually taken into account economical measures.

Especially useful for this purpose is the method introduced by H. Odum in 1980s [4] which has been improved and developed since then. The emergy analysis is an environmental accounting methodology based on the general assumption that, in every ecosystem as in the biosphere, all the energy fluxes belong from solar radiation. The solar emergy (emergy) of flow or storage is defined as the solar energy directly or indirectly required to generate that flow or storage. It is an extensive quantity and its units are solar emergy joules, seJ. In order to convert all the flows involved in the process into this common base, a conversion factors are used: the solar transformities, defined as the emergy per unit flow or unit product.

Emergy can consider as an energy memory because it takes into account all the energy, past and present, needed to check produce that product or flow. The emergy method can be used for resolving many research tasks such as: the efficiency and crops sustainability assessment[5], efficiency of biofuels production[6], and irrigation processes[7], the comparison of the efficiency of generators of elec-

F.D.R. Agostinho, *Sustainability of nations by indices comparative study between the environmental sustainability index, ecological footprint and the emergy performance indices.* "Ecological Economics", 2008, 67, p. 519-525; M.T. Brown, S. Ulgiati, *Updated evaluation of exergy and emergy driving the geobiosphere: A review and refinement of the emergy baseline*, "Ecological Modeling" 2010 No. 221, p. 2501-2508;

[4] H.T. Odum, *Environmental Accounting, Emergy and Environmental Decision Making*, J. Wiley & Sons, inc, New York, 1996.

[5] M.C. Ferreyra, *Emergy perspectives on the Argentine economy and food production systems of the Rolling Papas during the twentieth century*, University of Florida, Thesis 2001; J. Jankowiak, E. Miedziejko, *Energetyczna metoda oceny efektywności i zrównoważenia środowiskowego uprawy pszenicy*, „Journal of Agribusiness and Rural Development" 2009, p. 75-84; J. F. Martin, S.A.W. Diemont, E. Powell, M. Stanton, S. Levy-Tacher, *Emergy evaluation of the performance and sustainability of three agricultural systems with different scales and management*, "AGEE" 2006 No. 115, p. 128-140; E. Miedziejko, J. Jankowiak, *Energetyczna wycena usług środowiska w uprawie buraków*. „Ekonomia i Środowisko" 2010 No. 1, p. 190-200; E. Miedziejko, J. Jankowiak, *Energetyczna analiza usług i obciążenia środowiska w uprawie rzepaku*, „ZPPNR" 2010 No. 547, p. 237-248; E. Ortega, M. Miller, *Comparison of ecological and agro-chemical soybean cultivars using emergy analysis. Hypothesis and first results*, Book of Workshop Proceedings 2nd International Workshop Advances in energy studies Porto Venere Italy, 2007.

[6] D. Pimentel, T.W. Patzek, *Ethanol production using corn, switch grass and wood; biodiesel production using soybean and sunflower*, " Natural Resources Research" 2005 No. 14, p. 65-76.

[7] S. L. Brandt-Williams, *Handbook of Emergy Evaluation. A Compendium of Data for Emergy Computation Issued in Series of Folios*, Center for Environmental Policy Environmental Engineering Science, University of Florida, Gainesville 2002, p. 1-37.

trical energy coming from different sources[8], measurement of the concentration of the information flow in the cities[9], emergetic assessment of CO_2 emission impact on the climate changes[10].

The basis of this method is the assumption that the energy contained in the source or provided as a result of a service determines their values, i.e. "ecological price".

The aim of the study was the quantitive assessment of the efficiency and environmental sustainability, as well as the mutual relations of prices determined on the basis of monetary and emergetic measures as well as the development of the carbon dioxide balance in the crops of wheat, rape and sugar beets.

Methodology

Data sources

The economical data used in this work are mean values for Wielkopolska Region in years 2006-2008[11] in terms of outlays for the crop. The source of meteorological data are the measurements made in the Research Station of the Institute of Forest and Agricultural Environment PAS in Turew. The radiation balance and evapotranspiration quantity were calculated according to the scheme described in the work[12]. For the calculations there were taken into the account the time intervals in which positive radiation balance occurred.

Calculation basis

Emergy E_m of the specific product or service is the sum of exergy E_{xi} of all inflows „*i*" used directly or indirectly for their production. It is expressed by the formula:

$$E_m = \sum_i \tau_i E_{xi} \tag{1}$$

where τ_i is solar transformity of independent inflow constituent "*i*". Transformity is the amount of energy per unit of exergy of the component „*i*".

[8] M.T. Brown, S. Ulgiati, *Emergy evaluation and environmental loading of electricity production systems*, "Journal of Cleaner Production" 2002 No. 10, p. 321-334.

[9] Ch. Shaoging, Ch. Bin, *Assessing inter-city ecological and economic relations: An emergy based conceptual model*, "Frontiers of Earth Science" 2011 No. 5, p. 97-102.

10 M. J. Lennon, E. Nater, *Biophysical aspects of terrestrial carbon sequestration in Minnesota*, Minnesota Terrestrial Carbon Sequestration Project, 2006.

[11] *Kalkulacje rolnicze*, Wielkopolski Ośrodek Doradztwa Rolniczego, Poznań 2007, 2008, 2009.

[12] E. Miedziejko, L. Ryszkowski, A. Kędziora, *Produkcja entropii w różnych ekosystemach krajobrazu rolniczego*, in: *Bioenergetyka ekologiczna, Koncepcje i zastosowania praktyczne*, Wydawnictwo Werset, Lublin 2007, p. 68-81.

The transformities used in this work were calculated on the basis of the model processes in the global environment[13].

The emergy of solar radiation, wind, nitrogen, carbon dioxide, degraded organic matter of the soil, fuels and mineral fertilizers was calculated using the method described in earlier work of authors[14]. Transformity of the amount of labour in years 2006-2008 was calculated similarly on the basis of statistical data[15].

The emergetic calculation also takes into account the value of goods and services estimated on the basis of market prices after determination of global and national emergy use in relation to GGP and GDP. This way, the circulation of money is allocated to the emergy flow and it is possible to balance all driving forces for the sustainable process.

In contrast to the monetary values (economic prices) that depend on subjective preferences of people, ecological prices should be normative coefficients resulting from the models describing the mass and energy flow through natural habitats.

In the emergetic method the ecological prices which are alternatives to the economic prices should be expressed by the value of emergy expended by biosphere in order to produce economic good per unit of specific physical quantity, most often mass or energy.

In order to directly compare economic prices to the prices determined by the use of emergy (environmentally scaled prices) there should be accepted some simplifying assumptions.

Above all the ecosystems studied are the part of Polish territory which in turn is nested in the global system. Therefore the determination of ecological prices of the products studied requires taking into account certain interdependences. This task can be carried out in turn:

1) there should be calculated the emergy consumption on the global scale and there should be set the emergy/money quotient P(seJ/USD) in a given year which means calculating the ratio of emergy consumption in relation to GGP. It constitutes the value of emergy used to produce a unit of GGP (USD);
2) there should be calculated the emergy consumption on a national scale in a given year (taking into account imports and exports expressed by units of emergy with the consideration of P(seJ/USD) and there should be calculated national emergy/money quotient P_1(seJ/USD) as the relation of emergy consumption to the GGP – the amount of emergy used to produce monetary unit (USD) in the national turnover.

[13] H.T. Odum, *Environmental Accounting, Emergy and Environmental Decision Making*, J. Wiley & Sons, inc., New York 1996; M.T. Brown, S. Ulgiati, *Emergy Analysis and Environmental Accounting. Encyclopedia of Energy 2,* 2004, 2, p. 329-353; M.T. Brown, S. Ulgiati, *Updated evaluation ...*, 2010 No. 221, p. 2501-2508.

[14] Ibidem.

[15] *Rocznik Statystyczny Rzeczpospolitej Polskiej*, Wydawnictwo im. E. Romera S.A., Warszawa 2006, 2007, 2008.

3) emergy/money quotient of the national currency P_1'(seJ/PLN) should be determined by using the comparative method. Since the purchasing power of the currency determines its „driving force", it was assumed that it is an analogue of exergy in the formula 1, so E_x(PLN) or E_x(USD), whereas emergy/money quotients of both currencies are analogues of transformities. As the value of emergy used to produce GDP does not depend on the type of currency (USD) or (PLN) in which the monetary flow is expressed but depends on its purchasing power and emergy/money quotients of both currencies P_1(seJ/USD and P_1'(seJ/ PLN), formula 1 indicates the correlation:

$$E_x\,(PLN) \times P_1'(seJ/PLN) = E_x(USD) \times P_1(seJ/USD) \qquad (2)$$

Therefore the emegy/money quotient of the national currency is expressed by the following formula:

$$P_1'(seJ/PLN) = P_1(seJ/USD) \times E_x(USD)/E_x\,(PLN) \qquad (3)$$

In years 2006-2008 the relation of purchasing power of both currencies in the national turnover was E_x(USD)/E_x(PLN) = 3.102; 2.769; 2.962 and calculated emergy/money quotient was P_1 = 2.01TseJUSD; 1.74TseJ/USD; P_1 = 1.47 TseJ/USD respectively[16].

The values of market and non-market goods expressed in the environmentally scaled prices can be calculated by dividing the emergy used by P_1'(seJ/PLN).

It is proposed that the values of scaled prices obtained on the basis of emergetic calculation should be described as EmPLN, as the analogy to designations EmUSD functioning in the world literature.

The data were analyzed on the basis of emergetic indices[17] defined in the Table 1.

[16] E. Miedziejko, *Termodynamiczna analiza wykorzystania zasobów środowiska w latach 1995-2006*, in: *Zasoby i kształtowania środowiska rolniczego. – Agrofizyczne metody badań*, eds. B. Dobrzański jr, A Gliński, R, Rybczyński, Wydawnictwo Nauk RFNA, Komitet Agrofizyki PAN, Lublin 2009, rozdział 1, p. 9-28.

[17] M.T. Brown, S. Ulgiati, *Energy-based indices*..., op. cit., p. 31-69.

Table 1.
Emergy indices for crop efficiency and sustainability

Indice	Symbol	Definition
Used emergy	Y	R+MR+SR+N+MN+SN
Renewable Emergy Fraction	P_R	$\frac{R + M_R + S_R}{Y}$
Emergy Yield Ratio	EYR	$\frac{Y}{M_N + S_N}$
Environmetal Loading Ratio	ELR	$\frac{N + M_N + S_N}{R + M_R + S_R}$
Emergy Index of sustainability	EIS	$\frac{EYR}{ELR}$
Emergy Investment Ratio	EIR	$\frac{S_N}{Y}$
Emergy Exchange Ratio	EER	$\frac{Y}{E_p}$

Y – total emergy consumption, R – renewable crop emergy: solar irradiation, kinetic energy of wind, water, nitrogen and carbon dioxide, N – non-renewable emergy of organic matter of the soil, M_R – renewable energy of seeds, M_N – non-renewable emergy of fuels, fertilizers and plant protection chemicals, S_R-renewable emergy of labour, S_N-non-renewable emergy of financial outlays, Ep-emergy obtained from the crop sale.

Results and discussion

Emergy consumption

A very important achievement of the emergetic method is a quantitative comparison of qualitatively different inflows to the crop habitat. Figure 1 presents quantitative comparison of the emergy taken from different sources in crops of wheat, rape and beets. As we can see, renewable inflows in the form of solar radiation, kinetic wind energy, stream of atmospheric nitrogen and carbon dioxide absorbed are very small in comparison to the chemical energy of water. Among resources taken from the habitat, the largest share has the consumption of emergy in the form of soil organic matter, which is particularly important for the beet crop. It turned out that non-renewable energy taken during the fuel burning is significantly smaller than the emergy taken during soil organic matter degradation. Especially large share characterizes non-renewable emergy of ferti-

Figure 1.
Crop emergy resources

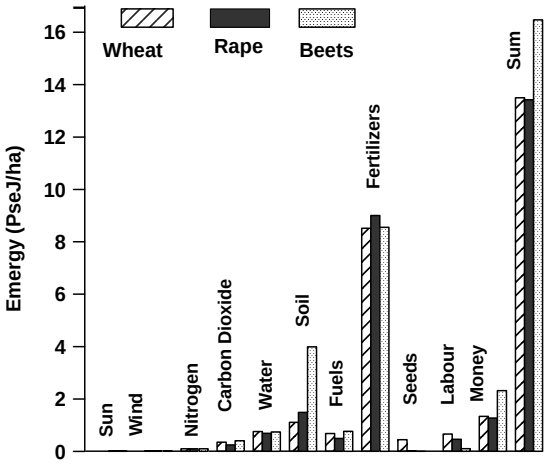
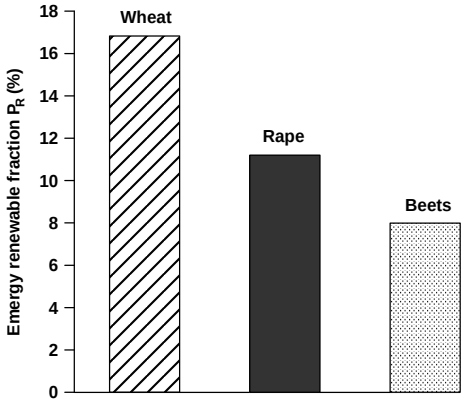


Figure 2.
Dependence of the renewable emergy fraction on the type of the crop



lizers. The renewable emergy of seeds is very small, similarly to emergy of labour. Non-renewable emergy of financial outlays is comparable to non-renewable emergy of degraded organic matter taken from the crop habitat.

The share of habitat renewable emergy in whole crop emergy consumption has been compared on Figure 2. The renewable emergy fraction used in Wielkopolska Region in wheat is comparable to cultivar performed in Argentina[18] and Italy[19]. Particularly low is emergy renewable fraction P_R used in sugar beet cultivar.

[18] M. C. Ferreira, op.cit.
[19] S. Ulgiati, C. Cialani, *Environmental and thermodynamic indicators in support of fair and sustainable policy making. Investigating equitable trade among Latvia, Denmark and Italy,* Pro-

As results of the crop cultivar was obtaining the mass: m = 6 t/ha (wheat), m = 3 t/ha (rape) and m = 48 t/ha (sugar beets). Since the exergy calculated on the basis of chemical composition was E_x = 100.7 GJ/ha; E_x = 68.97 GJ/ha and E_x = 198.8 GJ/ha and the calculated emergy consumption was Y = 13.5PseJ/ha; Y = 13.4PseJ/ha and Y = 16.47PseJ/ha there were obtained yield transformities: t = 134kseJ/J; 194.3 kseJ/J and 82.8kseJ/J for wheat, rape and sugar beets respectively.

For these values of emergy density is r = 2.25 TseJ/kg (wheat), r = 4.47 TseJ/kg (rape) and r = 0, 34 TseJ/kg (beets). It should keep in mind that transformity is a measure of emergy placed in a given product and is an indicator of "ecological price".

After dividing by P_1'the value of production expressed in environmentally scaled prices is 3979, 5123, 6623 EmPLN. The market value in economic prices was 6888PLN; 3498PLN and 3769PLN. The difference in prices scaled by using emergy method (EmPLN) and monetary price (PLN) is a measure of non-market environmental services. Therefore as a result, in the crop model described the values of non-market environmental services in the creation of profit from the crops of wheat rape and sugar beets is 53%, 60% and 48% respectively. As we can see, taking into consideration prices of market services and the value of production conditioned by supply and demand of agricultural products, the non-market environmental services in the rape crop were used the most effectively. Moreover the market value in economic prices was 173%, 68% and 57% environmental price for wheat, rape and sugar beets respectively.

Assessment of crops sustainability

In Figure 3. there are Emergy Yield Ratio of crops defined as the relation of emergy accumulated in product to the non-renewable emergy taken from the external environment

Form the definition of the Emergy Yield Ratio it results that reverse of EYR-1 equals the number of units of emergy taken from the outside per unit of emergy taken from the habitat. It is 3, 4 and 2 for whet, rape and sugar beets respectively.

The EYR reveals to what extent the crop environment can compete in providing emergy. It means that for the collection of habitat emergy the most effectively was used the external emergy in beets crop. Due to the fact that this was non-renewable emergy collected during the degradation of soil organic matter, the ELR coefficient was particularly high (Figure 4).

The environmental pressure in the cultivar model is characterized by the Environmental Loading Ratio (ELR) which is equal to the ratio of the P_R fraction

ceedings of 2th International Conference on integrative Approaches towards Sustainability, Riga, Latvia, 2005.

Figure 3.
Comparison of emergy Yield Ratio for crop analyzed

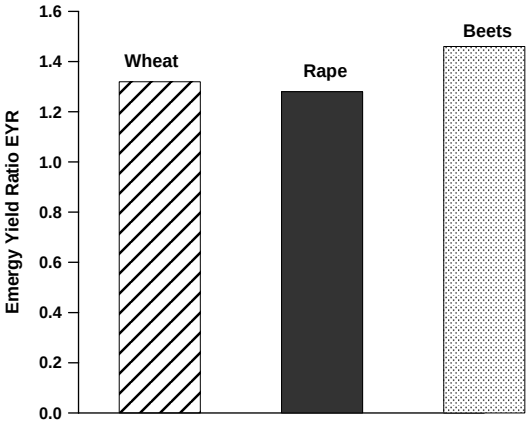
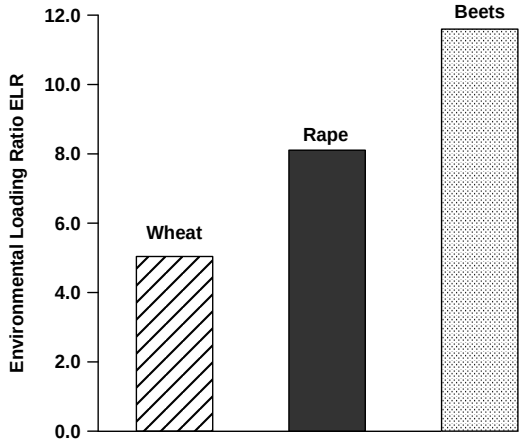


Figure 4.
Dependence of the Environmental Loading Ratio ELR on the type of the crop



of renovable to the fraction R_N nonrenevable sources, respectively in the total emergy consumption. The Figure 4. reveals that ELR is three times bigger in the beets crop than in the wheat crop and 1.5 times bigger than in the rape crop.

Received values are greater that obtained in Argentina, greater than the average for all cereals in U.S.[20] and close to the values obtained in Latvia for all agricultural production with a predominance of wheat. In order to improve the ELR

[20] S. L. Brandt-Williams, *Handbook of Emergy Evaluation. A Compendium of Data for Emergy Computation Issued in Series of Folios*, Center for Environmental Policy Environmental Engineering Science, University of Florida, Gainesville, 2002, p. 1-37.

Figure 5.
Dependence of the Emergy Index of Sustainability on the type of crop.

a great changes in the system of farming can be recommended based on existing data basis[21].

Generally we looking for the best production model there is a large EYR and little ELR. This feature assesses Emergy Index of Sustainability (EIS), which quantitatively specifies the yield of process per unit of environmental loading.

Crops were carried out with the usage of large amount of mineral fertilizers and small amount of work due to that fact they were characterized by small index of sustainability (Figure 5).

For the model of cultivar in Wielkopolska Region emergy evaluation reveals that EIS is much smaller than this, which is characterized by cultivation of cereals in Italy, Latvia and Brazil[22].

This situation is not surprising, taking into consideration the lack of economic sustainability on a national scale[23] in Poland.

The share of investments (EIS) means a number of emergy units which should be invested in crop in order to collect a unit of crop emergy. On the basis of Figure 6 data the calculated values are 4.6, 7.1 and 8.6 for wheat, rape and beets respectively. Therefore the biggest investment efficiency was obtained in wheat crop.

At agricultural products prices in years 2006-2008 the emergy included in the yield are 4.3, 4.2 and 3.2 times bigger in relation to the emergy achieved for

[21] J. Jankowiak, I. Małecka, *Uproszczenia uprawowe w zrównoważonym rozwoju rolnictwa*, Wydawnictwo Prac Instytutu Ekonomiki Rolnictwa i Gospodarki Żywnościowej, Program Wieloletni (6) 2008.
[22] S. Ulgiati, C. Cialani, op.cit.; E. Ortega, S. Ulgiati, *Expanded energy analysis of soybean production in Brazil*, Proc. 4th Bien. Int. Workshop" Advances in Energy Studies", Unicamp, Campinas, Brazil, 2004, p. 285-299.
[23] Ibidem.

Figure 6.
Comparison of Emergy Investment Ratio in crops analyzed

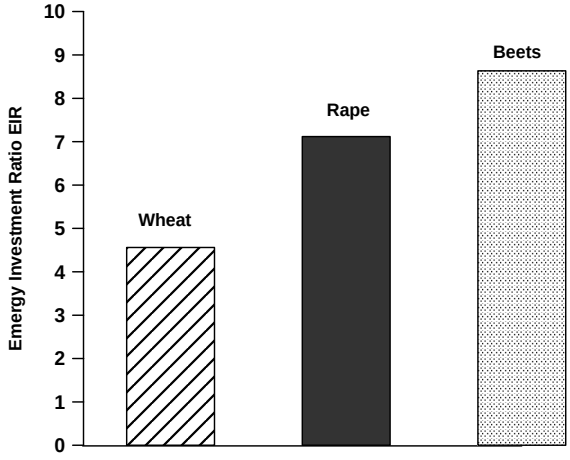
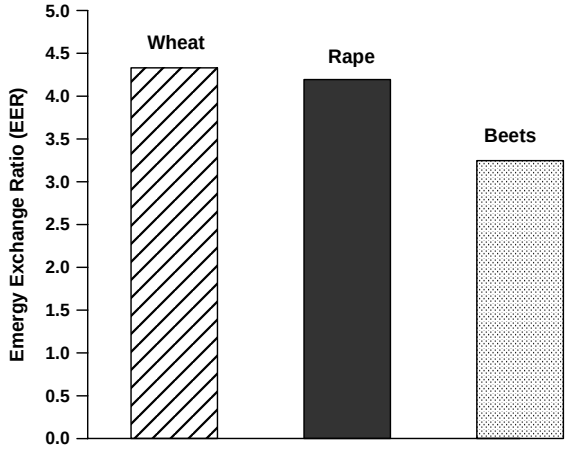


Figure 7.
Dependence of the emergy Exchange ratio on the type of crop



the money from the yield sale (Figure). If the sale had been done in emergetically scaled prices it would have turned out that this ratio would have been 0.58, 0.68 and 0.52 for wheat, rape and beets respectively. It means that on average a half of emergy included in yield is not taken into consideration in the market value as it results from non-market environmental services.

A comparison of emergy scaled prices with prices currently in force

On basis of emergy calculated you can express the value all the resources used by dividing the assigned them emergy (Figure1) by emergy/money quotient

Figure 8.
Emergy scaled prices for resources used

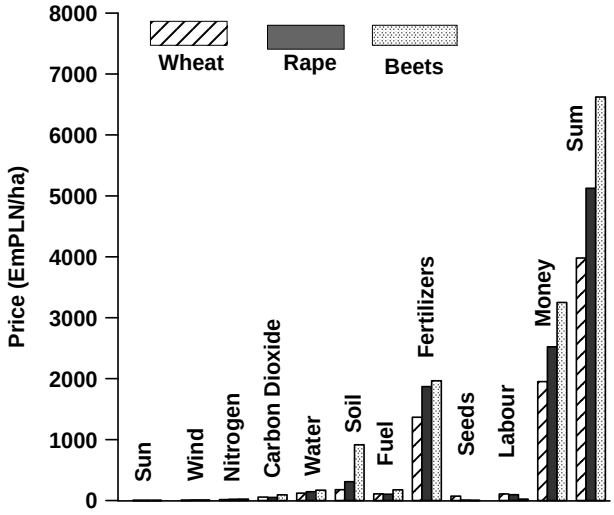
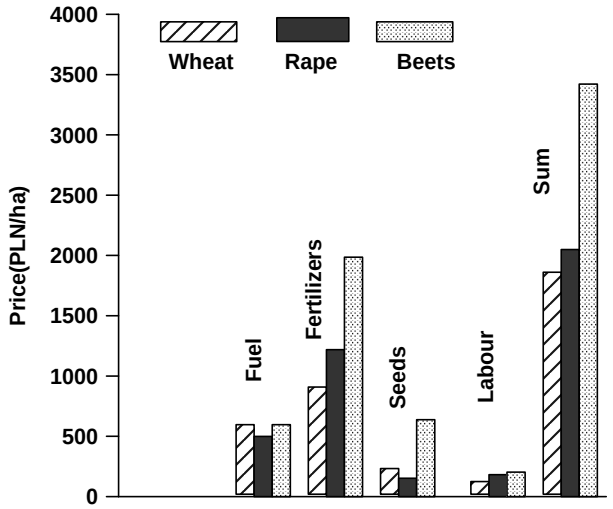


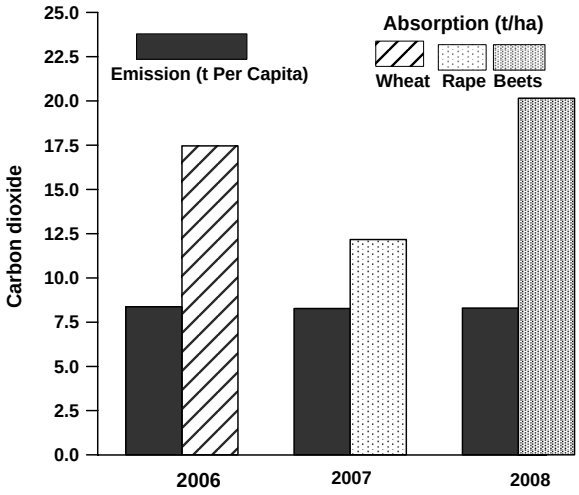
Figure 9.
Typical monetary prices for cultivar studied



of the national currency (P_1'(seJ/PLN). Therefore with the use of emergetic method it is possible to determine values of non-market environmental services such as transpiration, soil organic matter supply, nitrogen and carbon dioxide collection as well as emergy resources commonly analyzed. The results these calculations are shown on Figure 8. The relevant applicable prices are shown in Figure 9.

In comparison to the prices scaled with emergetic method in general market prices of fuels, work and seeds are too high and prices of fertilizers are similar.

Figure 10.
Net balance of carbon dioxide absorption in plant cultivar with comparing to the emissions per capita in Poland



The balance of carbon dioxide

In the crops studied there occur both carbon dioxide emission in the process of soil organic matter degradation and under the impact of burning of fuels used in agrotechnics and its absorption in the process of photosynthesis. It is known[24] that the unit of area of wheat crop as a result of soil organic matter degradation emits 13t/ha and a unit of the area of beets 22t/ha of carbon dioxide. The mean standard values in units (t/ha) calculated on the basis of published data[25] for carbon dioxide emission are: 0,35; 0.33; 0.51; as result of the fuel burning and

[24] M. Zieliński, *Efekty produkcyjne i ekonomiczne gospodarstw zbożowych sekwestrujących CO_2*. „Roczniki Naukowe STRiA", 2011, XIV, p. 219-223.

[25] L. Bakken, K. Refsgaard, S. Christensen, A. Vatn, *Energy use and emission of greenhouse gases from grassland agriculture systems*, Proceedings of the 15th General Meeting of the European Grassland Federation. Wageningen 1994, p. 361-376; M. J. Lennon, E. Nater, *Biophysical aspects of terrestrial carbon sequestration in Minnesota*, Minnesota Terrestrial Carbon Sequestration

1.13; 1,13; 3.02 due to organic matter degradation for wheat, rape and sugar beets respectively. The amount of CO_2 absorbed was determined on the basis of the value of the mass of transpired water.[26]

In the crops studied the balance of carbon dioxide was positive. The comparison of the stream of carbon dioxide absorbed in the wheat, rape and beets crops presents Figure 9. To show the potential role of the environmental services in stabilization of climate, the stream of carbon dioxide was compared to the stream of the carbon dioxide emitted by statistical citizen of Poland.

As we can see, the unit of the wheat crop area absorbs the same amount of carbon dioxide as 2 statistical citizens of Poland emit during the year. The unit of area of sugar beets compensates the emission of carbon dioxide of 2.4 statistical citizens and rape 1.5 of emission per capita.

Ecosystems services are therefore also diversified. In this case the highest value has the beets crop and the lowest the rape crop.

Conclusions

1. Emergetic method allows replacing the receptor system of values based on people preferences with the donor system of values based on the evaluation of goods and environmental services.
2. Emergetic researches allow obtaining a consistent balance of environmental resources and the assessment of their use on the basis of physical and economic data applied to the thermodynamic theories.
3. Although cultivation methods used in Wielkopolska Region do not indicate full compatibility with the principle of the environment sustainability, they compensate effectively emission of carbon dioxide resulting from the consumption of non-renewable energy sources. The factor that causes a lack of sustainability is intensive use of fertilizers.
4. The emergetic method can be used to estimate market values of the environmental services usually omitted and to express them in clear and understandable features. It can be a useful tool for the popularization of knowledge and behavior directed on environment protection.

Project, 2006; J.R Siche, F. Agostinho, E. Ortega, *Energy net primary production (ENPP) as basis for calculation of ecological footprint,* "Ecological Indicators" 2010 No. 70, p. 475-483.

[26] Ibidem.

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ECOSYSTEM SERVICES OF EXTENSIVE WET GRASSLANDS. WIELKOPOLSKA REGION (POLAND) CASE STUDY

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ŚWIADCZENIA EKOSYSTEMÓW EKSTENSYWNYCH PODMOKŁYCH UŻYTKÓW ZIELONYCH. STUDIUM PRZYPADKU REGIONU WIELKOPOLSKIEGO

STRESZCZENIE: Określono ekosystemowe świadczenia dwóch typów mikrokrajobrazów z seminaturalnymi łąkami z Calthion, a zarazem z bogactwem biocenoz naturalnych. Są one powiązane z ekstensywnymi (tradycyjnymi) formami użytkowania gruntów rolnych. W identyfikacji świadczeń ekosystemowych zastosowano system przedstawiony w Millennium Ecosystem Assessment, zmodyfikowany przez K. J. Wallace. Modyfikacja ta jest wynikiem krytycznego ustosunkowania się jej autora do konstrukcji powszechnie stosowanego systemu MA, rodzącego poważne problemy efektywnego zarządzania obszarami stanowiącymi mozaikę gruntów rolnych powierzchniowo zdominowanych przez antropogeniczne biocenozy synantropijne segetalne i ruderalne oraz geoekosystemów naturalnych. Wskazano zagrożenia świadczeń ekosystemowych związane z dynamicznym, gospodarczym rozwojem Wielkopolski. Omówiono jeden ze sposobów przeciwdziałania zagrożeniom świadczeń ekosystemowych w sektorze rolnictwa, jakim jest Program Rolno-Środowiskowy objęty Programem Rozwoju Obszarów Wiejskich na lata 2007-2013.

SŁOWA KLUCZOWE: Calthion, mikrokrajobraz, program rolno-środowiskowy, sigmasocjacja, symfitosocjologia, świadczenia ekosystemowe, łąki łęgowe

Introduction

Over the last decade, a distinct increase in the number of publications on ecosystem services (ES) has been observed, as shown by B. Fisher et al.[1]. Presumably, it is an after-effect of the work Millennium Ecosystem Assessment[2], calling for research on measuring, modelling and mapping ecosystem services. This subject has been discussed also in the Polish scientific literature (e.g. A. Mizgajski[3], Z. M. Rosin et al.[4]), however, without contribution of specialists in structure and functioning of ecosystems and, at the same time, in biodiversity conservation.

This article responds to a clarion of the MA[2]. Its aim was to determine ecosystem services served by vegetation cover of permanent meadows and permanent pastures. This has been accomplished through an analysis of two types of microlandscapes that are representative for natural conditions of Wielkopolska and widespread in this region. These microlandscapes are characterised by the surface dominance of seminatural wet *Calthion* meadows. Both types are connected with the extensive forms of grassland use. Due to these forms, mosaic arrangements of agricultural lands and natural ecosystems have developed (historically) and survived up to the present day. Such areas are characterised by high biodiversity, however, exposed to threat from the intensification of agricultural production. In Europe, they are regarded as disappearing P. Harrison et al.[5]. On account of their natural-seminatural character, they are considered by some scientists as hot spots of multiple delivery of ecosystem services (e.g. S. Lavorel et al.[6]). The analysed microlandscapes differ significantly one from the other in terms of biotic and abiotic characteristics, but, generally, they provide the same categories of ecosystem services. However, they differ in these ecosystem services that depend on the character of their flora and phytocoenotic structure of vegetation. Both types of microlandscapes are connected with the Natura 2000 habitat code *91E0, occurring in ecological corridors of river valleys. In 2009, in Poland, works on the projects of protective plans for the areas of European Eco-

[1] B. Fisher, R. K. Turner, P. Morling, *Defining and classifying ecosystem services for decision making*, "Ecological Economics" 2009 No. 68, p. 643-653.

[2] *The Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Biodiversity Synthesis*, Island Press, Washington 2005.

[3] A. Mizgajski, *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 10-19.

[4] Z. M. Rosin et al., *Koncepcja świadczeń ekosystemowych i jej znaczenie w ochronie przyrody polskiego krajobrazu rolniczego*, „Chrońmy Przyrodę Ojczystą" 2011 No. 67(1), p. 3-20.

[5] P. Harrison et al., *Identifying and prioritising services in European terrestrial and freshwater ecosystems*, "Biodiversity and Conservation" 2010 No. 19(10), p. 2791-2821.

[6] S. Lavorel et al., *Using plant functional traits to understand the landscape distribution of multiple ecosystem services*, "Journal of Ecology" 2011 No. 99(1), p. 135-147.

logical Network Natura 2000 were initiated. The aim of these plans is to ensure a proper protection condition of Natura 2000 natural habitats and species, among others, the aforementioned N2000 code *91E0, and, at the same time, to maintain them in the landscape as elements of socio-ecological system of ecosystem services. Tasks included in the plans involve recognition of biodiversity threats and ways of their minimalization or elimination. One of tools, which serves the implementation of protective proposals, already included in these plans, is the Agri-environmental Programme, covered by the Rural Development Programme (RDP) for 2007-2013[7], and financed by the European Agricultural Fund for Rural Development (*EAFRD*).

Material and methods

Ecosystem services of vegetation complexes connected with the potential biochores of two natural habitats, willow forest *Salicetum albae* and ash-alder tree stand *Fraxino-Alnetum*, were determined. These vegetation complexes, analysed typologically, are microlandscapes according to T. Chmielewski & J. Solon[8]. Their vegetation structure was documented by the symphytosociological method of R. Tüxen[9] for *relevés in sigmassociations.* In the two types of analysed microlandscapes, 20 *relevés were made, 10 in each. During the selection of patches for relevés, among others, the results of studies by J.* Borysiak[10,11] and J. Borysiak & M. Kasprowicz[12] *were used. The phytocoenotic differentiation of present vegetation complexes was determined following the* Braun-Blanquet method, using a syntaxonomic system included in the publication by A. Brzeg & M. Wojterska[13]. Specific names of plants were given according to Z. Mirek et al.[14].

[7] Rural Development Programme for 2007-2013 (RDP 2007-2013). 2007. Ministry of Agriculture and Rural Development, Warsaw, http://www.minrol.gov.pl/eng/content/view/full/18575 [Date of entry: 28-09-2012].

[8] T. Chmielewski, J. Solon, *Podstawowe przyrodnicze jednostki przestrzenne Kampinoskiego Parku Narodowego: zasady wyróżniania i kierunki ochrony*, in: *Badania ekologiczno-krajobrazowe na obszarach chronionych*, ed. Mariusz Kistowski, Uniwersytet Gdański 1996, p. 130-142.

[9] R. Tüxen, *Zür Homogenität von Sigmassoziationen, ihrer syntaxonomischen Ordnung und ihrer Verwendung in der Vegetations Kartierung*, "Doc. Phytosoc. N.S." 1977 No. 1, p. 321-327.

[10] J. Borysiak, *Struktura aluwialnej roślinności lądowej środkowego i dolnego biegu Warty*, Wydawnictwo Naukowe UAM, Biologia 52, Poznań 1994, p. 258.

[11] J. Borysiak, *Plant cover of The Lower Oder River Valley Landscape Park*, Wydawnictwo Naukowe UAM, Biologia 70, Poznań 2004, p. 143 + CD.

[12] J. Borysiak, M. Kasprowicz, *Mikrokrajobrazy roślinne dorzecza Prosny w okolicach Wieruszowa*, „Badania Fizjograficzne nad Polską Zachodnią" B' 1998 No. 47, p. 205-225.

[13] 220 A. Brzeg, M. Wojterska, *Zespoły roślinne Wielkopolski, ich stan poznania i zagrożenie*, w: *Szata roślinna Wielkopolski i Pojezierza Południowopomorskiego*, ed. Maria Wojterska, Bogucki Wydawnictwo Naukowe, Poznań 2001, p. 39-110.

[14] Z. Mirek, H. Piękoś-Mirkowa, A. Zając, M. Zając, *Flowering plants and pteridophytes of Poland. A checklist*, in: *Biodiversity of Poland 1*, ed. Zbigniew Mirek, W. Szafer Institute of Botany, Polish Academy of Sciences, Kraków 2002, p. 442.

Microlandscapes of extensive permanent grasslands of Wielkopolska

In Wielkopolska, private farms exceeding 1ha of agricultural land decidedly dominate (122,1 thous.). They conduct agricultural activity in the land area of 1475,0 thous. ha, in good agricultural condition. Within this area, 15% are permanent meadows (190,8 thous. ha) and permanent pastures (20,5 thous. ha). According to the Agricultural Census 2010, the average area of a private farm in Wielkopolska was 12,08 ha, in Poland 8,82 ha (H. Dmochowska[15]). Since many generations, in such small private farms extensive (traditional) forms of cultivation have been widely practised. They are advantageous for the preservation of historically shaped biodiversity of rural landscape. To illustrate this biodiversity and identify problems related to its protection, two types of natural-seminatural microlandscapes connected with permanent grasslands were selected. One of these types is connected with the habitats of potential natural vegetation of *Salicetum albae*, in which dominate *Ranunculo-Alopecuretum pratensis* meadows developed on Fluvisols. The domain of other type are potential biochores of *Fraxino-Alnetum*, with dominating *Angelico-Cirsietum oleracei* grasslands on Eutric Gleysols and Histosols. Vegetation complexes that correspond to these types are most widespread among permanent grasslands of Wielkopolska.

Microlandscapes with *Ranunculo repentis-Alopecuretum pratensis* meadows

The main axis (collecting and generating) of the natural system of Wielkopolska is the Warta river valley. It plays a function of the supraregional ecological corridor. The course of the river between Poznań and Koło is an important area for bird nesting and migration (A. Derc[16], A. Mizgajski & Zwierzchowska[17]. Most of this area has been included in the European Ecological Network of Natura 2000. Some fragments are not embanked, like Polders: Lądek, Wrąbczyn i Rataje. Due to frequent floods, these polders are extensively used. Within the riverbed of unregulated course, in the zone of systemic inundations, habitats with the potential natural vegetation of *Salicetum albae* and alluvial soils covered by permanent grasslands dominate. Vegetation complexes, which are related to

[15] H. Dmochowska, *Rocznik statystyczny województw 2011*. Główny Urząd Statystyczny, Warszawa. Statistical Yearbook of the Regions. Central Statistical Office, Warsaw http://www.stat.gov.pl/cps/rde/xbcr/gus/rs_rocznik_stat_wojew_2011.pdf [Date of entry: 10-09-2012].

[16] A. Derc (Chief Project Eng.) *Plan zagospodarowania przestrzennego województwa wielkopolskiego. Samorząd Województwa Wielkopolskiego* http://www.wbpp.poznan.pl/plan/index.html [Date of entry: 10-09-2012].

[17] A. Mizgajski, I. Zwierzchowska, *Środowisko przyrodnicze, w: Studium uwarunkowań rozwoju przestrzennego Aglomeracji Poznańskiej*, ed. Tomasz Kaczmarek, Centrum Badań Metropolitalnych Uniwersytetu im. Adama Mickiewicza w Poznaniu, http://metropolia2020.poznan.pl/tresc-dokumentu [Date of entry: 10-09-2012].

these areas, are distinguished by the high differentiation of phytocoenotic structure due to their connection with various fluvial landforms. The higher geodiversity of these landforms, the greater differentiation of plant communities of the complex at the levels α (intraphytocoenotic) and β, i.e., between the types of phytocoenoses (J. Borysiak & W. Stachnowicz[18]). In ten patches of such complexes selected for an analysis, in the examined sigmassociations (0,3-0,6 ha) decidedly dominated meadow phytocoenoses of *Ranunculo repentis-Alopecuretum pratensis* (Table 1). Persistently present, but in much lower surface proportion, were patches of *Stellario-Deschampsietum*. Both types of meadows belong to *Calthion*. In the intra-grassland depressions (mostly channel fills) or depressions situated by the natural levee, flooded swards of *Ranunculo repentis-Alopecuretum geniculati* or rushes of *Phalaridetum arundinaceae* occurred. In places often visited by wild water birds, phytocoenoses of *Potentilletum anserinae* and *Potentilletum reptantis* were noted. The grasslands were adjacent either to the present Warta river bed or old river bed, what was marked by the stands of *Salicetum albae* and *Salicetum triandro-viminalis*, which are rated as the Natura 2000 habitat code *91E0 (alluvial forests), of priority protection[19]. A manual characteristics of such habitats was presented by J. Borysiak[20]. Along water courses and in the ecotone zone of forests and thickets, hydrophilous and nitrophilous tall herb fringe communities of plains from *Convolvulion sepium*: *Achilleo salicifoliae-Cuscutetum lupuliformis*, *Carduo crispi-Rubetum caesii*, *Fallopio-Humuletum lupuli*, *Urtico-Convolvuletum sepium* and, less frequently, with *Convolvulo sepium-Cuscutetum europaeum* and *Fallopio-Cucubaletum bacciferi* were noted. All of them represent the Natura 2000 habitat code 6430. Sometimes, among grasslands, forbs of *Scutellario hastifoliae-Veronicetum longifoliae* were observed. On the muddy river banks of the Warta river, or in the fresh deposits of alluvial terraces, the annual pioneer nitrophilous communities of *Isoëto-Nanojuncetea* (*Cypero fusci-Limoselletum* and *Juncetum bufonii*) and *Bidentetea tripartitae* (*Agrostio stoloniferae-Pulicarietum vulgaris*, *Chenopodio rubri-Polygonetum brittingeri* and *Rumicetum maritime*) developed. These associations represent the Natura 2000 habitat code 3270. Their general characteristics is

[18] J. Borysiak, W. Stachnowicz, *Vegetation in relation to fluvial mesoforms – The River Warta case study*, "Perspectives in Environmental Sciences" 2000 No. 1, p. 7-12.

[19] Rozporządzenie Ministra Środowiska z dnia 13 kwietnia 2010 r. w sprawie siedlisk przyrodniczych oraz gatunków będących przedmiotem zainteresowania Wspólnoty, a także kryteriów wyboru obszarów kwalifikujących się do uznania lub wyznaczenia jako obszary Natura 2000 (Dz.U. 2010.77.510). [Regulation of the Minister of Environment of 13 April 2010 on habitats and species being the subject of interest for the European Union, and the selection criteria for the areas qualifying for recognition or designation as the Natura 2000 areas (Journal of Laws 2010.77.510)].

[20] J. Borysiak, *Nadrzeczny łęg wierzbowy Salicetum albae*, w: *Lasy i bory. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny* No. 5, ed. J. Herbich, Ministerstwo Środowiska, Warszawa 2004, p. 205-210, http://natura2000.gdos.gov.pl/strona/tom-6 [Date of entry: 10-09-2012].

included in the paper by J. Borysiak[21]. In the examined sigmassociations of the analysed microlandscape, 22 plant associations were recorded in total, including 15 (68%) of natural syngenesis and 5 (23%) seminatural. The latter (meadows and pastures) occupied 75-85% of the patch of vegetation complex. This spatial vegetation unit is characterised by a high degree of naturalness. Among natural associations, three are rated as vulnerable, according to the classification by A. Brzeg & M. Wojterska[13]. These are: *Fallopio-Humuletum lupuli*, *Salicetum albae* and *Scutellario hastifoliae-Veronicetum longifoliae*. In the phytocoenoses of associations found in sigmassociations or in various trophic subassociations and variants of these associations, from 10 to 20 threatened species of plants can potentially occur, including, two endangered (EN) – *Allium angulosum* and *Sonchus palustris*, and six vulnerable (VU): *Euphorbia lucida*, *Gratiola officinalis*, *Oenanthe fistulosa*, *Petasites spurius*, *Senecio fluviatilis* and *S. paludosus*. In addition, 4 species under strict protection, listed in the Regulation of the Minister of the Environment[22], can be found. These are: *Angelica archangelica*, *Centaurium pulchellum*, *Corrigiola litoralis* (threat category CR) and *Gratiola officinalis* (VU). Undesirable elements in the described microlandscape are phytocoenoses of two xenospontaneous associations (neophyte communities), i.e. *Bidenti-Atriplicetum prostratae* with the participation of expansive kenophyte *Bidens frondosa* and *Chenopodio rubri-Xanthietum riparii* with the alien species *Xanthium albinum*. A very high degree of naturalness causes that the threat of neophytisation with the participation of these and other anthropophytes is relatively small. Only sporadically such kenophytes (according to the classification by A. Zając et al.[23] as *Aster lanceolatus* and *Solidago gigantea* were observed. An alarming process is a mass appearance of *Echinocystis lobata* in the all mentioned associations of *Calystegion sepium*, which form a vegetation complex of the discussed type of microlandscape. This plant eliminates from the floristic composition numerous native species, such as: *Calystegia sepium*, *Cucubalus baccifer*, parasitic *Cuscuta europaea* and *C. lupuliformis*, *Fallopia dumetorum*, and *Humulus lupulus*. These species represent a quite rare life form for the flora of Poland – climbers. An economic growth noted in Wielkopolska can result in the appearance of new kenophytes – plants brought, among others, for ornamental purposes.

[21] J. Borysiak, *Zalewane muliste brzegi rzek*, w: *Wody słodkie i torfowiska. Poradniki ochrony siedlisk i gatunków Natura 2000 – podręcznik metodyczny* No. 2, ed. Jacek Herbich, Ministerstwo Środowiska, Warszawa 2004, p. 107-112, http://natura2000.gdos.gov.pl/strona/tom-3 [Date of entry: 10-09-2012].

[22] Rozporządzenie Ministra Środowiska z dnia 5 stycznia 2012 r. w sprawie ochrony gatunkowej roślin Dz.U. 2012, nr 0, poz. 81 [Regulation of the Minister of Environment of 5 January 2012 on plant species protection] (Journal of Laws 2012.81).

[23] A. Zając, M. Zając, B. Tokarska-Guzik, *Kenophytes in the flora of Poland: list, status and origin*, "Phytocoenosis" 1998 No. 10(9), p. 107-116.

Table 1
Phytocoenotic structure of the grassland microlandscape in the Warta river valley with the surface domination of *Ranunculo repentis-Alopecuretum pratensis* hay meadows

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Date (year)	2009	2010	2011	2011	2010	2010	2011	2011	2011	2011
Forests, shrubs [%]	5	10	10	5	10	10	10	10	10	10
Meadows, pastures [%]	85	75	75	80	70	75	75	75	75	80
Tall forbs [%]	10	10	10	10	10	10	10	10	10	10
Reeds [%]	<5	5	5	5	10	5	5	5	5	<5
Therophytic phytocoenoses [%]	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Area of sigmassociation [ha]	0,4	0,4	0,4	0,3	0,4	0,4	0,6	0,3	0,5	0,4
Number of associations	20	19	15	14	12	12	15	13	10	12
Salicetea purpureae:										
Salicetum albae	1.	2/	2/	1.	1.	2/	2/	2/	2/	2/
Salicetum triandro-viminalis	1.	2.	2/	1.	2/	1.	2/	1.	2/	1.
Molinio-Arrhenatheretea:										
Ranunculo repentis-Alopecuretum pratensis	40	40	30	40	40	40	40	40	40	30
Stellario palustris-Deschampsietum cespitosae	+.	1.	20	1.	1.	1.	1.	1.	20	20
Ranunculo repentis-Alopecuretum geniculati	1.	1.	20	+.	+.	1.	1.	+.	+.	20
Potentilletum anserinae	20	1.	1.	1.	+.	+.	20	+.	.	.
Potentilletum reptantis	20	+.	20	1.	.	+.	+.	+.	.	+.
Artemisietea:										
Urtico-Convolvuletum sepium	1.	2.	20	2/	2.	1/	2.	2/	2.	2/
Carduo crispi-Rubetum caesii	2/	1.	1.	1.	1.	2/	1.	1.	+.	+.
Convolvulo sepium-Cuscutetum europaeae	.	1.	1.	1.	1.	.	.	.	1.	1.
Fallopio-Humuletum lupuli	1.	1.	.	+.	.	1.	1.	.	.	.
Achilleo salicifoliae-Cuscutetum lupuliformis	1.	.	.	.	.	.	1.	1.	.	.
Scutellario hastifoliae-Veronicetum longifoliae	1.	1.	.	.	.	.	.	.	.	.
Fallopio-Cucubaletum bacciferi	.	.	.	.	.	.	+.	.	.	.
Phragmitetea:										
Phalaridetum arundinaceae	1.	2.	2.	2.	2/	2.	2/	2.	2.	1.
Isoëto-Juncetea bufonii et Bidentetea:										
Bidenti-Atriplicetum prostratae	1.	1.	1.	1.	1.	1.	+.	1.	1.	1.
Cypero fusci-Limoselletum	+.	1.	1.	+.	1.	.	.	.	.	.
Juncetum bufonii	+.	1.	1.	.	.	.	+.	.	.	+.
Rumicetum maritimi	1.	1/	.	.	.	.	.	+.	.	.
Chenopodio rubri-Polygonetum brittingeri	1.	1.	.	.	.	.	.	.	.	.

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Chenopodio rubri-Xanthietum riparii	+.	.	1.	.	.	.	.	.	.	.
Agrostio stoloniferae-Pulicarietum vulgaris	+.	1.	.	.	.	.	.	.	.	.

Occurrence way of plant community in vegetation complex: 0 – over great surface, / – in long, narrow linear form, . – singular or dispersed in irregular form; quantity – Braun-Blanquet scale: + – in a minimal degree, 1 – ≤5% vegetation cover, 2 – 5-25%, 3 – 25-50%, 4 – 50-75%, 5 – 75-100%

Microlandscapes with *Angelico-Cirsietum oleracei* meadows

Wielkopolska has a well developed hydrographic network, particularly, within the Wielkopolska Lakeland. In addition to the Warta river, the network is formed by the Warta tributaries of various order. Among the larger right-bank tributaries are: Ner, Wełna and Noteć rivers, while among the left-bank are Prosna and Obra. In the Land Development Plan prognosis (M. Czerniak et al.[24]) for the Wielkopolska province, on the map 'Natural Environment', watercourses smaller than Warta are designated as regional and local ecological corridors. In the valleys of aforementioned Warta tributaries and, also, their larger branches, the range of alluvial soils is strongly restricted and, thus, microlandscapes with the participation of *Ranunculo repentis-Alopecuretum pratensis* hay meadows occur only sporadically. Generally, well developed, flat terraces of the discussed hydrographic network are a domain of Eutric Gleysols or Histosols and habitats of the potential natural vegetation of *Fraxino-Alnetum*. They are characterised by a high level of ground water for most of the year and are used as meadows. Within them, as a result of extensive management, vegetation complexes dominated by the *Angelico-Cirsietum oleracei* phytocoenoses are most frequently noted. In the examined sigmassociations, 17 plant associations were recorded in such complexes in total (Table 2), including 14 of natural syngenesis and 3 seminatural. Grassland phytocoenoses covered 85-95% of the complex area (0,4-1,2 ha), forests and thickets 5-15%, while the remaining types <5%. The constant and frequent elements of that microlandscape included: treestands of *Fraxino-Alnetum* (Natura 2000 habitat code *91E0[19]); thickets of *Aegopodio-Sambucetum nigrae*; grasslands of *Angelico-Cirsietum oleracei*, *Scirpetum sylvatici* and *Stellario-Deschampsietum*; and ecotone tall herb fringe communities of Natura 2000 code 6430: *Eupatorietum cannabini*, *Fallopio-Humuletum* and *Urtico-Convolvuletum*. In the analysed complexes, 6 associations threatened with extinction in Wielkopolska were found, according to the classificaction by A. Brzeg & M. Wojterska. Under the category V (vulnerable) fall grassland communities – *Angelico-Cirsietum oleracei*, *Caricetum cespitosae*, *Poo palustris-Lathyretum palustris* and *Scirpetum sylvatici*, and, also, the spring community

24 M. Czerniak et al., *Plan zagospodarowania przestrzennego województwa wielkopolskiego. Prognoza oddziaływania na środowisko*. Samorząd Województwa Wielkopolskiego, http://www.wbpp.poznan.pl/plan/index.html [Date of entry: 10-09-2012].

Cardamino-Chrysosplenietum alternifolii. On dirt roads used for hay transport, *Poetum annuae* was noted, while in the wallows of the wild boar *Sus scrofa* or in tractor ruts, muddy annual communities – *Bidenti-Polygonetum hydropiperis* or *Bidenti-Polygonetum mitis*. In the different forms of patches of the above-mentioned associations (subassociations and variants) about 20 species threatened with extinction and 15 under the law's protection can be found. According to the red list by B. Jackowiak et al.[25], the following species fall under the category EN: *Alchemilla acutiloba*, *Cirsium rivulare*, *Neottia nidus-avis* and *Thalictrum simplex*, while under the category VU: *Alchemilla gracilis*, *Astrantia major*, *Calamagrostis stricta*, *Circaea intermedia*, *Senecio aquatica*, *Trisetum flavescens* and *Trollius europaeus*. From the group of plants under the strict law's protection, listed in the Regulation of the Minister of the Environment[22], there are such species as: *Dactylorhiza incarnata* (LC), *D. majalis* (LC), *Daphne mezereum* (LC), *Epipactis helleborine*, *Hepatica nobilis*, *Leucoium vernum* (DD), *Neottia nidus-avis* (EN) and *Trollius europaeus* (VU), while among the species partially protected – *Asarum europaeum*, *Climacium dendroides*, *Frangula alnus*, *Galium odoratum*, *Hedera helix*, *Menyanthes trifoliata* and *Viburnum opulus*.

Table 2

Phytocoenotic structure of the grassland microlandscape in the Warta river valley with the surface domination of *Angelico-Cirsietum oleracei* hay meadows

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Date (year)	2010	2010	2011	2011	2011	2010	2011	2012	2010	2011
Stream valley										
Forests, shrubs [%]	10	10	10	10	5	10	5	15	10	5
Meadows, meadow tall forbs [%]	90	90	90	90	95	90	95	85	90	95
Tall forbs [%]	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Carpet phytocoenoses [%]	-	<5	<5	<5	<5	-	<5	-	-	-
Therophytic phytocoenoses [%]	<5	<5	<5	-	-	-	-	-	<5	-
Spring phytocoenoses [%]	-	-	-	-	-	-	<5	-	<5	-
Area of sigmassociation [ha]	0,6	0,8	0,4	0,5	0,6	0,4	0,6	1,2	0,4	0,7
Number of associations	13	14	13	10	9	8	8	9	9	8
Querco-Fagetea:										
Fraxino-Alnetum	20	20	2/	10	20	20	20	2/	10	2/
Rhamno-Prunetea:										
Aegopodio-Sambucetum nigrae	1.	1.	1.	2/	+.	1.	+.	1/	2/	+.
Molinio-Arrhenatheretea:										

[25] B. Jackowiak, Z. Celka, J. Chmiel, K. Latowski, W. Żukowski, *Red list of vascular flora of Wielkopolska (Poland)*, „Biodiversity: Research and Conservation" 2007 No. 5-8, p. 95-127.

Number of sigmassociation	1	2	3	4	5	6	7	8	9	10
Angelico-Cirsietum oleracei	40	40	40	50	50	50	40	40	40	40
Scirpetum sylvatici	+.	+.	1.	+.	+.	+.	20	1/	20	20
Stellario palustris-Deschampsietum cespitosae	1.	1.	20	1.	+.	.	.	20	1.	+.
Lysimachio vulgaris-Filipenduletum	+.	+.	.	.	+.	+.	.	+.	.	.
Caricetum cespitosae	30	20	1.	.	.	.	.	+.	.	.
Filipendulo-Geranietum palustris	+.	.	+.	+.	.	.	.	.	.	+.
Poo palustris-Lathyretum palustris	+.	1.	.	.	.	.	.	.	.	.
Artemisietea:										
Fallopio-Humuletum	+.	1/	+.	1/	+.	1.	+.	1/	.	+.
Urtico-Convolvuletum sepium	1.	+.	1.	+.	.	+.	+.	.	+.	.
Eupatorietum cannabini	+.	1/	1.	.	+.	.	.	+.	+.	.
Epilobio hirsuti-Convolvuletum sepium	.	+.	+.	+.	.	.	+.	.	.	.
Bidentetea:										
Bidenti-Polygonetum mitis	+.	.	+.	.	.	.	.	.	.	.
Bidenti-Polygonetum hydropiperis	.	+.	.	.	.	.	.	.	+.	.
Polygono arenastri-Poetum annuae:										
Poetum annuae	.	1/	1/	1/	+.	+.	+.	.	.	.
Montio-Cardaminetea:										
Cardamino-Chrysosplenietum alternifolii	.	.	.	.	.	.	.	.	1.	+.

Occurrence way of plant community in vegetation complex: 0 – over great surface, / – in long, narrow linear form, . – singular or dispersed in irregular form; quantity – Braun-Blanquet scale: + – in a minimal degree, 1 – ≤5% vegetation cover, 2 – 5-25%, 3 – 25-50%, 4 – 50-75%, 5 – 75-100%

Ecosystem services of microlandscapes with *Calthion* hay meadows

According to the classification of the Millennium Ecosystem Assessment2, ecosystem services provided by the analysed microlandscapes with *Calthion* meadows comprise: provisioning ES – food production, genetic resources, natural medicines; regulating ES – air quality regulation, climate regulation, water regulation, erosion regulation, disease regulation, pest regulation and pollination; cultural ES – cultural diversity, spiritual and religious values, recreation and ecotourism, aesthetic values, knowledge systems and educational values; and supporting ES – soil formation, photosynthesis, primary production, nutrient cycling and water cycling. A large modification of the MA system (l.c.) is the classification of ecosystem services (ES) proposed by K. J. Wallace[26]. This classification is the result of a critical stance on the construction of the commonly used MA system, which gives rise to serious problems in the effective manage-

[26] K. J. Wallace, *Classification of ecosystem services: Problems and solutions*, "Biological Conservation" 2007 No. 139, p. 235-246.

ment of a mixture of agricultural land and natural vegetation. Earlier, it has been shown that the analysed extensive microlandscapes with the surface domination of wet *Calthion* meadows are connected with such areas. K. J. Wallace (l.c.) groups ecosystem services in the category of human values. He ascribes to each category a list of ecosystem services. Moreover, he mentions those ecosystem services and natural assets which should be managed to ensure that their ecosystem services are provided. Accordingly, the two analysed plant microlandscapes, despite substantial geobotanical differences between them (Table 3), provide the same multiple services resulting form the complex phytocoenotic composition – a mosaic of seminatural (dominating meadow and pasture phytocoenoses) and natural (forests, thickets and tall herb communities) ecosystems. These comprise the following services, experienced at the individual human level: food, oxygen, protection from disease and benign environmental regimes (of temperature, moisture, light and chemical). In the category socio-cultural fulfilment these are: spiritual/philosophical contentment, recreation/leisure, aesthetics, capacity for cultural and biological evolution (knowledge/education resources, genetic resources). According to Wallace (l.c.), to secure these services, it is necessary to manage such processes and assets as: biological regulation, climate regulation, disturbance regimes (flooding), gas emission regulation, management of 'beauty' at the landscape and local scales, management of land for recreation, nutrient regulation, pollination, production of food, production of medicines, soil formation, soil retention, waste regulation and economic processes. Management of the mentioned processes is expected to protect a particular composition and structure of ecosystem elements (biotic and abiotic).

Threats to ecosystem services of microlandscapes with *Calthion* meadows

In 2010, the land development plan for the Wielkopolska region (A. Derc16) was passed. The data included in the plan prognosis, presented by M. Czerniak et al., show that ecosystem services of microlandscapes with *Calthion* meadows are seriously threatened. In the years 2001-2008, in Wielkopolska (also generally in Poland), alarming change trends in the environment resources and natural values occurred, resulting from the increased anthropization generated by the economic development of this region. In these years, investment in housing development and technical infrastructure substantially raised. This caused, among others, an increase in spatial fragmentation and decrease in agricultural land area by 0.6%. Disappearance of agricultural functions is particularly visible in the area of Poznań Agglomeration (see also A. Mizgajski and I. Zwierzchowska). Waters of the whole region continue to be of a very low quality, mainly due to the poorly developed sewer system in rural areas and high chemization of agriculture. Waters of the class IV (of unsatisfactory quality) were found in 47% of measurement and control points, while of the class V (of poor quality) in as many

Table 3

Geobotanical outline of the river valley microlandscapes of Wielkopolska with surface domination of *Calthion* meadows

	Microlandscape with the surface domination of wet hay meadows	
	Ranunculo repentis-Alopecuretum pratensis	*Angelico-Cirsietum oleracei*
Area of occurrence	floodplains in the Warta river valley	well developed bottom terraces with slight transverse and longitudinal gradients and high level of groundwater in the valleys of Warta river larger tributaries and their branches
Position in the ecological network of Wielkopolska	national ecological corridor	local and regional ecological corridors
Natural potential vegetation	*Salicetum albae*	*Fraxino-Alnetum*
Soil cover	Fluvisols	Histosols, Eutric Gleysols
Number of plant associations (natural/seminatural); acc. to Table 1* and Table 2^	22 (15/5)*	17 (14/3)^
Number of threatened plant associations in Wielkopolska; acc. to Table 1* and Table 2^	3*: *Fallopio-Humuletum lupuli*, *Salicetum albae*, *Scutellario hastifoliae-Veronicetum longifoliae*	6^: *Angelico-Cirsietum oleracei*, *Cardamino-Chrysosplenietum alternifolii*, *Caricetum cespitosae*, *Poo palustris-Lathyretum palustris*, *Scirpetum sylvatici*
Natural habitats of the European Ecological Network Natura 2000 and their representative plant associations; acc. to Table 1* and Table 2^	91E0*: *Salicetum albae*, *Salicetum triandro-viminalis* 6430: *Achilleo salicifoliae-Cuscutetum lupuliformis*, *Carduo crispi-Rubetum caesii*, *Fallopio-Humuletum lupuli*, *Urtico-Convolvuletum sepium*, *Convolvulo sepium-Cuscutetum europaeum*, *Fallopio-Cucubaletum bacciferi* 3270: *Agrostio stoloniferae-Pulicarietum vulgaris*, *Chenopodio rubri-Polygonetum brittingeri*, *Cypero fusci-Limoselletum*, *Juncetum bufonii*, *Rumicetum maritime*	91E0^: *Fraxino-Alnetum* 6430: *Eupatorietum cannabini*, *Fallopio-Humuletum*, *Urtico-Convolvuletum*
Threatened species in Wielkopolska that may occur	EN: *Allium angulosum*, *Sonchus palustris* V: *Euphorbia lucida*, *Gratiola officinalis*, *Oenanthe fistulosa*, *Petasites spurius*, *Senecio fluviatilis* i *S. paludosus*	EN: *Alchemilla acutiloba*, *Cirsium rivulare*, *Neottia nidus-avis*, *Thalictrum simplex* VU: *Alchemilla gracilis*, *Astrantia major*, *Calamagrostis stricta*, *Circaea intermedia*, *Senecio aquatica*, *Trisetum flavescens*, *Trollius europaeus*
Species under strict protection that may occur	*Angelica archangelica*, *Centaurium pulchellum*, *Corrigiola litoralis* (CR), *Gratiola officinalis* (VU)	*Dactylorhiza incarnata* (LC), *D. majalis* (LC), *Daphne mezereum* (LC), *Epipactis helleborine*, *Hepatica nobilis*, *Leucoium vernum* (DD), *Neottia nidus-avis* (EN), *Trollius europaeus* (VU)
Species under partial protection that may occur		*Asarum europaeum*, *Climacium dendroides*, *Frangula alnus*, *Galium odoratum*, *Hedera helix*, *Menyanthes trifoliate*, *Viburnum opulus*

as 36%. Still, only a part of rural population has sewage treatment service provided (29% of the whole population). Pesticides (NPP) usage has increased by 56.6%, which corresponds to the agricultural intensification. As much as 8.3% of the region are sensitive waters and areas particularly exposed to the contamination by nitrogen compounds of agricultural origin. These areas comprise reception basins of 13 watercourses. Also, the extent of acoustically favourable areas decreased. In some fragments of the roads S2, S5, S11, 25, 92 and A2, and also for the railway No. 3, the forecast indicator of daily traffic of high threat level to acoustic climate was exceeded. An emission of gaseous contaminants from the particularly burdensome factories increased by 2.3%, while the number of such factories by 1.6%. In the whole region, the target level and long-term target level of ozone O_3 were exceeded. The investment expenditures for small water retention decreased by 77%. A considerable area of the region (4%) is directly threatened with flooding. A high frequency and dynamics of floods has been observed. A decrease in afforestation activities occurred, from 1584 ha in 2001 to 442 ha in 2008. The size of protected areas (excluding the Natura 2000 sites), which ensure a relative balance of ecological processes supporting ecosystem services, increased as little as 1%.

In the quoted prognosis by M. Czerniak et al., the presented data for the years 2001-2008 were optimistic in terms of preservation of ecosystem services provided by the discussed plant microlandscapes with *Calthion* meadows. Significantly increased expenditures (by 65%) for fixed assets (per inhabitant) that serve environmental protection. The sewage quantity, requiring purification, channelled to surface waters or to the ground decreased by 8%. The estimation of atmospheric air pollution, conducted in 2008 in terms of plant protection, showed the class A level due to SO_2 and NO_x pollution. Crop fields in Wielkopolska were contaminated with heavy metals only to a small degree and met requirements for healthy food production. The number of certified ecological farms increased almost 12 times (by 190). According to H. Dmochowska, 456 certified organic farms on 20,755 ha of organic agricultural land and 292 organic farms under conversion on 22,758 ha were recorded in Wielkopolska in 2010.

Agri-environmental Programme – a tool for protecting ecosystem services of microlandscapes with *Calthion* meadows

The Agri-environmental Programme[27] is one of tools which secures ecological processes and assets required for the maintenance of ecosystem services

[27] Rozporządzenie Ministra Rolnictwa i Rozwoju Wsi z dnia 26 lutego 2009 r. w sprawie szczególnych warunków i trybu przyznawania pomocy finansowej w ramach działania 'Program rolnośrodowiskowy' objętego Programem Rozwoju Obszarów Wiejskich na lata 2007-2013. Dz.U. 2009.33.262 [Regulation of the Minister of Agriculture and Rural Development of 26 February 2009 on specific conditions and mode of granting financial support within the 'Agri-

provided by microlandscapes with *Calthion* meadows. This programme is covered by Rural Development Programme for 2007-2013[7], financed by the European Agricultural Fund for Rural Development (*EAFRD*). *Every farmer (in the whole country), who has the farm ID number and agricultural land of no less than* 1 ha, can voluntarily enter this programme. Within the programme, a farmer's task, equally important as food production, is to maintain and shape natural values. A farmer performs this task through realization of the Programme packages requirements, over the subsequent 5 years. The protection of semi-natural grasslands included in the European Ecological Network Natura 2000 is addressed by the Package 3. 'Extensive permanent grassland', and Package 5. 'Protection of endangered bird species and natural habitats in Natura 2000 areas' Variant 6. 'Semi-natural wet meadows', while these not covered by Natura 2000, by the Package 4. 'Protection of endangered bird species and natural habitats outside of Natura 2000 areas' Variant 6 'Semi-natural wet meadows'. The broader range of protection of ecosystem services provided by the analysed microlandscapes ensure the Packages 4 and 5. To realize them, a farmer is required to have the Natural Habitat Documentation prepared by an expert botanist, authorised by the Ministry of Agriculture and Rural Development of Poland and specifically prepared to serve the Agri-environmental Programme. An expert prepares documentation based on the field analysis of grassland vegetation condition and its environmental determinants. Over a 5 year period, a farmer conducts agro-technical procedures, following strictly the requirements of the declared package. These requirements (Table 4) were specified in the Regulation of the Minister of Agriculture and Rural Development[27]. Experts are entitled to formulate their own protective recommendations. They are introduced to the agri-environmental plan as obligatory liabilities. The approved plan is a basis for receiving a bonus payment for meeting the requirements and additional recommendations. In case of the package 3, the payment amounts to 500 PLN/ha/year x 5 years, while for the package 4.6 – 800 PLN/ha/year x 5 years, and for the package 5.6 – 840 PLN/ha/year x 5 years. If the statutory requirements have not been met, a farmer incurs financial sanctions, adequate to the character and scale of an offence.

The author of this article, in the environmental documentation prepared in line with the requirements of the RDP 2007-2013, repeatedly formulated protective recommendations that support the maintenance or revival of biodiversity at all levels of biological organisation: populational, biocoenotic and landscape. She took them into account, among others, in the plans of mowing and grazing, prepared for a farmer, adequately to the natural environment condition. The important populations of protected and threatened plant species and, also, phytocoenoses of threatened plant associations were covered by monitoring con-

-environmental Programme' included in the Rural Development Programme for 2007-2013] (Journal of Laws 2009.33.262).

Table 4
Requirements of Agri-environmental Programme 2007-2013[27], protecting biological and nutrient regulation processes of ecosystem services of extensive wet grasslands

Package.Variant	3	4.6, 5.6
Hay meadow management		
Season of mowing	1.06-30.09	15.06-30.09
Size of unmown area of meadow, each year different [%]	5-10	5-10
Height of mowing [cm] that does not damage meadow sward and soil surface	5-15	5-15
Removal or stacking of biomass two weeks after harvest or, in justified circumstances, later, soon after the cause of delay ceased	+	+
Ban on circular mowing from the outside to centre of a mowed area	+	+
Maximal number of harvests per year	2	2
Hay meadow* and pasture management		
Grazing periods in Wielkopolska, at the altitude ≤300 m a.s.l.	1.05-15.10	21.07-15.10
In floodplains, grazing not earlier than two weeks after water withdrawal; *Polish and Hucul horses all over the year	+*	+
Number of animals per area [DJP/ha]	≤0,3	≤1
Maximal strain on pasture [t/ha; DJP/ha]	≤5;10	≤5;10
Not mowing the leftover vegetation beyond the period of 1.08-30.09	+	-
*Haymeadow management as above	+	+
Other agro-technical treatments		
Ban on ploughing, rolling and resow	+	+
Ban on harrowing from 1.04-1.09	+	+
Ban on the construction and extension of drainage appliances, except for those used for natural values protection (does not apply to current conservation practices)	+	+
Ban on nitrogen fertilization in the areas fertilized by river mud and in other areas >60kg/ha/year	+	+
Ban on the use of plant protection products, except for selective and local eradication of persistent weeds, using appropriate equipment	+	+
Ban on the use of sewage and sewage sediments	+	+
Ban on the use of lime, if it affects negatively environment and package realization	+	-

ducted jointly with a farmer (e.g. J. Borysiak[28]). The objects of high natural value, like natural forests and thickets, ecotone tall herb communities and peatbog ecosystems, were distinguished as ecological sites (Package 4 or 5 Variant 10), while other objects were located on a ortophotomap, attached to the documentation, and introduced to a plan to preserve their proper condition over the declared 5 years of programme realization.

[28] J. Borysiak, B. Grabowska, T. Kubala, *Conservation of vegetation cover in the Głuszec stream valley in Poznań town (Poland) in the Agri-environmental programme 2007-2013*, "Biodiversity Research and Conservation" 2012 (in print).

A negative phenomenon is a low participation of Polish farms in the Agri-environmental Programme 2007-2013, partially related to the maintenance and improvement of permanent grasslands condition. The Report[29] from the realization of Rural Development Programme for 2007-2013 shows that up to the 31 December 2011, the lowest number of applications for payment allocation concerned the Packages 4 and 5. In the case of Package 4, the total area of supporting land qualified for agri-environmental payments will amount to 38,580.69 ha of permanent meadows and pastures falling to 3,105 farms (about 0.2% of a total number in Poland), financed for an overall sum of 49,990,817 PLN. The most popular was the Variant 4.1 'Protection of bird breeding habitats' (86.53% of funding used within the package). For Package 5, the total area of supporting land will amount to 66,305.82 ha, falling to 3,677 farms (also about 0.2% of the country's total number) and financed for an overall sum of 104,293,079 PLN. Also in the case of this package, the most popular was the ornithological Variant 5.1 (89.42%). Most attractive turned out to be the Package 3, which did not require documentation prepared by an authorised expert-botanist. In this case, the area of supporting land will amount to 252,452.35 ha, falling to 38,916 farms (2.5% of a total number) and financed for an overall sum of 238,691,388 PLN. It would be advisable to find a reason of farmers' reluctance to participate in the Packages 4-5 of Agri-environmental Programme. Perhaps, this results from the lack of relevant knowledge, as with such situation the author of this article often dealt with in practice.

Conclusions

Multi-functional microlandscapes of river valleys, shaped by the extensive agricultural use of wet seminatural grasslands, were presented. They are still widely spread in Wielkopolska. Furthermore, ecosystem services to human welfare, provided by the natural and seminatural vegetation of these microlandscapes, were determined. Also, the temporal and spatial gradients of human impact, resulting in vegetation degradation and reduction of ecological services, were discussed in connection with the dynamic economic development of the region and country. One of activities that restrains this phenomenon is the Agri-environmental Programme and its Packages 3-5, addressing the protection of species and natural habitats of a key importance for the preservation of regional and national biodiversity, including these (Packages 4 and 5) that are realized with the participation of expert-botanists. The legal package requirements and additional protective recommendations formulated by an expert-botanist specifically for an individual farm, allow not only to halt further progress in loss of

[29] Sprawozdanie z realizacji Programu Rozwoju Obszarów Wiejskich na lata 2007-2013. Sprawozdanie za 2011 r. Ministerstwo Rolnictwa i Rozwoju Wsi, http://www.minrol.gov.pl/pol/Wsparcie-rolnictwa-i-rybolowstwa/PROW-2007-2013/Monitoring-i-sprawozdawczosc--PROW-2007-2013 [Date of entry: 4.09.2012].

biodiversity, which is the base of essential ecosystem services, but also to increase species richness in local and regional biodiversity. Benefits of implementation the Packages 4 and 5 depend significantly on the expert's specialist knowledge. Such knowledge has to be particularly sound in the area of ecological dynamics of biotic and abiotic elements of natural environment, and, also, in autecology of plant and animal species. Additionally, it has to be supported by many years' practical experience.

Since 2004, in Poland (in the European Union since 1993), the Agri-environmental Programme has been a tool for sustainable management of agriculture extensification. Currently, the Programme's Packages 3-5 regulate drawing of natural resources from the environment and shape the dynamics of ecosystem services. Thus, ensure stability of multiple ecosystem processes and services of extensive seminatural grasslands. At present, the agri-environmental plan, based on the guidelines for the years 2007-2013, are realized. They should be continued in future, at least in the similar shape, to ensure long-term economic interests.

Małgorzata Stępniewska

WATER FOOTPRINT AS AN INDICATOR OF WATER SUPPLY – ECOSYSTEM SERVICES. A CASE STUDY FOR URBAN MUNICIPALITIES OF WIELKOPOLSKA REGION

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ŚLAD WODNY JAKO WSKAŹNIK ŚWIADCZEŃ ZAOPATRUJĄCYCH ZWIĄZANYCH Z DOSTARCZENIEM WODY. PRZYKŁAD GMIN MIEJSKICH WOJEWÓDZTWA WIELKOPOLSKIEGO

STRESZCZENIE: Celem artykułu jest ukazanie możliwości oceny świadczeń ekosystemów związanych z zaopatrzeniem w wodę za pomocą wskaźnika, jakim jest ślad wodny regionalnej konsumpcji. Tradycyjnie regionalne bilanse wodne uwzględniają tylko bezpośrednie zużycie wody, wyrażane jako wielkość poboru wód. Jednakże wskaźniki poboru wody nie dostarczają informacji na temat rzeczywistych potrzeb wodnych mieszkańców w relacji do ich konsumpcji. W analizie wzięto pod uwagę także zużycie pośrednie – objętość wody zużytej do wytworzenia dóbr, które są konsumowane przez ludność (wirtualna woda). Jako studium przypadku posłużyły gminy miejskie województwa wielkopolskiego. Całkowity ślad wodny przeciętnego konsumenta na analizowanym obszarze w latach 2008-2009 wynosił 1437 m^3/rok (w tym 73% zielony komponent śladu wodnego, 9% niebieski i 18% szary).
Około 89% całkowitego śladu wodnego było związane z konsumpcją produktów rolniczych, 10% z konsumpcją dóbr przemysłowych, a nieco poniżej 1% z bezpośrednim zużyciem wody w gospodarstwach domowych. Spośród artykułów rolniczych największy wkład do całkowitego śladu wodnego przeciętnego konsumenta miało spożycie mięsa, a następnie produktów zbożowych, kawy, herbaty i kakao. Import wirtualnej wody towarzyszący handlowi produktami rolniczymi i przemysłowymi odgrywa znaczącą rolę w oszczędzaniu zasobów wodnych regionu.

SŁOWA KLUCZOWE: świadczenia zaopatrujące, zaopatrzenie w wodę, ślad wodny, wirtualna woda

Introduction

Water supply is recognized within the provisioning services as a major group of services.[1] Traditionally, water withdrawal indicators are used as indicators of water usage for human consumption. They are used to show the amount of water abstraction with the division into three sectors – the domestic, agricultural and industrial one.[2] This approach reflects the "Proposal for Common International Classification of Ecosystem Services" (CICES).[3] In CICES, within the provisioning services related to water supply, three classes of ecosystem services were distinguished – water supply for household consumption, water for agricultural use and water for industrial and energy uses. The size of services related to water supply is proposed to be expressed by abstracted water in these sectors. However, the water-withdrawal indicators do not give information about the actual water needs of people in relation to their consumption pattern. In addition to tap water consumption, significant amounts of water are used to produce goods that are consumed by the population. In 2002, the water footprint concept was introduced in order to have a consumption-based indicator that could provide useful information, in addition to the classical production-sector-based indicators of water use.[4] The European Parliament proposes the inclusion of water footprint to the basket of four resource use indicators, beside land, material and carbon footprints.[5]

The purposes of the study is to show the possibility of assessment ecosystem services related to water supply using an index which is the water footprint of regional consumption. Urban municipalities of Wielkopolska Region were chosen as the area of study. The total water footprint is considered in division into two components: direct and indirect water footprint. Within each of them, the aim was assumed to determine the blue, green and grey components, taking into

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[1] R. Costanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997 No. 387, p. 254; *The Millennium Ecosystem Assessment, Ecosystems and Human Well-being: Synthesis*, Island Press, Washington, 2005, pp. VI; R.S. de Groot, M.A. Wilson, R.M.J. Boumans, *A typology for the classification, description and valuation of ecosystem functions, goods and services*, "Ecological Economics" 2002, No. 41, p. 396.

[2] AQUASTAT – FAO's global information system on water and agriculture. Source: http://www.fao.org/nr/water/aquastat/main/index.stm; OECD, Stat Extracts. http://stats.oecd.org; Eurostat. http://epp.eurostat.ec.europa.eu/portal/page/portal/environment/data/database; CSO, Local Data Bank. http://www.stat.gov.pl/bdl [Date of entry: 30-09-2012].

[3] European Environment Agency, *Common International Classification of Ecosystem Services (CICES) version 4 (update July 2012)*, Source: http://unstats.un.org/unsd/envaccounting/seeaLES/egm/Issue8a.pdf [Date of entry: 30-09-2012].

[4] A.Y. Hoekstra, P.Q. Hung, *Virtual water trade: A quantification of virtual water flows between nations in relation to international crop trade*, Value of Water Research Report Series, No.11, UNESCO-IHE 2002. A.Y. Hoekstra (ed.), *Virtual water trade: Proceedings of the International Expert Meeting on Virtual Water Trade*, Value of Water Research Report Series, No.12, UNESCO-IHE 2003;

[5] European Parliament resolution of 24 May 2012 on a resource-efficient Europe (2011/2068(INI), P7_TA-PROV(2012)0223.

account water source (ground or surface) and water pollution. To determine the degree of strain on water resources, the relation between the water demand and water availability is examined.

The water footprint concept

The water footprint has been developed in analogy to the ecological footprint concept, as introduced in the 1990s.[6] The 'ecological footprint' of a population represents the area of productive land and aquatic ecosystems required to produce the resources used, and to assimilate the wastes produced, by a certain population at a specified material standard of living, wherever on Earth that land may be located. Whereas the 'ecological footprint' thus quantifies the *area* needed to sustain people's living, the 'water footprint' indicates the *water* required to sustain a population.

The water footprint is an indicator of freshwater use that examines not only the direct water usage of a consumer, but also the indirect water usage (Fig. 1). The water footprint of a regional consumption is defined as the total volume of freshwater that is used to produce the goods and services consumed by the inhabitants of the region. Water usage is measured in terms of water volumes consumed (evaporated or incorporated into a product) and polluted per unit of time.[7] It is a multi-dimensional indicator, showing water consumption volumes from the source and volumes of polluted water. The blue water footprint refers to consumption of blue water resources (surface and ground water) as a result of the production of a good. Consumption refers to the loss of water from the available ground-surface body of water in a catchment area, which occurs when water evaporates, returns to another catchment area or the sea or is incorporated into a product. The green water footprint is related to the consumption of rainwater, stored in the soil as soil moisture, which is particularly relevant in crop production. The grey water footprint refers to the pollution and is defined as the volume of freshwater that is required to assimilate the load of pollutants based on existing ambient water quality standards.[8]

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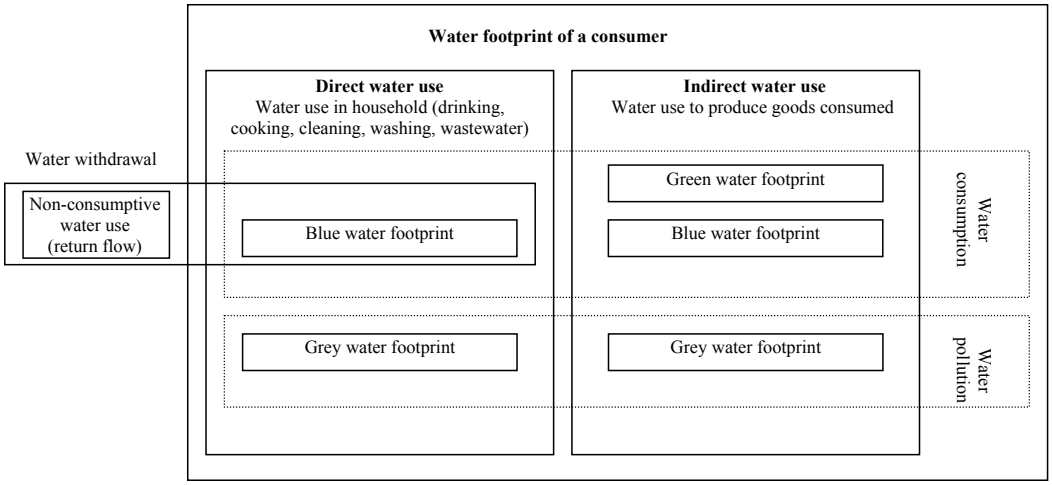
[6] W. E. Rees, *Ecological footprints and appropriated carrying capacity: what urban economics leaves out,* "Environment and Urbanization" 1992 No. 2(4), p. 120-130; M. Wackernagel, W. Rees, *Our ecological footprint: Reducing human impact on the earth,* New Society Publishers, Gabriola Island, B.C., Canada 1996; M. Wackernagel et al., *Ecological footprints of nations: How much nature do they use? How much nature do they have?* Centre for Sustainability Studies, Universidad Anahuac de Xalapa, Mexico 1997.

[7] A.Y. Hoekstra et al., *The water footprint assessment manual: Setting the global standard*, Earthscan, London 2011, p. 195.

[8] M.M. Mekonnen, A.Y. Hoekstra, *National water footprint accounts: the green, blue and grey water footprint of production and consumption*, Value of Water Research Report Series, No. 50, UNESCO-IHE, Delft, the Netherlands 2011.

Figure 1.
Schematic representation of the components of a water footprint



Source: A.Y. Hoekstra et al., *The water footprint assessment manual: Setting the global standard*, op. cit.

The water footprint is closely linked to the virtual water concept. Virtual water is defined as the volume of water required to produce a commodity or service. The concept was introduced by Allan in the early 1990s as a tool to describe the 'virtual' water flows exported from a region as a result of export of water-intensive commodities.[9]

As an indicator of water usage, the water footprint differs from the classical measure of water withdrawal in three respects:

- it is not restricted to blue water use, but also includes green and grey water,
- it is not restricted to direct water usage, but also includes indirect water usage,
- it does not include blue water use if this water is returned to the original catchment.[10]

Water footprint thus offers a wider perspective on how a consumer is related to the usage of limited freshwater resources. Water footprint accounts provide a basis for discussing water allocation and issues related to sustainable, equitable and efficient water use. Besides, the water footprint forms a basis for assess-

[9] J.A. Allan, *Fortunately, there are substitutes for water otherwise our hydro-political futures would be impossible*, in: *Priorities for Water Resources Allocation and Management*, UK: Overseas Development Administration, London 1993, p. 13-26; J.A. Allan, *Overall perspectives on countries and regions*, in: P. Rogers, P. Lydon (ed.), *Water in the Arab World: perspectives and prognoses*, Harvard University Press, Cambridge, Massachusetts 1994, p. 65-100.

[10] A.Y. Hoekstra, A.K. Chapagain, M.M. Aldaya, M.M. Mekonnen, *Water Footprint Manual State of the Art*, Water Footprint Network, Enschede, The Netherlands 2009.

ing the impact of goods and services consumption at local level and formulating strategies to reduce this impact.[11]

Methodology

This study adopts the terminology and calculation methodology as set out in "The Water Footprint Assessment Manual", which contains the proposal for global standard for water footprint assessment developed by the Water Footprint Network.[12]

The water footprint of regional consumption (in m^3/yr) is calculated by adding the direct water footprint of consumers to two indirect water footprint components:

$$WF_{cons} = WF_{cons,dir} + WF_{cons,indir}\,(\text{agricultural commodities}) + \\ + WF_{cons,indir}\,(\text{industrial commodities}) \quad (1)$$

The direct water footprint of consumers within the region ($WF_{cons,dir}$) refers to the consumption and pollution of water related to domestic water supply. The indirect water footprint of consumers ($WF_{cons,indir}$) refers to the water usage by others to make the commodities consumed, with differentiation into agricultural and industrial commodities.

Direct water use – Water footprint of domestic water consumption

The blue water footprint within region related to domestic water supply is estimated using the water withdrawal data from the *Central Statistical Office* of Poland (CSO) database.[13] It is assumed that 10% of the water withdrawn is actual consumption (blue water footprint) and that the remaining fraction is the return flow.

The part of the return flow which is disposed into the environment without prior treatment has been taken as a measure of the grey water footprint.[14] The amount of raw sewage was estimated on the basis of the population not served by sewage treatment plants and the average water consumption per 1 inhabitant in the studied urban municipalities. This data was obtained from the CSO database.[15]

[11] A.Y. Hoekstra et al., *The water footprint assessment manual: Setting the global standard,* op. cit.
[12] Ibidem.
[13] CSO, *Local Data Bank* http://www.stat.gov.pl/bdl [Date of entry: 30-09-2012].
[14] M.M. Mekonnen, A.Y. Hoekstra, *National water ...*, op. cit., p. 12.
[15] CSO, Local Data Bank, op. cit.

Indirect water use

Water footprint of consumption of agriculture products

For agricultural commodities, the water footprint of regional consumption is calculated by multiplying the set of agricultural products consumed by the inhabitants of the region by their respective product water footprint:

$$WF_{cons,indir}(\text{agricultural commodities}) = \sum (C[p]) \text{ X } WF_{prod}[p]) \quad (2)$$

C[*p*] the is consumption of agricultural product *p* by consumers within the region (ton/yr) and $WF_{prod}[p]$ the water footprint of this product (m^3/ton). The following range of final agricultural goods is considered:

- Cereals – wheat, barley, rye, oat, rice, pasta,
- Coffee, tea, cocoa beans,
- Fruits – grapefruit, bananas, oranges, mandarines, lemons, limes, apples, pineapples, grapes,
- Livestock products – butter, cheese, eggs, milk, yogurt, pork, bovine, poultry,
- Oil crops – ground-nuts, coconut, olives,
- Oil from oil crops – soya-bean oil, ground-nut oil, sunflower-seed oil, rape and mustard oil, palm oil,
- Pulses – beans, peas,
- Roots and tubers – potatoes,
- Vegetables – tomatoes, onions,
- Sweeteners – raw sugar, beet/sugar (raw equivalent),
- Beverages – beer, wine.

The data on the average consumption of agricultural products per person in Poland for the period 2008-2009 were taken from CSO[16] and FAO databases[17]. The blue, green and grey water footprints of crop and derived crop products and the blue, green and grey water footprints of farm animals and animal products were obtained from M.M. Mekonnen and A.Y. Hoekstra studies.[18]

Water footprint of consumption of industrial products

The virtual water content of an industrial product can be calculated in a similar manner as described earlier for agricultural products. There are however numerous categories of industrial products with a diverse range of production

[16] CSO, *Statistical yearbook of agriculture 2010*, http://www.stat.gov.pl/gus/5840_6243_PLK_HTML.htm [Date of entry: 30-09-2012].

[17] Food and Agriculture Organization of the United Nations, Faostat, http://faostat.fao.org/site/368/default.aspx#ancor [Date of entry: 30-09-2012].

[18] M.M. Mekonnen, A.Y. Hoekstra, *The green, blue and grey water footprint of crops and derived crop products*, Value of Water Research Report Series, No. 47, UNESCO-IHE, Delft, the Netherlands 2010; M.M. Mekonnen, A.Y. Hoekstra, *The green, blue and grey water footprint of farm animals and animal products*, Value of Water Research Report Series, No. 48, UNESCO-IHE, Delft, the Netherlands 2010.

methods and detailed standardized statistics related to the production and consumption of industrial products are hard to find. For this reason, for the analysis the data was used of the blue and grey water footprint of consumption of industrial products per capita in Poland, presented by M.M. Mekkonen and A.Y. Hoekstra.[19] Their global study contains national water footprint accounts carried out in the configuration of states in a high spatial resolution and taking into account international trade of products. For industrial commodities, they calculated the water footprint of national consumption as the water footprint of industrial processes taking place within the nation plus the virtual-water import related to import of industrial commodities minus the virtual-water export.

Blue water scarcity analysis

The blue water footprint exerts impact on the freshwater system, contributes to water scarcity and associated environmental problems. In order to gather insight into the impact of water consumption, its value was compared to the actually available water resources. As the blue water-scarcity indicator (WS_{blue}), there was used the water consumption-to-availability ratio:

$$WS_{blue} = (W_{cons} / WA_{blue}) \cdot 100 \quad (3)$$

A blue water scarcity of hundred percent means that the available blue water has been fully consumed. As a measure of water availability (WA_{blue}) there were used the capacities of renewable water resources in 16 Groundwater Bodies (GWB) covering the region.[20] Two scenarios were analyzed. In the first of them, as an indicator of water consumption (W_{cons}), the water withdrawal was used, whereas in the second – the total blue water footprint:

1. Scenario 1 (CURRENT) – Water scarcity level by GWB expressed as the ratio of the withdrawal to the total renewable water resources,
2. Scenario 2 (POTENTIAL) – Water scarcity level by GWB expressed as the ratio of the total blue water footprint to the total renewable water resources.

The water footprint of the urban municipalities in Wielkopolska Region

Wielkopolska Region is located in central western Poland and is one of the 16 administrative regions in the country. Urban areas include 28,3 thousand km^2. In 2009, they were inhabited by 1 912 thousand people, concentrated in 109 towns and cities. The most populated urban municipalities of region were Poznań

[19] M.M. Mekonnen, A.Y. Hoekstra, *National water ...*, op. cit, p. 14-15.
[20] National Water Management Authority, *Jednolite Części Wód Podziemnych (Groundwater Bodies).*

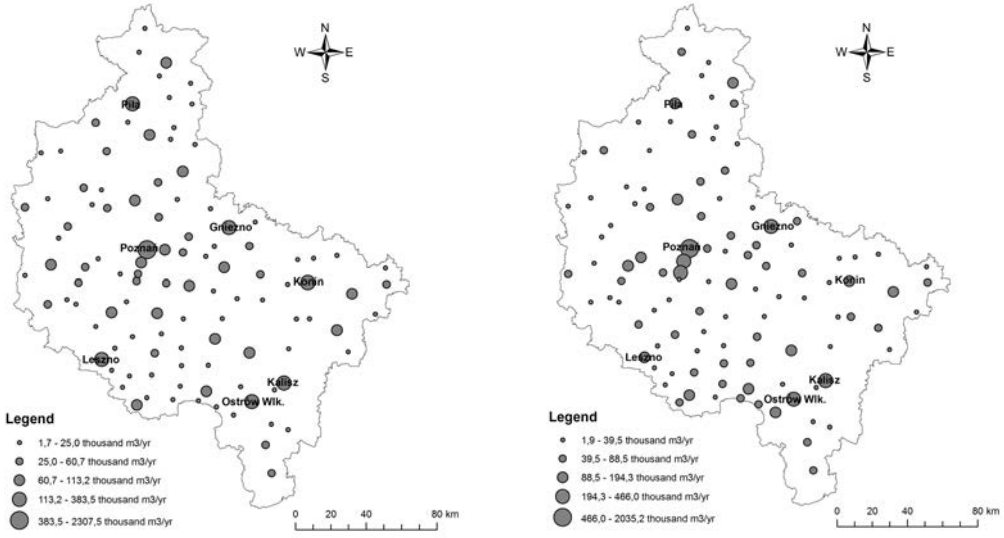
(554,2 thousand inhabitants), Kalisz (107,0 thousand), Konin (79,5 thousand), Piła (74,6 thousand), Ostrów Wielkopolski (72,4 thousand), Gniezno (69,5 thousand) oraz Leszno (64,3 thousand). Population of 31 other urban centers ranged 10-30 thousand inhabitants, and 71 – below 10 thousand inhabitants.

Direct water footprint

The total water footprint of domestic water consumption in the analyzed region in 2009 was 15,6 million m^3/yr (44% blue, 56% grey). The spatial distribution of its value with the breakdown into blue and grey components is shown in Fig. 2. The blue water footprint was approximately 6,9 million m^3, which constituted only slightly more than 2,5% of the total blue water footprint of regional consumption. Slightly more than half of blue water footprint of domestic water consumption concentrated in the 7 most populated cities in Wielkopolska – Poznań (2308 thousand m^3/year), Kalisz (384 thousand m^3/year), Ostrów Wielkopolski (285 thousand m^3/year), Piła (265 m^3/year), Konin (254 m^3/year), Leszno (224 thousand m^3/year) and Gniezno (213 thousand m^3/year) (Fig. 1). The grey water footprint of domestic water consumption in Wielkopolska urban municipalities in 2009 was approximately 8,7 million m^3. Its highest values were found in Poznan (2035 thousand m^3/year), Kalisz (466 thousand m^3/year), Luboń (311 thousand m^3/year), Gniezno (257 thousand m^3/year), Ostrów Wielkopolski (254 thousand m^3/year) and Puszczykowo (224 thousand m^3/year).

Figure 2.

The water footprint of the domestic water consumption in the urban municipalities of Wielkopolska in 2009
a) The blue water footprint of the domestic water consumption, b) The grey water footprint of the domestic water consumption



Source: Own study.

Indirect water footprint

The total water footprint of the agricultural products consumption in 2009 was 2456,2 million m^3/yr (82% green, 9% blue, 9% grey). The water footprint due to the consumption of agricultural products can be divided into product categories (Table 1). Consumption of livestock products gives the largest contribution to the total water footprint of agricultural products consumption (57%), followed by cereals (21%) and coffee, tea, cocoa beans (6%). The remainder of the footprint is related to other agricultural products (16%).

Table 1.

Water footprint (WF) of consumers related to the consumption of agricultural products in the urban municipalities of Wielkopolska Region in 2009

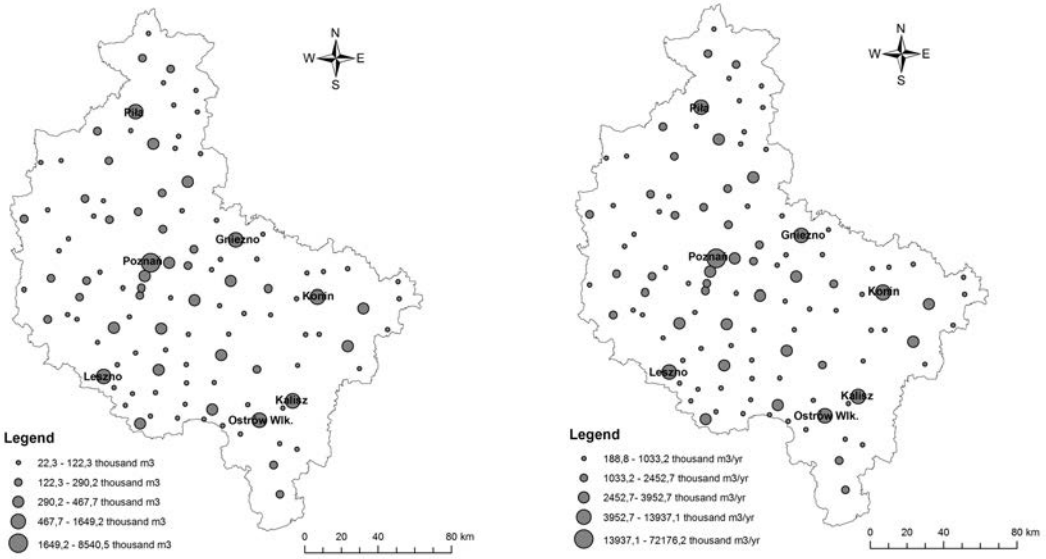
Product category	WF, million m^3/yr				Total WF
	Green	Blue	Grey	Total	%
Livestock products	1189,66	103,93	116,28	1409,88	57,40
Pork	358,63	33,65	45,50	437,78	17,82
Milk, 1-6% fat	322,12	31,81	27,11	381,05	15,51
Bovine meat and meat offal	162,98	6,19	5,10	174,26	7,09
Poultry, live,over 185g	113,18	9,58	14,90	137,66	5,60
Cheese processed, not grated or powdered	107,24	10,56	8,57	126,37	5,14
Eggs, bird, in shell, fresh, preserved or cooked	56,03	5,27	9,27	70,57	2,87
Butter	37,72	3,74	3,16	44,61	1,82
Yogurt	17,04	1,68	1,43	20,15	0,82
Milk, > 6% fat	14,74	1,46	1,23	17,43	0,71
Cereals	380,86	77,06	52,70	510,61	20,79
Wheat	264,05	70,72	42,80	377,57	15,37
Rye	87,13	1,54	6,08	94,74	3,86
Dry pasta	10,68	2,87	1,74	15,28	0,62
Barley	12,99	0,85	1,40	15,24	0,62
Oat	3,96	0,48	0,34	4,79	0,19
Rice groats and meal	2,04	0,61	0,33	2,99	0,12
Coffee, tea, cocoa beans	149,74	2,39	4,86	157,00	6,39
Coffee, roasted	86,81	0,66	3,03	90,50	3,68
Cocoa Beans	49,10	0,01	0,45	49,55	2,02
Tea	13,83	1,72	1,39	16,94	0,69
Oil from oil crops	89,71	5,45	8,33	103,49	4,21
Rape and Mustard Oil	30,24	4,11	5,96	40,30	1,64
Palm Oil	27,47	0,01	1,04	28,52	1,16
Soya-bean oil	16,75	0,58	0,31	17,63	0,72
Sunflower-sed oil	13,97	0,69	0,93	15,59	0,63
Ground-nut oil	1,28	0,08	0,08	1,44	0,06

Product category	WF, million m³/yr				Total WF
	Green	Blue	Grey	Total	%
Sweeteners	43,60	13,61	13,20	70,40	2,87
Raw sugar, beet/Sugar (Raw Equivalent)	43,60	13,61	13,20	70,40	2,87
Roots and tubers	42,71	7,38	14,09	64,18	2,61
Potatoes	42,71	7,38	14,09	64,18	2,61
Fruits	36,12	8,56	7,32	52,00	2,12
Apples	21,14	5,01	4,79	30,94	1,26
Oranges, Mandarines	5,22	1,35	1,19	7,76	0,32
Grapes	3,25	0,74	0,67	4,66	0,19
Bananas	2,65	0,39	0,13	3,17	0,13
Lemons, Limes	1,98	0,70	0,27	2,95	0,12
Grapefruit, fresh or dried	1,54	0,36	0,23	2,13	0,09
Pineapples	0,33	0,01	0,05	0,39	0,02
Beverages	42,09	3,11	4,75	49,95	2,03
Beer made from malt	39,31	2,48	4,18	45,96	1,87
Grape wines	2,79	0,63	0,57	3,99	0,16
Vegetables	9,53	3,88	3,25	16,66	0,68
Tomatoes	4,48	2,62	1,78	8,88	0,36
Onions	5,05	1,26	1,46	7,78	0,32
Pulses	12,31	0,37	3,29	15,97	0,65
Beans	9,81	0,31	2,44	12,57	0,51
Peas, dry	2,50	0,06	0,85	3,41	0,14
Oil crops	5,59	0,32	0,17	6,08	0,25
Ground-nuts shelld	2,02	0,12	0,13	2,28	0,09
Coconut	2,63	0,00	0,01	2,64	0,11
Olives	0,94	0,19	0,02	1,15	0,05
Total	**2001,93**	**226,06**	**228,22**	**2456,21**	**100,00**

Source: Own study.

The total water footprint related to the consumption of industrial products in 2009 was 278,6 million m³/yr (11% blue, 89% grey). It was calculated by assuming the values for the blue and grey water footprint per capita respectively as 15,4 m³/year and 130,2 m³/year in the period 1996-2005. Variation of the analyzed indicator in the urban municipalities of Wielkopolska is shown in Fig. 3. The highest values of the total water footprint of industrial products consumption were recorded in Poznań (80,7 million m³/year), Kalisz (15,6 million m³/year), Konin (11,6 million m³/year), Piła (10,9 million m³/year), Ostrów Wielkopolski (10,5 million m³/year), Gniezno (10,1 million m³/year) and Leszno (9,4 million m³/year). These cities, with a total population of 957 thousand people, were characterized by the total blue water footprint of industrial products consumption at the level of 148,8 million m³/year.

Figure 3.
The water footprint of the industrial products consumption in the urban municipalities of Wielkopolska in 2009
a) The blue water footprint of the industrial products consumption b) The grey water footprint of the industrial products consumption



Source: Own study.

The total water footprint

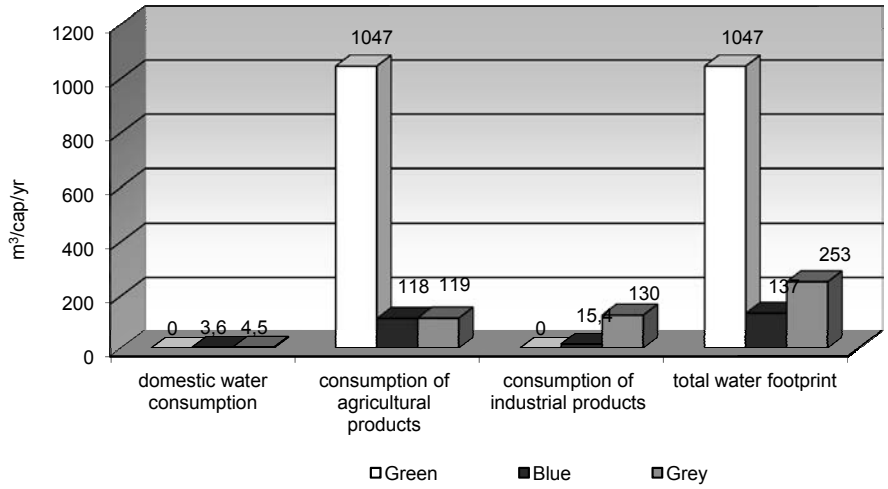
The total water footprint of regional consumption in the period 2008-2009 was 2750,4 million m^3/yr (73% green, 10% blue, 18% grey). The average consumer in the Wielkopolska Region had a water footprint of 1437,5 m^3/yr. A detailed overview of the individual contribution of consumption categories to the water footprint of Wielkopolska consumers is given in Figure 4. Agricultural goods are responsible for the largest part of the total water footprint (1284,0 m^3/person/year), industrial goods are responsible for 145,4 m^3/person/year and domestic water usage for approximately 8,1 m^3/person/year.

Table 2 summarizes the values of water footprint of regional consumption from the results of two global water footprint studies. In the case of M.M. Mekonnen and A.Y. Hoekstra study[21] it is possible to compare the results directly, because the same method and assumptions are applied. The calculated values of the water footprint are close to the average values for Poland given by these authors. The exception is the water footprint of domestic water consumption, which for the urban municipalities of Wielkopolska is significantly lower than the national average. It is mainly determined by the grey component, relatively

[21] M.M. Mekonnen, A.Y. Hoekstra, *National water ...*, op. cit.

low due to the high (89%) share of population using sewage treatment plants in the urban municipalities. Whereas as compared to global averages, the studied area is characterized by much higher water footprint of industrial product con-

Figure 4.
The total water footprint of consumption per capita in the urban municipalities of Wielkopolska



Region in the years 2008-2009

Source: Own study.

Table 2.
Water footprint of consumer (m^3/person/year) in Wielkopolska Region urban municipalities as compared to average values for Poland and the World

Total WF components	Period 2008-2009[a] Wielkopolska Region	Period 1996-2005[b]		Period 1997-2001[c]	
		Poland	World	Poland	World
$WF_{domestic\ water\ consumption}$	8,1	35,9	52,6	48,0	57,0
$WF_{agricultural\ commodities}$	1284,0	1223,9	1267,4	828,0	1067,0
$WF_{industrial\ commodities}$	145,4	145,6	65,0	226,0	119,0
Total WF	**1437,5**	**1405,4**	**1385,0**	**1102,0**	**1243,0**

[a] own study.
[b] M.M. Mekonnen, A.Y. Hoekstra, *National water footprint accounts: the green, blue and grey water footprint of production and consumption*, op. cit.
[c] A.K. Chapagain, A.Y. Hoekstra, *Water footprints of nations*, op. cit.

sumption. In the case of A.K. Chapagain and A.Y. Hoekstra study[22] when comparing the results, methodological differences should be taken into account. Their study excludes the grey water footprint component and is restricted to the analysis of the blue and green water footprints. Moreover, in that study, the water footprint of domestic water consumption represents the total water withdrawal in the domestic sector. Whereas in the study for Wielkopolska Region, the non-consumptive part of water withdrawal (the return flow) is not the part of the water footprint.

Blue water scarcity

In scenario 1, the current pressure on water resources arising from direct water usage was specified. The average share of water withdrawal in the total renewable groundwater resources in the region was 3,6% in 2009. The values of this ratio were characterized by large regional variations, from below 0,5% (GWB no 43, 71 and 79) to 17,7% for GWB no 62, located within Poznań agglomeration. Scenario 2 reflects a hypothetical situation in which the total water needs of residents (both direct and indirect water use) would be satisfied from the groundwater resources available in the region. In this scenario, the average value of „blue water scarcity" is 16,8%, therefore it is almost 5-fold higher than in current state. This shows the scale of water saving as a result of the trade of commodities. Use of regional water resources is significantly reduced through the import of water contained in agricultural and industrial products.

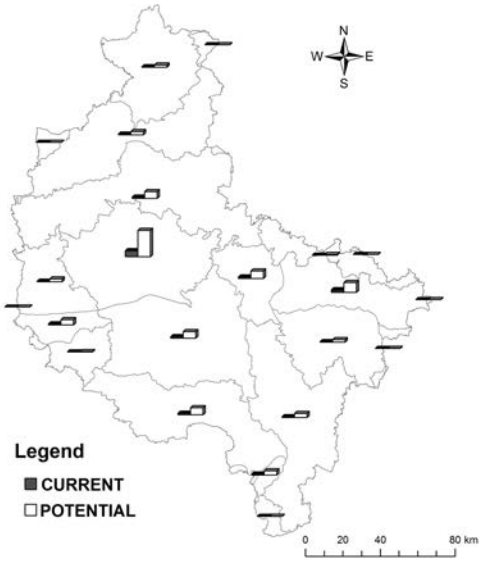


Figure 5.
The degree of strain on groundwater resources caused by addressing water needs of the urban municipalities of Wielkopolska in 2009 (%)

CURRENT: the water demand equals the water withdrawal

POTENTIAL: the water demand equals the total blue water footprint of regional consumption

Source: Own study.

[22] A.K. Chapagain, A.Y. Hoekstra, *Water footprints of nations*, Value of Water Research Report Series, No. 16, UNESCO-IHE, Delft, the Netherlands 2004.

Conclusion

The study illustrates the possibility of assessing water supply ecosystem services by using the water footprint as an indicator of water use in relation to the volume and pattern of consumption by the people. The total water footprint of the urban municipalities of Wielkopolska Region in the period 2008-2009 was 2750 million m^3/yr, which is in average 1437 m^3/cap/yr. The largest contribution to the total water footprint was the consumption of agricultural products (2456 million m^3/yr). In particular, the consumption of livestock products significantly contributes to the total water footprint. Next to agricultural products, the consumption of industrial goods plays an important role in the total water footprint of the region. The total water footprint related to the consumption of these products in the period 2008-2009 was 278,6 million m^3/yr. Whereas the domestic water withdrawal was responsible for slightly below 1% (15,6 million m^3/yr) of the total water footprint.

As an aggregated indicator, the water footprint shows the total water demand of inhabitants, and it is a rough measure of the impact of human consumption on the water environment. However, further detailed study is necessary, including more precise analysis of the components and characteristics of the total water footprint, the analysis of the blue versus the green water use, as well as the analysis of the international and interregional virtual water flows and water dependency.

Damian Łowicki

LAND PRICES AS AN INDICATOR OF THE RECREATIONAL SERVICES OF ECOSYSTEMS

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CENA GRUNTU JAKO WSKAŹNIK WARTOŚCI ŚWIADCZEŃ REKREACYJNYCH EKOSYSTEMÓW

STRESZCZENIE: Poza produkcją roślinną i zwierzęcą, tereny rolne dostarczają szeregu różnych świadczeń ekosystemowych. Jednymi z nich są świadczenia rekreacyjne i estetyczne. Do takich świadczeń na przykład należy możliwość spacerowania wzdłuż brzegów jezior lub podziwiania krajobrazu z punktu widokowego. Właściciele gruntów dostrzegają część z tych świadczeń i kapitalizują je w cenach transakcyjnych sprzedawanych działek. Niniejsze badania pokazują zmienność cen działek w zależności od odległości do atrakcyjnych miejsc wypoczynku, biorąc jednocześnie pod uwagę warunki techniczne położenia działki takie, jak obecność mediów, usytuowanie działki względem dróg i zabudowy, wielkość działki czy też decyzje administracyjne niezbędne do rozpoczęcia budowy. Przeanalizowano położenie 445 działek rolnych zlokalizowanych na terenie powiatu poznańskiego, które zostały sprzedane pomiędzy 01.01.2011 a 08.05.2012 r. Spośród czynników przyrodniczych mających wpływ na walory turystyczne danego obszaru największy wpływ na cenę działki okazała się mieć odległość od terenów zieleni urządzonej oraz stref brzegowych wykorzystywanych na potrzeby turystyki pieszej i rowerowej. Promień oddziaływania tych terenów to odpowiednio 3 i 2 km, a wartość metra kwadratowego działki maleje wraz z oddalaniem się od tych miejsc odpowiednio o 17 i 10 PLN na każde 1000 m.

SŁOWA KLUCZOWE: świadczenia rekreacyjne ekosystemów, ceny ziemi, tereny rolne, metoda cen hedonicznych, aglomeracja poznańska

Introduction

The uniqueness of agricultural land in context of measuring the ecosystem services is due to three facts. Firstly, agricultural land occupies a very large area. The World Bank estimates the share of agricultural land in the world as about 38,5%. In Poland, its share is 53%, which puts it on the 60th position in the world in this respect[1]. Secondly, there is a strong pressure on agricultural land, associated with destining it for housing purposes. This was particularly important in recent years, when there was a significant increase in the demand for plots destined for construction purposes, which in Poland is associated with the liberalization of regulations on spatial planning and on excluding agricultural plots from agricultural holdings. Growth of the agricultural land's area designated for non-agricultural purposes in the last 10 years[2] and thereby reduction of ecosystem services is a sign of high pressure on agricultural plots, especially in urban and suburban areas. Thirdly, an agricultural plot contains large numbers of very different ecosystems, including the typically agricultural land, but also water, forests, grasslands, etc, so these plots may provide many different ES. The most important of them are provisioning services such as food or fibre and recreational and aesthetic services like open landscapes of fields, lakes or network of hedgerows and wild ways. The first of the mentioned ES have market nature and can be relatively easily measured, for example by the crops height. However, recreational services do not have market nature, and their valuation usually takes place with the use of Stated Preference Methods, mainly through the Willingness To Pay method. Another way is to measure these services with the use of indirect means based on the Revealed Preferences. Travel Costs method is a method frequently used in this group[3,4]. The method, which accounts pleasure arising from the use of environmental goods, is called the Hedonic Pricing Method. It is most commonly used to estimate economic benefits or costs associated with environmental amenities, such as aesthetic views. One of the economic benefits measure is the value of land intended for construction works[5]. On the one hand, this approach seeks to determine to what extent does the property's value depend on environmental conditions, and on the other to evaluate how much are we willing to pay for the environment's improvement[6].

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[1] The World Bank, 2009 http://data.worldbank.org/indicator/AG.LND.AGRI.ZS [Date of entry: 12-09-2012].

[2] *Ochrona* Środowiska, GUS, Warszawa 2011, p. 110.

[3] J. Bergin, C. Price, *The travel cost method and landscape quality,* „Landscape Research" 1994 No. 19, p. 21-23.

[4] M. Czajkowski, M. Giergiczny, J. Kronenberg, P. Tryjanowski, *The economic value of a White Stork nesting colony: a case of 'stork village' in Poland,* „Working Papers" 2012 No. 11(77), p. 1-19.

[5] S. Ma, S.M. Swinton, *Valuation of Ecosystem Services from Rural Landscapes Using Agricultural Land Prices*, „Ecological Economics" 2011 No. 70(9), p. 1649-1659.

[6] T. Bajerowski et al., *Ocena i wycena krajobrazu: wybrane problemy rynkowej oceny i wyceny krajobrazu wiejskiego, miejskiego i stref przejściowych*, Educaterra, Olsztyn 2007 p. 85-86.

The direct and indirect methods are often combined[7,8]. In this research, the author used the Hedonic Pricing Method for the following purposes: 1) comparison of Poznań district municipalities in terms of number and size of purchase and sale transactions for agricultural plots held for development and its equipment in the utilities, 2) identifying the tourism's most important natural values affecting the price of a plot, 3) determining the size of relation between tourism's natural conditions and the plots' price as well as interpolation of results in Poznań district's area. The research results may be helpful in determining the agricultural plots' use in the Study of the Conditions and Directions of the Spatial Management of the Commune and in the Local Spatial Management Plan (LSMP). It can also be used as a tool in setting guidelines for Environmental and Financial Impact Assessments of a Plan.

Methods

The plot's transactional prices along with the plot's area and the information about the presence of Conditions of Development and Spatial Management, Building License or Local Spatial Management Plan for the plot have been made available by the District Centre for Geodetic and Cartographic Documentation in Poznań. Other technical data of the plots, including equipment and information on the neighborhood was obtained from the iGeoMap system. The plots chosen for analysis had to meet the following conditions: 1) appear in the land and buildings register as agricultural, 2) were sold between 01/01/2011 and 05/08/2012, 3) were covered by the numerical version of Master Map, 4) the buyer's share amounted 100%, 5) their purpose was building development. Data on recreational and aesthetic values in the Poznań district was received from the team that developed this information for the Illustrated Atlas of the Poznań Agglomeration[9]. Spatial analysis and price interpolation for the 445 agricultural plots was performed in ArcGIS 9.3.1 program, and statistical analyzes were performed with the use of Statistica 10 software. The relation between the plot's transactional price and the technical and recreational conditions was analyzed with the use of multiple regression method.

[7] T. Cameron, *Combining contingent valuation and travel cost data for the valuation of nonmarket goods*, „Land Economics" 1992 No. 68, p. 302-317.
[8] A. Fleischer, Y. Tsur, *Measuring the Recreational Value of Agricultural Landscape,* „European Review of Agricultural Economics" 2000 No. 27(3), p. 385-398.
[9] S. Bródka, *Walory przyrodnicze turystyki*, in: *Studium Uwarunkowań Rozwoju Przestrzennego Aglomeracji Poznańskiej*, ed. T. Kaczmarek, Centrum Badań Metropolitarnych, Poznań 2012, p. 168-171.

Results

The square meter value for an average agricultural plot destined for building development in the Poznań district equalled 164 PLN, and its average area was 1970 m^2 (Table 1). The research has shown that the Decision about Conditions of Development and Spatial Management as well as the plot's allocation within the LSMP had no significant effect on the plot's price. Large differences in prices were observed in the case of land's equipment in the utilities, especially sewerage, gas and electricity. The price of plots equipped with those utilities was about 60 PLN/m^2 higher.

Table 2 shows the average transactional price of land, along with the number of analysed transactions in Poznań district municipalities. It shows that the highest prices were reached by agricultural plots in Luboń urban municipality, i.e.

Table 1.

Average, minimum and maximum values and standard deviation for indexes describing the technical and recreational conditions of plots traded in the Poznań district in the period between 01.01. 2011 – 08.05.2012

	Unit	Mean	St. dev.	Min./No	Max./Yes
Sales price	PLN/m^2	164,1	102,7	0,16	833,3
Technical conditions					
Plot's area	m^2	1970,1	3746,2	100,0	36600,0
Local Spatial Management Plan	Y/N	-	-	159,0	170,0
Decision about Conditions of Development and Spatial Management	Y/N	-	-	166,0	162,0
Proximity of buildings and roads	Y/N	-	-	138,0	178,0
Water supply	Y/N	-	-	139,0	178,0
Sewerage	Y/N	-	-	147,0	216,0
Gas	Y/N	-	-	130,0	191,0
Electricity	Y/N	-	-	124,0	184,0
The tourism's natural values – the distance to the nearest:					
Vantage point	m	6396,9	4114,3	314,0	17881,4
Cultivated greenery	m	1639,9	1121,1	154,8	6757,7
Lake shore or river used for:					
Cycling and walking	m	4386,2	2386,3	19,4	11412,0
Sunbathing and swimming	m	4713,1	2517,0	34,3	11664,5
Lake	m	864,2	546,0	31,8	2926,4
Lake with high recreational and scenic qualities	m	5042,7	2725,5	34,3	11572,1
Forest	m	683,6	555,2	0,0	2554,2
Forest with high recreational and scenic qualities	m	1345,3	1026,9	14,5	4475,5

Source: Author's own study.

271 PLN, and in Komorniki rural municipality, i.e. 242 PLN. The plots situated in the eastern part of the district had the lowest prices. In Czerwonak, Pobiedziska, Kleszczewo or Kostrzyn municipalities, the prices did not exceed 150 PLN/m^2. Swarzędz municipality, where prices were significantly higher than average, was an exception in this part of the district. Considerable variations in terms of the municipalities' plots for development preparation can be observed. The average share of plots with LSMP or with basic utilities is slightly more than 50%, and the share of sold plots with direct access to both, electricity and water supply, as well as gas and sewage system was 22%. In this respect, the situation is worst in the Murowana Goślina municipality, and the best in Komorniki municipality.

Table 2.
Number of analyzed transactions, agricultural plots average transactional prices and shares of the plots with LSMP and basic utilities in Poznań district's municipalities during 01.01.2011-8.05.2012

Name of municipality	Number of plots analyzed	Average price [PLN/m^2]	Share of the plots with LSMP [%]	Share of the plots with basic utilities[a] [%]	Share of the plots with all utilities[b] [%]
Buk	0	-	-	-	-
Czerwonak	4	103,1	50,0	25,0	0,0
Dopiewo	86	173,8	48,8	67,4	0,0
Kleszczewo	34	110,3	94,1	64,7	0,0
Komorniki	48	241,8	70,8	79,2	66,7
Kostrzyn	19	147,7	63,2	63,2	15,8
Kórnik	42	119,2	38,1	28,6	9,5
Luboń	28	270,5	35,7	50,0	25,0
Mosina	58	107,3	31,0	34,5	15,5
Murowana Goślina	12	144,4	25,0	25,0	0,0
Pobiedziska	14	104,6	42,9	50,0	0,0
Puszczykowo	4	208,4	100,0	50,0	50,0
Rokietnica	19	167,9	47,4	78,9	63,2
Stęszew	13	136	0,0	53,8	46,2
Suchy Las	17	146	88,2	29,4	0,0
Swarzędz	34	200,6	14,7	55,9	14,7
Tarnowo Podgórne	13	185,2	76,9	53,8	38,5
Average	26,2	160,4	51,7	50,6	21,6

[a] electricity and water supply, [b] electricity, water supply, sewerage and gas

Source: Author's own study.

Multiple regression results analysis allowed to identify the factors affecting the land's prices. Table 3 shows that, among technical conditions, the plot's area and its equipment in the sanitary sewage system as well as electricity has the greatest impact on land's transactional prices. Along with the plot's area increase, its price is reduced by 3 PLN for every 1000 m^2. Bringing sewage system to the plot's border increases its price by 46 PLN, and by 36 PLN in case of water supply. Among the tourism's natural conditions, distance to cultivated greenery and coastal areas used for hiking and cycling had the greatest importance for the vacant plots' price shaping. The first of those features reduced the plot's value by 17 PLN and the next by about 10 PLN for every thousand meters distance from it.

Table 3.
Influence of the qualities of agricultural plots traded within the Poznań district during 01.01.2011-8.05.2012 on their price, basing on the multiple regression analysis

	Coefficients	Standard error	p-value
Intercept	118,91[a)]	20,032	0,000
Technical conditions			
Plot's area	-0,003[a)]	0,001	0,007
Local Spatial Management Plan	-4,639	9,600	0,629
Decision about Conditions of Development and Spatial Management	13,902	10,070	0,168
Proximity of buildings and roads	16,183	11,716	0,168
Water supply	2,159	13,966	0,877
Sewerage	45,516[a)]	12,365	0,000
Gas	15,567	12,263	0,205
Electricity	35,746[b)]	14,091	0,012
The tourism's natural values – the distance to the nearest:			
Vantage point	0,000	0,001	0,920
Cultivated greenery	-0,017[a)]	0,004	0,000
Lake shore or river used for:			
Cycling and walking	-0,010[a)]	0,003	0,000
Sunbathing and swimming	0,008	0,005	0,112
Lake	0,008	0,009	0,374
Lake with high recreational and scenic qualities	-0,001	0,005	0,892
Forest	0,019	0,010	0,067
Forest with high recreational and scenic qualities	-0,002	0,006	0,731
N = 445			
Adjusted R-square = 0.2			

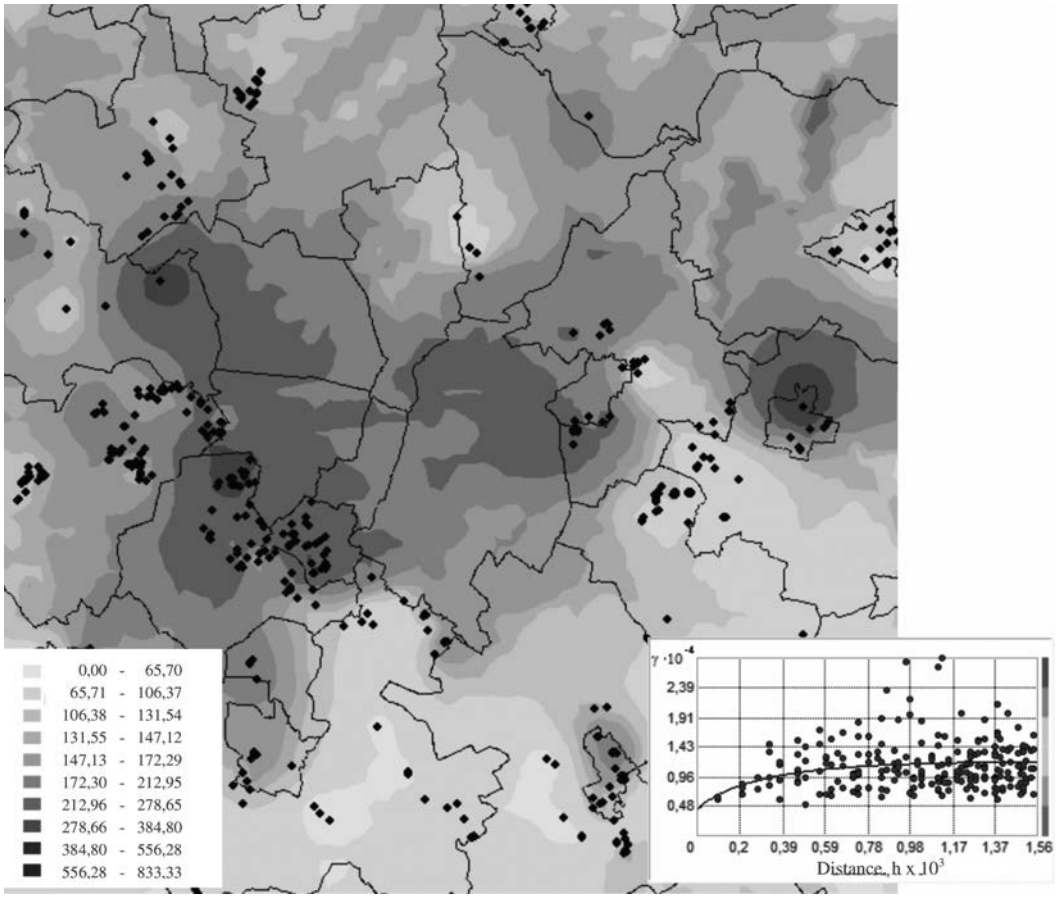
[a)] Significant at 1% level; [b)] Significant at 5% level,

Source: Author's own study.

High spatial aggregation of land similar in price provided ground for variogram based research. It related to the changes in land prices differentiation in dependence on their distance from each other. The research shows that the influence of one plot on another is visible in the distance of up to about 800 m (Figure 1). Basing on a semivariogram, kriging method was used to estimate the market value of plots in Poznan district. Figure 1 shows that the highest land prices, exceeding even 400 PLN/m^2, should be expected near the south-western border of Poznań, in Luboń, Komorniki, Wiry, Sady, Plewiska and Skórzewo. The impact of other urban centres, such as Stęszew, Mosina, Kostrzyn, Swarzędz or Kórnik, on the price of plots is relatively small in comparison with Poznań.

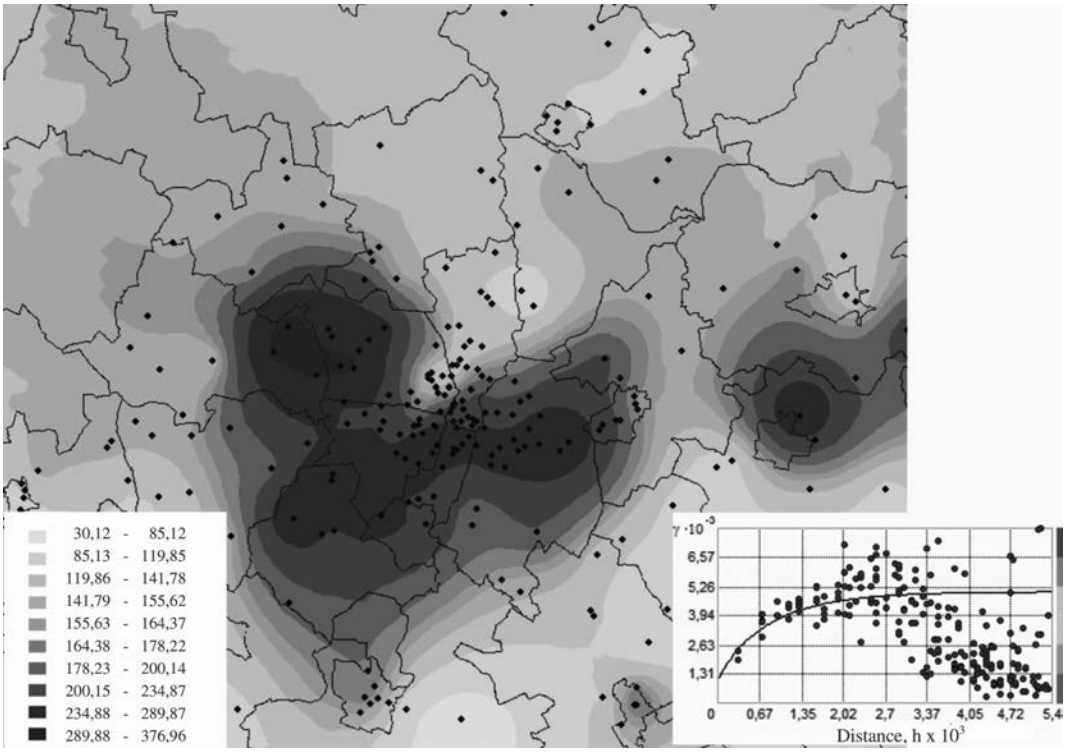
Figure 1.

Spatial distribution of traded plots and their interpolation in the Poznań district. Below: semivariogram showing the relation between the distance between parcels of land (X-axis) and the differentiation of their transactional prices (Y-axis)



Source: Author's own study.

Figure 2.
Spatial distribution of cultivated greenery areas and projected plot prices resulting from those areas proximity. Below: semivariogram showing relation between the distance between parcels of land (X-axis) and the differentiation of their transactional prices (Y-axis) in proximity of greenery areas



Source: Author's own study.

In the later stage of research, the relation between plot prices and the distance between them in the proximity of cultivated greenery, including urban parks, didactical gardens and allotments, was evaluated, basing on kriging, with the use of moving-windows method. Semivariogram analysis showed that the zone of those areas effect on plot prices equals over 3000 m (Figure 2).

Discussion and conclusions

The poor environmental conditions in large cities and the increasing wealth of Polish citizens have growing effects on the people's decision on changing their place of residence. One of the criteria for selecting a place in those circumstances is the active recreation possibility in the immediate surroundings. The statistical relation between the recreation areas' distance and the plots' transactional price shows that, for example the ability to walk or ride a bike in a relatively slightly transformed rural landscape is calculated into the plot's price at the moment of purchase. However, the calculations for this area are rather intuitive, since there is no methodology for the integration of environmental amenities in the process of property's valuation. Environmental conditions resulting from the legal status of valuated land, or value reduction caused by the environmental factors, such as noise or chemical pollution are currently, taken into consideration above all[10]. The research results described in this article are intended to strengthen the argumentation for the need of accounting the landscape values in the municipalities' spatial policy. On the one hand, those advantages result from maintaining the environment and landscape conditions on a satisfactory level, and on the other from providing those goods in a way that ensures permanent preservation of their values. According to Wańkowicz[11], finding balance between protections of the high landscape valued areas and making them available is the essence of spatial planning. Basing on the results of this study it can be concluded that the natural values do not have such a great impact on the real estate prices in Poznań agglomeration, as the recreational values. Hence spatial planning on the suburban areas should be particularly focused on protecting environmental amenities. The results of this research show, however, that such protection is not present. It is especially true for the legally binding land use in local land management plans and the land basic utilities equipment.

[10] *Standardy zawodowe Polskiej Federacji Stowarzyszen Rzeczoznawcow Majatkowych*, wyd. 8 poszerzone, Warszawa 2004.

[11] W. Wankowicz, *Planowanie przestrzeni o wysokich walorach krajobrazowych, problemy ekonomiczne*, in: *Krajobraz a turystyka*, ed. Wiaczeslaw Andrejczuk, Prace Komisji Krajobrazu Kulturowego No. 14, Sosnowiec 2010, p. 352-359.

Tadeusz J. Chmielewski • Malwina Michalik-Śnieżek

A METHOD OF INTEGRATED EVALUATION OF CULTURAL ECOSYSTEM SERVICES AT THE LANDSCAPE SCALE AND ITS APPLICATION IN THE VISTULA RIVER GORGE IN THE KAZIMIERZ LANDSCAPE PARK

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METODA ZINTEGROWANEJ OCENY KULTUROWYCH USŁUG EKOSYSTEMOWYCH W SKALI KRAJOBRAZU I JEJ ZASTOSOWANIE NA OBSZARZE MAŁOPOLSKIEGO PRZEŁOMU WISŁY W KAZIMIERSKIM PARKU KRAJOBRAZOWYM

STRESZCZENIE: Koncepcja usług ekosystemowych umożliwia w sposób syntetyczny przedstawienie powiązań między koncepcjami ekologicznymi i ekonomicznymi oraz zintegrowaną analizę tych dwóch podsystemów. Umożliwia również przeprowadzenie oceny różnych scenariuszy rozwoju gospodarczego i różnych strategii ochrony przyrody określonego obszaru. W myśl Europejskiej Konwencji Krajobrazowej, w tego typu analizach istotne znaczenie powinna mieć ocena wpływu rozwoju zagospodarowania terenu na walory estetyczne krajobrazu.

W publikacji przedstawiono metodę zintegrowanej oceny walorów estetycznych krajobrazu i oferty kulturowych usług krajobrazowych. Inspiracją do opracowania tej metody była z jednej strony metoda „krzywej wrzeń" K. Wejcherta, z drugiej zaś – prace nad metodami oceny ekologicznej wartości i gospodarczej przydatności systemów krajobrazowych.

Pierwszą próbę praktycznego zastosowania tej metody przeprowadzono na obszarze Małopolskiego Przełomu Wisły w granicach Kazimierskiego Parku Krajobrazowego. W niniejszej publikacji zaprezentowano najważniejsze rezultaty tych prac.

SŁOWA KLUCZOWE: walory estetyczne krajobrazu, kulturowe usługi ekosystemowe, Małopolski Przełom Wisły, Kazimierski Park Krajobrazowy

Introduction

In September 2004, Poland ratified the European Landscape Convention. According to the document, landscape is understood as *an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors*[1]. The European Landscape Convention emphasises the importance of beautiful, harmoniously designed, and sustainably managed landscapes as an essential element of quality of life of local and regional communities.

The first step towards such a situation should be to identify, analyze, and evaluate the resources and values of various landscapes[2].

The process of evaluation of particular values of land is called *valorisation.* The concept of land valorisation involves the assessment and comparison of the value of particular parts of a given area. Land valorisation may be carried out by a variety of methods and techniques. Different objectives and criteria of evaluation can be developed based on geographical, biological, social, and economic sciences, as well as for a variety of planning studies. It follows a wide variety of land valorisation methods[3]. By analyzing different approaches to the assessment of land values, Chmielewski distinguishes five basic groups of methods based on certain evaluation criteria as follows:

1) land valorisation conducted according to the criteria of universal values (abundance of resources, diversity, uniqueness, beauty forms, etc.), mainly used for the delimitation of protected areas;
2) land valorisation conducted according to the criteria of land suitability to perform specific functions (agricultural, recreational, residential, etc), mainly used for planning studies;
3) land valorisation focusing on the abilities of land (environmental, social, economic potential, resistance to degradation, the ability to regenerate, etc.), mainly used for studies with a character of a policy or strategy (e.g. strategy of development, environmental protection strategy);

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[1] European Landscape Convention, Florence, 20 October 2000; www.coe.int/europeanlandscapeconvention [Date entry: 20-09-2012].

[2] Landscape and sustainable development. *Challenges of the European Landscape Convention*. Council of Europe Publishment, Strasburg 2006, p. 1-214.

[3] S.W.F. Ploeg, L. Vlij, *Ecological evaluation nature conservation and land use planning with particular reference to methods used in the Netherlands*, "Biological Conservation" 1978 Vol. 14, p. 197-221; P.G.R. Smith., J. B.Theberge, *A Review of Criteria for Evaluating Natural Areas "*Environmental Management" 1986 Vol. 10(6), p. 715-734; K.H. Wojciechowski, *Problemy percepcji i oceny estetycznej krajobrazu*. Uniwersytet Marii Curie-Skłodowskiej, Lublin 1986, p. 1-283; T.J. Chmielewski, *System planowania przestrzennego harmonizującego przyrodę i gospodarkę*. Politechnika Lubelska, Lublin 2001 Vol. 1, 2; M. Kistowski, B. Korwel-Lejkowska, *Waloryzacja środowiska przyrodniczego w planowaniu przestrzennym*, "Problemy Ekologii Krajobrazu" t. 19; Uniwersytet Gdański, PAEK; Gdańsk, 2007, p. 1-305.

4) land valorisation based on an integrated analysis of values, problems, and potentials, used for the development of strategies and protection plans;
5) multi-criteria land valorisation used for particularly difficult problem and conflict areas[4].

The methods of assessment of the values of landscape physiognomy raise particularly heated debate. The results of such assessment largely depend on the subjective perception of the landscape by individual recipients[5]. These methods include one particularly appreciated in Poland, namely the „experience curve method", developed by K. Wejchert in the 1970's. It is applied for the evaluation of urban composition[6]. The method has been recently adapted by Chmielewski and Michalik-Śnieżek to assess the degree of anthropogenic transformation of landscape, including open landscapes[7].

Nowadays, ecosystem services, constituting the third group of valorisation methods, have become a very popular research subject, and a conceptual framework for numerous research projects.

Ecosystem services are *ecological components directly consumed or enjoyed to produce human well-being*[8].

Ecosystem services are usually classified into four categories:

1. *Provisioning services*, including: water resources and water supply,food production, sourcing organic raw materials (wood, fibrous materials, fuel from biomass), genetic resources, natural medical resources, decorations of natural origin.
2. *Regulating services*, including: climate control, soil formation processes, erosion prevention, biological control (at the level of populations and ecosystems), absorbing dust and gas pollutants, water self-purification processes, etc.
3. *Supporting services*,such as circulation of elements, hydrological cycle, primary production.
4. *Cultural services*,including: aesthetic values, recreation, cultural and artistic resources, intellectual and spiritual inspiration, science and education[9].

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[4] T.J. Chmielewski, *Systemy Krajobrazowe, Struktura-Funkcjonowanie-Planowanie*, PWN, Warszawa 2012.

[5] K.H. Wojciechowski, *Problemy percepcji i oceny estetycznej krajobrazu*. Uniwersytet Marii Curie-Skłodowskiej, Lublin 1986, p. 1-283; E. Malinowska, *The influence of visual quality of landscape on the touristic potential of the Narwiański National Park and its buffer zone,* "Problemy Ekologii Krajobrazu" 2010 Vol. 27, p. 277-285.

[6] K. Wejchert, op.cit., p. 1-279.

[7] T.J. Chmielewski, M. Michalik-Śnieżek, *Adaptacja metody krzywej wrażeń K. Wejcherta dla potrzeb badań krajobrazów o różnym stopniu antropogenicznego przekształcenia*. Uniwersytet Przyrodniczy, Lublin 2011, mat. niepublikowany: 1-16; T.J. Chmielewski, *Systemy Krajobrazowe...*, op. cit., p. 1-408.

[8] J. Boyd, S. Banzhaf, *What are Ecosystem Services?* The Reed of Standarized Environmental Accounting Units. RFF DP 06-02. Resourece for the Future 2006 Washington.

[9] MEA, *Ecosystem and Human Well-being: Current State and Trends*; Vol. 1. *Findings of the Condition and Trends. Working Group of the Millennium Ecosystem Assessment (MEA)*, Island Press, Washington, Covelo, London 2005, p. 1-917; DEFRA. *An Introductory Guide to Valuing Ecosys-*

The concept of Ecosystem Services demonstrates, in a synthetic manner, the links between the basic ecological and economic concepts, as well as the integrated analysis of these two subsystems[10]. It also permits the evaluation of different scenarios of economic development, and different conservation strategies[11]. Finally, it constitutes an effective tool to explain and promote the idea of sustainable development. The methods of mapping ecosystem services offered at the landscape scale, however, are still at the early stages of development[12].

The aesthetic value of landscape is one of the essential components of cultural ecosystem services. The authors of this paper attempted to develop a method for the integrated assessment of cultural ecosystem services at the landscape scale (including the aesthetic value of the area). This paper presents a method of performing such an assessment, and the results of its application in the Vistula River George in the Kazimierz Landscape Park.

Study area

The Lesser Poland Vistula River Gorge is mainly developed by the Vistula River valley, with two Polish uplands on both sides of the river – Małopolska Upland to the west, and Lublin Upland to the east. The gorge is 82 kilometres long, extending from the town of Zawichost in the south, to Puławy in the north. The valley is 1 to 10 km wide, and its banks are very steep, reaching up to 60-90 meters above the water level[13]. The river banks reach their highest approximation and elevation in the Kazimierz Landscape Park, in the vicinity of the following locations: Podgórz, Męćmierz, Janowiec, Kazimierz Dolny, Bochotnica, Parchatka. This section of the Vistula River Gorge was selected as the study area (Figure1).

This section of the Vistula river is very attractive in visual terms. The river flows at the edge of the Nałęczów Plateau, covered with a thick layer of loess (up to 30 meters thick) with the densest network of gorges in Europe. Creamy-white limestone walls locally protrude from the loess layer. In spite of the flood embankments constructed in the 1950's and 60's, this section of the Vistula River retained the features of a wild river, with a highly variable stream. Numerous

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tem Services. Department for Environment, Food and Rural Affairs (DEFRA), London 2007, p. 1-214.

[10] J. Solon, *Ecosystem Services concept and its application in landscape-ecological studies,* in: *The Problems of Landscape Ecology,* ed. T.J. Chmielewski, Wydawnictwo Print 6, Lublin 2008, p. 26-44.

[11] F. Wätzold et al., *Cost-effectiveness of managing Natura 2000 sites: an exploratory study for Finland, Germany, the Netherlands and Poland* in: "Biodiversity and Conservation" 2010 No. 19, p. 2053--2069.

[12] T.J. Chmielewski, *Systemy Krajobrazowe* ..., op. cit., p. 1-408.

[13] J. Kondracki, *Geografia regionalna Polski*, Wydawnictwo Naukowe PWN, Warszawa 1998, p. 1-441.

Figure1.
The location of the study area: A – in Poland, B – in Kazimierz Landscape Park. 1 – boundaries and names of physico-geographical mezoregions, 2 – simplified boundary of the research area, 3 – reservoirs and watercourses, 4 – Kazimierz Landscape Park area, 5 – Kazimierz Landscape Park buffer zone, 6 – Natura 2000 areas.

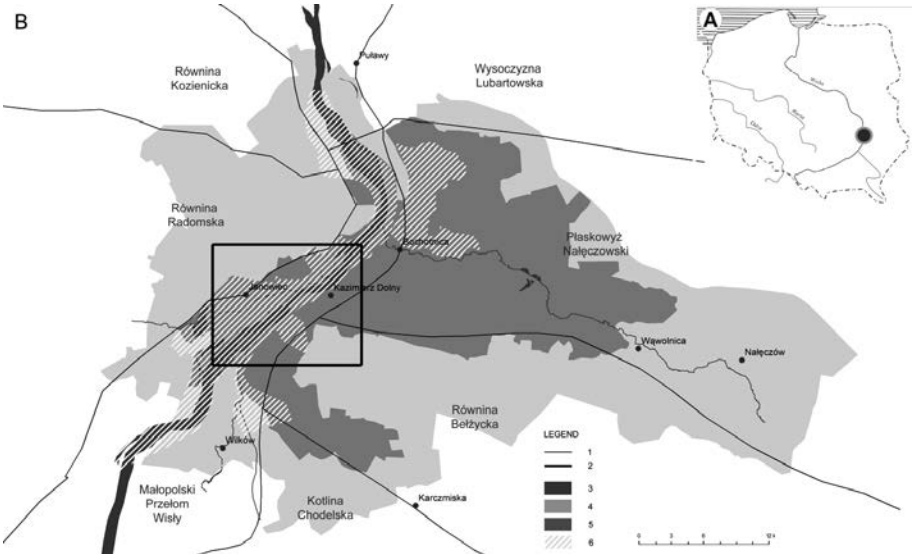
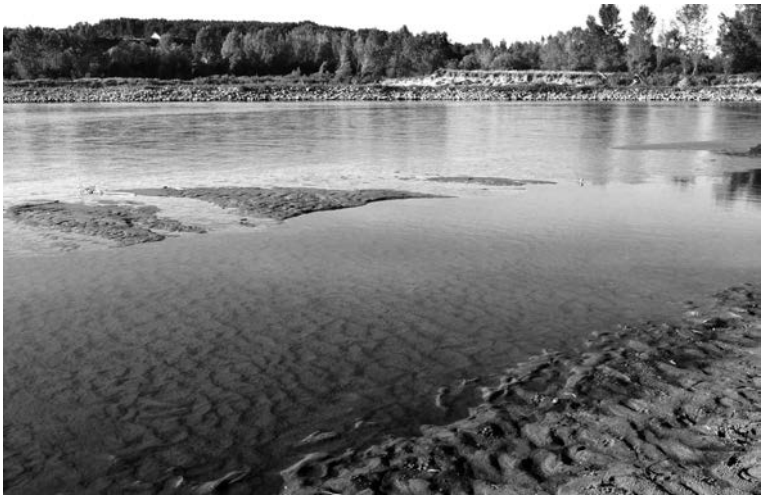


Figure 2.
The Vistula River in the Kazimierz Landscape Park (photo by T.J. Chmielewski)



sandbars and sandy islands make the river unique at the European scale[14] (Figure 2).

The most valuable plant communities include: a) xerothermic grasslands, thermophilic shrub communities, and small patches of oak forests occurring on steep, sunny slopes of the Vistula River valley, b) riparian willow and poplar trees growing on the valley floodplain terraces, and c) linden-hornbeam forests occurring on the slopes of ravines (Figure 3). Wide riparian scrub wicker belts are typical of this section of the Vistula River[15].

The Lesser Poland Vistula River Gorge has a very rich fauna. It is an important part of Europe's bird habitat area. Vistula sandbanks and islands are nesting places and feeding areas for many rare species of avifauna. For this reason, the region has been established a Natura 2000 area of Special Bird Protection[16]. A number of valuable insect species also occur there, mainly in the xerothermic grasslands.

The fragment of the Lesser Poland Vistula River Gorge located in the Kazimierz Landscape Park also has unique cultural heritage values. The Kazimierz Dolny and Janowiec urban systems are iucluded in the register of historic monuments. The architectural monuments worth special attention include: the

Figure 3.
Loessravine "Korzeniowy Dół" in Kazimierz Landscape Park (photo by T. J. Chmielewski)

[14] T.J. Chmielewski, *Skarby Małopolskiego Przełomu Wisły*, "Ezop" 1996 No. 9, p. 4-5.
[15] Ibidem.
[16] T. Wilk, J. Krogulec, P. Chyralecki, *Ostoje ptaków o znaczeniu międzynarodowym w Polsce*. Ogólnopolskie Towarzystwo Ochrony Ptaków, Marki 2010, p. 1-595.

ruins of the late Gothic-Renaissance castles in Kazimierz Dolny and Janowiec, as well as the great Renaissance architecture of Kazimierz Dolny, including: the Parish Church, Franciscan Monastery, sumptuously decorated town houses, 5 granaries, several wooden huts in the Męćmierz village, and many other historic buildings (Figure 4, 5).

Figure 4.
The main square in Kazimierz Dolny (photo by T.J. Chmielewski)

Figure 5.
Holiday cottage in Męćmierz (photo by T.J. Chmielewski)

Beautiful topography, wildlife, and valuable urban and rural complexes harmoniously integrated into the landscape, make the landscape of the Vistula River Gorge in the Kazimierz Landscape Park one of the most beautiful in Poland. The town of KazimierzDolny is one of the most popular tourist destinations in the country.

Methods

The paper presents an original method of the integrated assessment of cultural services of ecosystems at the landscape scale. In accordance with the recommendations of DEFRA, cultural services of ecosystems include:

- aesthetic values
- recreation (possible use of ecosystems for various forms of recreation)
- cultural and artistic resources
- functions of a spiritual experience (beyond aesthetics)
- science and education[17]

Due to the limited volume of the publication, this paper presents the results of the analysis of only the first, second, and third category. The quintessence of cultural ecosystem services are values of landscape physiognomy, associated with natural and almost natural ecosystems in the landscape, i.e. those with a certain degree of anthropogenic landscape transformation.

The method of assessment of the composition of the urban area called the "experience curve method" was developed by Kazimierz Wejchert in the 1970's. The authors of this article adapted this method to evaluate the aesthetic values of an open landscape.

According to K. Wejchert, the "experience curve" is a measure used to compare different fragments of space, compare their forms, architecture, greenery, and perspective views. "The experience curve" is presented as a graph, whereas the horizontal axis represents the temporal and linear scale designating subsequent vantage points along the route of an observer moving in urban areas. The vertical axis presents the subjective assessment of sensations resulting from viewing systems with different spatial and semantic values at a scale of 1 to 10 points. Monotonous systems with no urban or architectural values, with a limited view, receive the lowest number of points. The highest number of points is scored by complexes with high urban and architectural values, constituting an important element of the spatial structure of a city, involving several dominants of fundamental importance for the city's shape and landscape. The author admits that the graphical representation of the emotional experiences that occur while moving in space and time are only relative comparisons of the impact of consecutive urban interiors[18].

[17] DEFRA. *An Introductory Guide to Valuing Ecosystem Services*. Department for Environment, Food and Rural Affairs (DEFRA), London, 2007, p. 1-214.
[18] K. Wejchert, *Elementy kompozycji urbanistycznej*, Arkady, Warszawa 1984, p. 1-279.

A modification of this method of assessment of the aesthetic values of landscape was developed by Tadeusz J. Chmielewski in 1985, and applied in the draft of borders and scientific documentation necessary to establish the complex of the Ponidzie Landscape Parks[19].

Another modification of this method, presented herein, focuses on the integrated assessment of the degree of anthropogenic landscape transformation and its aesthetic values. Moving along a specified route at equal distance intervals (details will depend on the specific terrain situation), the intensity of anthropogenic landscape transformation is assessed. The assessment applies a 12-step classification developed by Chmielewski[20], awarding points from 1 to 12, according to the following list:

1 – degraded cultural landscapes,
2 – disharmonious cultural landscapes,
3 – cultural landscapes subject to renewal,
4 – harmonious cultural landscapes,
5 – degraded nature – cultural landscapes,
6 – disharmonious nature – cultural landscapes,
7 – nature – cultural landscapes subject to renewal,
8 – harmonious nature – cultural landscapes,
9 – degraded natural landscapes,
10 – natural landscapes subject to restoration,
11 – harmoniously used natural landscapes,
12 – primary landscapes.

The results of the assessment refer to the cultural landscape units distinguished on the map and evaluated in the field, and are presented as a graph. A different colour is applied for the evaluation of aesthetic landscape values (registered along the same route) on the same graph. The course of the two lines is compared. Maps of the spatial distribution of nature-cultural landscape units included in each bonitation rank are developed based on the analysis of the view range.

A trail of approximately 4 km was selected in the study area, leading from Góra Trzech Krzyży in Kazimierz Dolny to the Męćmierz village. A total of 13 observation points were determined along the route, used for the evaluation of view values with the application of the experience curve method.

A total of 31 such units (nature-cultural units[21]) were included in the fields of view. the units constituted a common area of the study concerning all of the three categories of the integrated assessment of cultural ecosystem services.

[19] T.J. Chmielewski, *Dokumentacja do utworzenia Zespołu Parków Krajobrazowych Ponidzia*. Instytut Kształtowania Środowiska, Lublin, 1985, mat. niepubl., Vol. 1-2.
[20] T.J. Chmielewski, *Systemy Krajobrazowe ...,* op. cit., p. 1-408.
[21] B. Sowińska, T.J. Chmielewski, *Metoda delimitacji i analiza typologicznego zróżnicowania jednostek przyrodniczo-krajobrazowych Roztocza i Równiny Biłgorajskiej*, in: ed. T.J. Chmielewski, *Struktura i funkcjonowanie systemów krajobrazowych: Meta-analizy, modele, teorie i ich zastosowania*, "Problemy Ekologii Krajobrazu", t. 21, Lublin – Warszawa, 2008 p. 161-176.

Services provided by ecosystems for recreational purposes are mainly related to:

- the possibility of using the natural values of the terrain and natural or semi-natural resources constituting elements of ecosystems (in particular: water, forests, grassland plant communities, and habitats of open sand and bare rocks),
- the possibility of using agricultural areas for recreational purposes (in particular: recreational walks through the fields, orchards and meadows),
- the presence of various elements of recreational development, such as: access roads and car parks, accommodation, restaurants, marinas, swimming pools, playgrounds, hiking trails, bicycle paths, tourist information centres, etc.

The adopted method of assessment of recreational ecosystem services was used to evaluate 31 nature-cultural landscape units for each of the three aspects, at a scale from 1 to 4 points. 1 point received units with not very varied terrain, with very little attractive forms of land cover, where were observed communication problems and low intensity recreation, whereas 4 points received units with very varied terrain, very attractive forms of land cover, with well-developed communication and with many elements of recreational development. Each of the units could receive a maximum of 12 points in this category. The bonitation results were registered in tables and presented in a valorisation map.

The artistic and cultural resources of a given area are the result of human activity conducted there in various historical periods. Therefore, they are not typical of natural or semi-natural ecosystems, but rather of settlements and agricultural areas.

The assessment of the cultural and artistic resources of individual nature-cultural landscape units was carried out taking into account the following criteria:

- maintenance of spatial layout typical of a specified historical era (both settlement systems, and the fields),
- presence of architectural monuments,
- performing the artistic functions (artistic centres, cultural festivals, art galleries, etc.).

Each of the units can be awarded from 1 to 4 points for each criterion. Analogically as in the case of other categories of assessment, one unit may receive a maximum of 12 points. 1 point received units with lack of preserved characteristic spatial systems, with lack of architectural monuments (or with very poorly preserved historical architectural forms), with lack of artistic functions, whereas 4 points received units with preserved characteristic spatial systems, with many historic buildings and with clear artistic functions. The bonitation results were registered in tables, and presented in a valorisation map.

The final stage of the work involved the presentation the results of cumulative bonitation in the form of a diagram and a map. Because the theoretical maximum number of points scored by 1 unit could be 48 (aesthetic value – 12, degree of anthropogenic transformation – 12, recreation – 12, cultural and artistic resources – 12), for practical reasons, the resulting scale was aggregated to 12 degrees evaluation.

Results

The integrated assessment of aesthetic values and degree of anthropogenic landscape transformation for nature-cultural landscape units revealed that in this part of the Vistula River Gorge, the aesthetic value rating was generally higher (in 8 out of 13 cases) than the assessment of naturalness/anthropogenic landscape transformation. In 3 cases, the situation was the opposite. In 2 cases, the assessment of aesthetic values and landscape naturalness resulted in the same valuation ratios (Figure 6A).

Units in which attractive anthropogenic forms (e.g., historic architectural buildings) are harmoniously composed with the landscape received the highest ratings in terms of aesthetic values. The lowest ratings were received by nature-cultural landscape units with no anthropogenic objects that would interfere with valuable ecosystems due to their structure, material, or functions (e.g. quarry, ugly and chaotically arranged buildings, flood embankments).

Two of the nature-cultural landscape units gained the maximum number of points. These are units No. 2 and 29, with the historic town of Kazimierz Dolny and Janowiec. Four other units were also highly evaluated, namely Nos. 1, 7, 8, and 30 (11 points each). They are in the immediate vicinity of the aforementioned towns. Also the units in which the Męćmierz village is located obtained high ratings. The lowest evaluation was received by the unit including the area of the flood embankment (3), as well as units 4, 6, 17, i.e. areas with anthropogenic objects particularly strongly conflicting with the surrounding landscape (Figure 6B).

Following the methodology, all of the nature-cultural landscape units were further assessed according to the possibility of use of their ecosystems for various forms of recreation. The highest potential of cultural ecosystem services related to recreation was recorded for units 4, 7, and 29 (this assessment is related to the possibility of use of the natural values of the terrain, and the presence of various elements of recreational development). The lowest potential was recorded for units 21 and 22 with monotonous area poor in varied elements of recreational development. Low potential for cultural benefits of ecosystem services related to recreation was also observed in the case of units 11, 12, and 13. These units include the islands on the Vistula River. Their low evaluation regarding the potential of their use is related to their low accessibility (Figure 7, line 3).

The next step was to evaluate the nature-cultural landscape units of the study area according to the potential of the use of their cultural and artistic resources. The assessment of the potential cultural ecosystem services related to artistic resources revealed the highest potential of units 2, 7, and 29 (they are units including centres of artistic life – the town of Kazimierz Dolny, Janowiec, and Męćmierz village). A high potential was also recorded for the areas in the immediate vicinity of the towns, namely units 1 and 8. The remaining units fulfil no artistic functions, or fulfil them to a very low degree (Figure 7, line 2).

Figure 6.

The integrated assessment of aesthetic values and degree of anthropogenic landscape transformation for nature-cultural landscape units in Kazimierz Landscape Park. A – line graph presents evaluation of aesthetic landscape values (blue line), and the degree of anthropogenic landscape transformation (red line) of nature-cultural landscape units which were included in the fields of view. B – map of aesthetic values of nature-cultural landscape units, a – observation points, b – route march, c – boundaries of nature-cultural landscape units, 1-12 assessment of landscape aesthetic values (1 – the lowest values, 12 – the highest values)

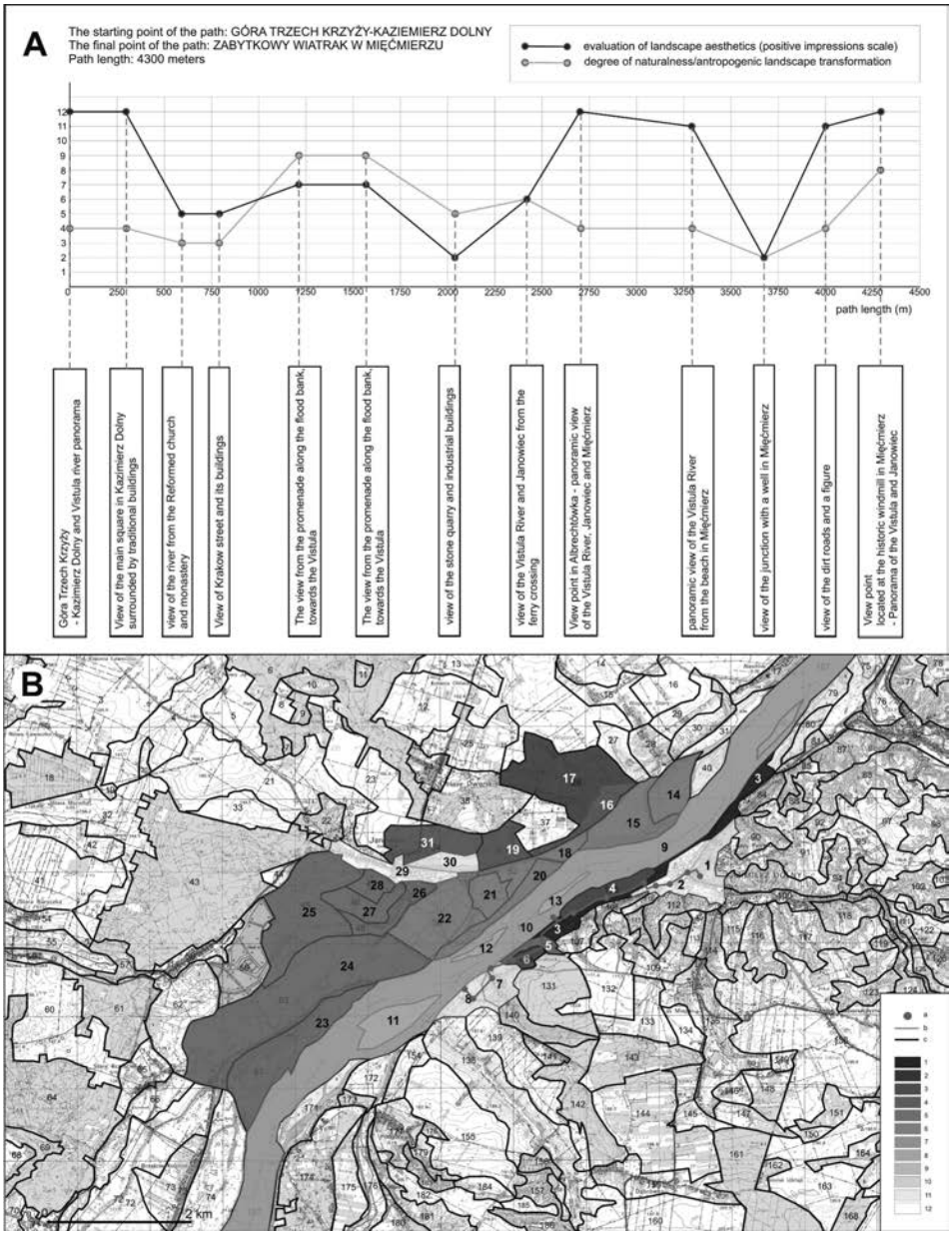


Figure 7.
Diagram of usefulness of the various nature-cultural landscape units (visible from the road march) to provide the specific type of cultural ecosystem services. The darker the color the higher bonitation of specific services offer

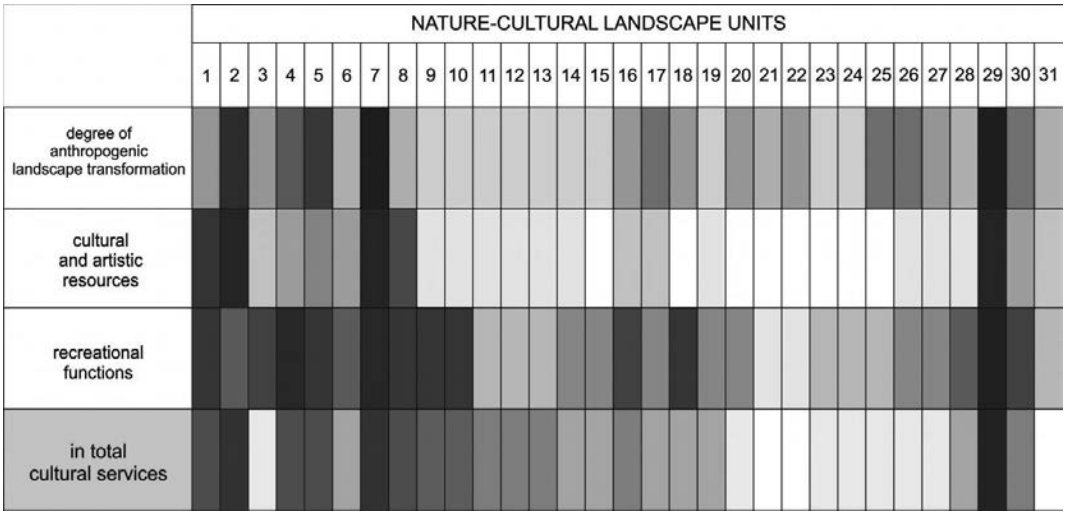
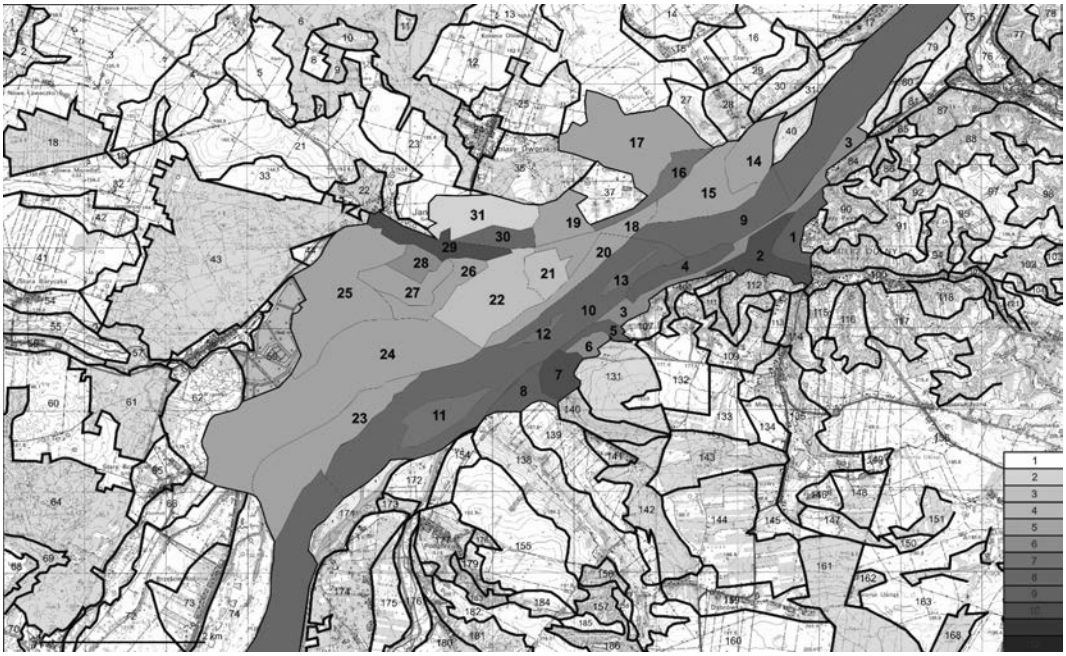


Figure 8.
The resulting bonitation of the complex of nature-landscape units (the darker the color the higher bonitation of specific services offer)



The resulting bonitation of the complex of nature-landscape units reveals the highest potential of cultural ecosystem services for 3 units (2, 7, and 29) the area of which includes centres of cultural life, i.e. Kazimierz Dolny, Janowiec, and Męćmierz. Also units 1, 4, 5, 8, and 30 have high potential. It is worth mentioning that units 4 and 5 were assessed relatively low in terms of aesthetic landscape values. The lowest potential of providing cultural services was recorded for units 21, 22, and 31. (Figure 7, line 4, Figure 8).

Conclusions

1. The presented method of the integrated assessment of cultural ecosystem services at the landscape scale can be applied in various types of environment assessment studies and in studies on the predisposition (usefulness) of specified landscapes for various forms of management.
2. The results of testing the method on the fragment of the Lesser Poland Vistula River Gorge located in the Kazimierz Landscape Park revealed among others that:
   - The bonitation of aesthetic sensations usually (in 8 out of 13 cases) showed higher values that bonitation of the scale of landscape naturalness;
   - The highest scores for aesthetic values were obtained by units in which attractive anthropogenic forms (e.g. historic architectural objects) were harmoniously composed with the natural landscape systems;
   - The lowest ratings in terms of aesthetic values were recorded for units including, among valuable ecosystems, anthropological objects colliding with them due to their structure, material, or functions;
   - The highest potential for the provision of cultural ecosystem services related to recreation occurred in the case of units offering the possibility of the recreational use of the natural land relief values, and the presence of a number of elements of recreational development;
   - 2/3 of the units located within the study area fulfils no artistic functions, or fulfils them to a very low degree;
   - Units assessed relatively low in terms of aesthetic landscape values can show high potential of cultural services.
3. The presentation of the results of the aforementioned evaluations in relation to the local complexes of nature-landscape units permits the development of a number of new landscape maps.

Arnold Bernaciak • Małgorzata Cichoń

ECOSYSTEM SERVICES' CHANGES CAUSED BY HUMAN PRESSURE (CASE OF THE LAKES OF MIDDLE POMERANIA, POLAND) WIELKOPOLSKA REGION (POLAND) CASE STUDY

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ZMIANA WARTOŚCI ŚWIADCZEŃ EKOSYSTEMÓW JEZIORNYCH POMORZA ŚRODKOWEGO POD WPŁYWEM ANTROPOPRESJI

STRESZCZENIE: Działalność człowieka wywołuje negatywne zmiany w ekosystemach, ujawniające się w zmniejszonej ilości i obniżonej jakości dostarczanych świadczeń. Dotychczasowe badania w tym zakresie pokazują, że zmiany wartości ekosystemów, ujawniają się w różnym stopniu, w zależności od kategorii świadczenia, rodzaju ekosystemu oraz obszaru badań. W niniejszym opracowaniu przeprowadzono identyfikację zmian poziomu dostarczanych świadczeń ekosystemów jeziornych Pomorza Środkowego w efekcie presji wywoływanej przez system społeczno-gospodarczy. Zastosowana metodyka badawcza, w tym autorska klasyfikacja jezior do sześciu typów ekosystemów oraz Millenium Ecosystem Assessment, pozwoliła na określenie, żeniewielka antropopresja powoduje zwiększenie podaży świadczeń i w konsekwencji przyczynia się do wzrostu ich wartości. Mechanizm ten jest widoczny szczególnie dla świadczeń kulturowych. Po przekroczeniu pewnego, maksymalnego poziomu, szczególnie w ekosystemach zdegradowanych, następuje stopniowe obniżenie oferowanych przez ekosystem świadczeń, głównie regulacyjnych. Zaobserwowano także, że wraz ze spadkiem ilości i jakości świadczeń, przede wszystkim zasobowych, zmniejsza się z czasem deklarowana gotowość do ponoszenia kosztów na utrzymanie określonego ekosystemu.

SŁOWA KLUCZOWE: świadczenia ekosystemów, jeziora, antropopresja, wpływ na środowisko

Introduction

Economic growth, along with social development, may only take place when supported by ecosystems and their services[1]. The usage of such services leads to an interference in structures and processes of ecosystems. However, there is a certain degree, characteristic to a given type of an environment, to which ecosystems are resistant to changes which may lead to a degradation of an ecosystem. Crossing such a border leads to negative changes in an ecosystem - decreasing the amount and quality of ecosystems. According to the authors of *The economy ecosystems and biodiversity*[2], the degradation of ecosystems may cause certain goods and services to be less valuable in the future (to be a smaller part of future income).

There is a different extent, depending on the category of service[3], to which changes in ecosystem services caused by people may be revealed. It is shown by research concerning the level of services, depending on the ground usage. When it comes to provisioning services, anthropogenic changes lead to an increase in levels of services. Only after a certain, maximum value has been obtained, levels start to decrease. The situation is different when it comes to regulating and cultural services. Their level is decreased along with the growth of ground exploration intensity (Figure 1).

The aim of the research is to identify changes of ecosystem services' level, caused by the socio-economic pressure. An attempt is made to determine changes in each service category. Moreover, the initial value of services is established and compared with its changes adequately to human pressure.

Middle Pomerania Lakes – object, scope and methods of research

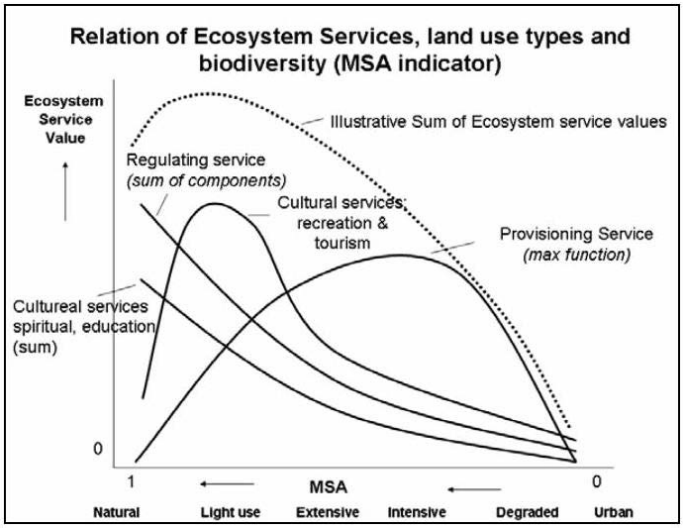
The research concerning changes in the levels of services, which are consequences of human pressure proves to be multi-level and extremely difficult. It demands a long cycle of observations, field measurements and good knowledge concerning the functioning of lake ecosystems. It was crucially important to register changes in the environment caused by humans. Apart from the applica-

[1] B. Burkhard at al., *Mapping Ecosystem service supply, demand and Budgets*, „*Ecological Indicators*" 2012, Vol. 21, p. 18, *The Millennium Ecosystem Assessment, Ecosystem and Human Well-being: Synthesis*, Island Press, Washington 2005.

[2] *The economy ecosystems and biodiversity – report*, ed. P. Sukhdev, A. Banson Production, Cabridge 2008.

[3] L. Braat, P. ten Brink (ed.), *The cost of Policy inaction: the case of not meeting the 2010 biodiversity target. Study for the European Commission*, DG Environment, Alterra Report 1718, Wageningen 2008, p. 25-26; R.S de Groot at al., *Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making*, "Ecological Complexity" 2010 Vol. 7, p. 268.

Figure 1.
Generalized functional relationship between land use / biodiversity and ecosystem services



Source: L. Braat, P. ten Brink (eds.), *The cost of...*, p. 25.

tion of standard research methods, the analysis of documents, maps, statistics etc., a survey, taking tourists' preferences into consideration, was also carried out. Travel cost estimation, and a survey concerning the willingness to pay a fee for the possibility to use the beach, were carried out for some of the ecosystems.

The problem of lakes functioning under human pressure has rarely been taken up in literature. Most papers, especially in the 80s, focused on evaluating lakes' environments and their coast lines, for tourism and recreation[4]. Due to serious changes, which have occurred in lake coastlines recently, a debate has been raised in order to include the human factor into any evaluation of such ecosystems. The research into human usage of environment shall be started with areas which are, at this point, affected to a small extent.

In order to identify changes in the level of ecosystem services as a result of socio-economic pressure, Middle Pomerania Lakes, which are affected to a small extent, were chosen for the research. Middle Pomerania Lakes are chain and kettle lakes, which are located at the northern part of Middle Pomerania moraine, and are often visited by the local inhabitants. However, the lack of basic landscaping leads to exceeding the tourist capacity of the area[5]. The level of

[4] T. Bartkowski, *Metoda oceny przydatności do rekreacji linii brzegowej jezior*, Sprawozdania PTPN 1985 nr 104 za 1985, p. 187-190; D. Sołowiej D., *Podstawy metodyki oceny* środowiska *przyrodniczego człowieka*, Poznań 1987.

[5] M. Cichoń, *Podatność na degradację stref brzegowych jezior Pomorza* Środkowego, in: E. Jekatierynczuk-Rudczyk, M. Stiepaniuk, M. Mazur (ed.) *Współczesne problemy badawcze geografii polskiej – geografia fizyczna*, Dokumentacja Geograficzna 37, Warszawa, 2008, p. 62-67.

human pressure is different among certain ecosystems. It must be pointed out that lakes of Middle Pomerania have never been the case of research, which would establish relations between people and environment, but were only researched into concerning matters such as water pollution, eutrophication, or the effect of tourism on the coastline[6].

Establishing criteria which are decisive when it comes to the level of human pressure was the first step taken in order to identify services' changes under pressure. Four groups of criteria were chosen; the quality of water, state of the beach, industry in the neighborhood, and landscape changes (Table1).

On the basis of 16 criteria, a level of pressure for 20 ecosystems located in Middle Pomerania, was set. Next, all the lakes were divided into 6 different types of ecosystems (natural, small scale conversion, converted, large scale conversion, degraded, completely degraded). Finally, 6 lakes, each representing different extents of change were chosen. They are Białe Lake, Dołgie Lake, Spore Lake, Wierzchowo Lake, Wielimie Lake and Trzesiecko Lake, which is an example of lake located in a city.

The research has taken the typology introduced by Millennium Ecosystem Assessment[7]. The level of each of the services has been analyzed using a four-grade scale: 0 – lack of service, 1 – a low level of service, 2 – an average level of service, 3 – a high level of service. Criteria which allow establishing the level in the most objective manner, have been established for each service. It is essential to bear in mind the fact that due to the lack of fully objective measurement of services provision level, such a study is only a demonstrative material, and are shall not undergo an unambiguous scientific evaluation.

The results which have been obtained have been added up in specific categories (source, regulating, cultural, supporting).

The lake, the coastline and the closest environment up to 100 m from the water have been established as the field of research. The data has been obtained from Forestry Management Szczecinek, fish farms, The Council of Szczecinek, along with the statistical data coming from Chief Environmental Protection, Szczecin.

The results of the survey which took place in 2011 have also been used. There were 117 surveys in total. An average price, which a tourist would be willing be to pay in order to use the beach, was calculated on the basis of them. The Contingent Valuation method was based on asking „How much are you willing to pay for using this beach for an entire day?"

The travel costs were calculated on the basis of means of transport, place of living and people travelling in the same vehicle.

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[6] S. Podsiadłowski, *Method of precise phosphorus inactivation in lake waters,* "Limnological Review" 2008 No. 8 (1-2), p. 51-56, Cichoń M., *Present-day changes in the morphology of the shore zone in the conditions of heavy tourist use: The case of Lake Czarne (Upper Parsęta Catchment),* "Quaestiones Geographicae" 2011 No. 30 (3), p. 5-12.

[7] *The Millenium EcosystemAssessment ...,* op. cit., p. 42-45.

Table 1.
The evaluation of lake ecosystems' pressure in Middle Pomerania

No.	Criterion	Scale
Quality of water		
1	Class of water	1 – water in the lake has 2nd quality class, 2 – water in the lake has 3rd quality class, 3 – water in the lake is out of the quality class marking system
2	Fishing activities	1 – fishing developed to a limited extent, 2 – well developed fishing, fishing competition is organized, 3 – there is a fish farm in the ecosystem and several fishing boats
3	Water collection	1 – there are no water intakes in the ecosystem, 2 – there is 1 water intake, 3 – there are more than 2 water intakes used for fire-fighting purposes
4	The presence of cyanophyta	1 – there are no cyanophyta in the ecosystem, 2 – cyanophyta are present in the ecosystem 2-3 times a year for a maximum of 3 days, 3 – cyanophyta are present for a couple of days, several times in the summer
State of the beach		
5	Access to beach	1 – ecosystem can be approached to a maximum of 100 meters, 2 – ecosystem can be approached to a maximum of 50 meters, 3 – direct access to the beach
6	Characteristics of the beach	1 – natural beach, 2 – mixed beach, partially natural, and partially artificial, 3 – artificial beach
7	The level of litter in the ecosystem	1 – there is no litter in the ecosystem, 2 – there is little litter in the ecosystem, 3 – there is litter in the ecosystem, for several weeks
8	The level of noise	1 – the level of noise is below 45dB, 2 – the level of noise is between 45 and 60 dB, 3 – the level of noise is above 60dB (the effect of traffic and tourism)
Economic activity		
9	Agriculture	1 – the agricultural areas in the environment of the ecosystem constitute no more that 15% of the whole area, 2 – the agricultural areas in the environment of the ecosystem constitute between 16% and 30% of the whole area, 3 – the agricultural areas in the environment of the ecosystem constitute above 30% of the whole area
10	Industry	1 – there are no industrial objects and power plants in the environment of the ecosystem, 2 – there is either an industrial object or a power plant in the environment of the ecosystem, 3 – there are both industrial objects and power plants environment of the ecosystem
11	Tourism	1 – no tourist facilities in the environment of the ecosystem, 2 – several tourist facilities in the environment of the ecosystem, 3 – in the environment of the ecosystem there are holiday camps and chalets
12	Transport	1 – no hardened roads in the environment of the ecosystem, 2 –one hardened road in the environment of the ecosystem, 3 – several hardened roads in the environment of the ecosystem, including a national road.
Landscape changes		
13	Air pollution	1 – air is not polluted in the environment of the ecosystem, 2 – low air pollution, mainly exhaust fumes in the environment of the ecosystem, 3 – high air pollution in the environment of the ecosystem
14	The damage of vegetation	1 – no vegetation damage in the environment of the ecosystem, 2 – vegetation damage in several places in the environment of the ecosystem, 3 – vegetation in the environment of the ecosystem is seriously damaged due to tourism, fishing and traffic.

Socio-economic pressure on lake ecosystem and the quality of services

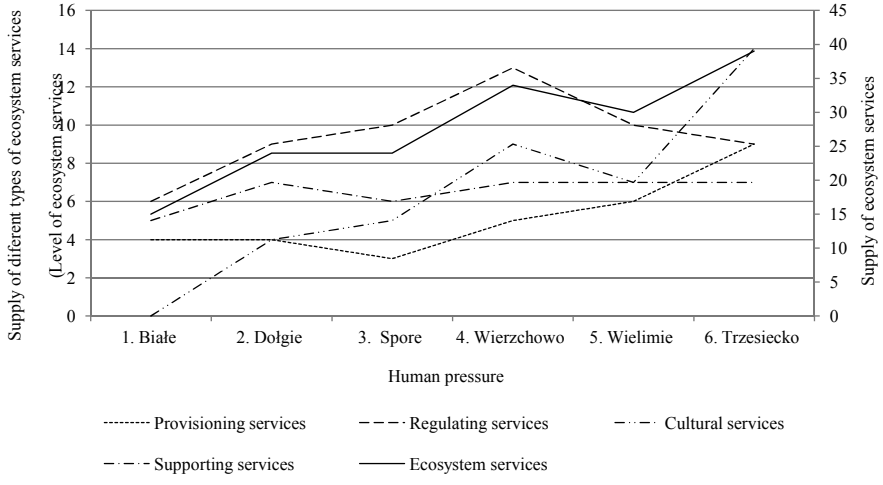
The research has shown that there is a relation between the level of human pressure and the range and intensity of services provided by lake ecosystems. Cultural services is the field in which it is possible to observe the biggest relation between the level of ecosystem change and quality and quantity of ecosystem services. It lead to the conclusion that the bigger the human pressure is, the more services are provided by the ecosystem. (Table 2, Figure 2). The rule might as well be reversed; the more the people are connected with the ecosystem, through leisure, education or art, the more interesting it proves to be for them, and subsequently it is used, converted and finally abandoned The case of Lake Trzesiecko illustrates this idea.

Table 2.
Ecosystem services supply for given lakes of a different human pressure level

Service category	Białe Lake	Dołgie Lake	Spore Lake	Wierzchowo Lake	Wielimie Lake	Trzesiecko Lake
Provisional services	4	4	3	5	6	9
Regulating services	6	9	10	13	10	9
Cultural services	0	4	5	9	7	14
Supporting services	5	7	6	7	7	7
Services together	15	24	24	34	30	39

Source: Own elaboration.

Figure 2.
Human pressure and ecosystem services supply



Source: Own elaboration.

Ecosystems with a higher level of pressure, and consequently of a larger level of conversion, are characterized by a higher intensity and range of services provided for the socio-economic system. Little impact of humans and economy on the environment, allows for a better and wider usage of services, e. g. using the lake for touristic and recreational purposes. Without any pressure, the level of usage of the service is relatively low. A small level of facilities; water equipment rentals, paths etc. is decisive when it comes to this matter. Gradual implementation of various facilities increases the quality and accessibility of services, which increases the chance of using services provided by the ecosystem (swimming, sunbathing, water sports etc.). The supply increases, and more people use the service.

The relation between human pressure and the supply of services provided by lake ecosystems is an example of a positive feedback loop. The intensification of pressure increases the supply, which subsequently increases the pressure as well. Self-strengthening set is developing towards a higher pressure and a higher level of provided services. The resistance and capacity of a given ecosystem both set an extent to which there is a possibility for such an activity. The relation is inverted when the limit has been exceeded - the feedback loop starts to have a negative character. People who come to visit the lake, would not be able to use its services due to polluted water, crowded paths or beaches, negative acoustic climate caused by traffic, and amount of people who spend time in the most attractive places of the ecosystem. The limited possibility to use the services would systematically decrease the number of people willing to do so, which will consequently limit the pressure. However, the dynamics of increasing the set will be bigger than the dynamics of decreasing - the growth of the pressure will be much faster than its further limitation.

The aforementioned mechanism is especially visible when it comes to regulating services. A low level of human pressure (Lakes: Białe, Dołgie, Spore) increases the supply of the service, which means that the level of services can possibly increase only within ecosystems with a low level of conversion. However, when it comes to lakes in the degradation stage, the amount and the quality of services is gradually limited, which can be seen at Fig 1. The converted ecosystem, for which the resistance level has been exceeded is Wierzchowo Lake, where the ecosystem has ceased to control processes such as self-cleaning, erosion or air quality. Similar reaction shall be expected for other services categories, but together with a higher level of human pressure, than the one assumed for the purpose of the research. It shall be presumed that Fig 1, shows only fragments of services supply curve, before the maximum values have been reached.

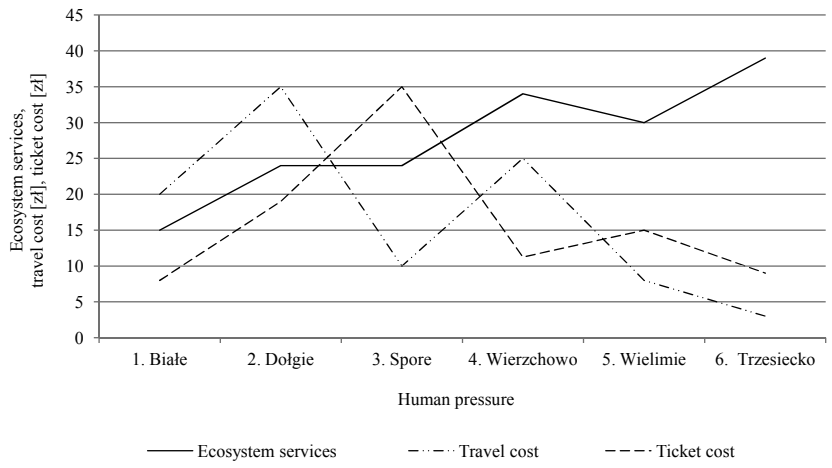
On the basis of the research, it has been stated that at the initial stage, the pressure increases the supply of services. The number of people using the ecosystem increases, and it becomes a subject of research interest, inspiration for artists, or a place for field classes. Together with the increasing supply, people become more willing to pay for using the ecosystem. Such a willingness has been present for some years among the citizens of Szczecinek. However, re-

cently, a higher pressure, along with a decreasing level of services have been observed, which means that the willingness to spend money decreases as well. Society is generally less eager to spend money, and the declared amounts of money, which are the potential entrance fees, are lower as well. The increasing supply of services causes them to be perceived as a common good, which is not worth paying a high price for. The citizens of Szczecinek, especially middle-aged, are more eager to pay a higher price for using the Wierzchowo Lake ecosystem, than for Trzesiecko Lake. It should be noted here, that the observed decrease of value, may be the aforementioned symptom of decreasing both human pressure and the level of services supplied.

Ecosystems with a low level of pressure, where the supply of services is relatively low, are seen as goods worth spending bigger amounts of money. Through an analogy with goods and services market, they may be labeled as higher order good. It can be proven by the high level of interest of Spore and Dołgie lakes which are both ecosystems of a little conversion. The level of services, measured by the travel cost to Dołgie lake, and the potential entrance fee for Spore lake, are the highest for both the cases (Fig 3). The high level of services and good leisure conditions are the decisive factors here, and the access difficulties are often disregarded for this matter. Due to limited space zoned for building purposes, the allotment prices are some of the highest in the whole area.

A lake ecosystem which is characterized by a lack of pressure, and consequently by limited supply of services (Białe lake) is not seen as the most valuable. The value of services measured by the travel costs and potential entrance fee is the lowest in this case. The decisive factor is the lack of access to the beach and

Figure 3.
Human pressure on the environment and the ecosystem services supply & costs



Source: Own elaboration.

the lake. A limited level of cultural services is compensated by a proper level of provisional and supporting services, which makes the Białe lake ecosystem especially attractive for fishermen and walkers.

The level of correlation coefficient between the ecosystem service supply and travel costs is -0,41 (Table 3). The same coefficient for service supply and entrance fee is - 0,21. The value of the coefficient is much higher when only provisional and cultural services are taken into consideration. For the former it is -0,56 for travel costs, and - 0,58 for the entrance fee, for the latter it is -0,50 and -0,20.

Table 3.
The value of correlation coefficient for services supply and ecosystem value, measured with the travel cost and potential entrance fee method

Service category	Correlaion coeffcient	
	Travel cost	Ticket price
Provisional services	-0,56	-0,58
Regulating services	-0,06	-0,20
Cultural services	-0,50	-0,20
Supporting services	-0,01	-0,06
Services together	-0,41	-0,21

Source: Own elaboration.

A low level of interdependency between regulating and supporting services, and the expenses made in order to obtain services, points to a low level of interest. However important such services are for the ecosystem from a wider perspective, they are relatively unimportant from a single person's point of view. The financial effort made by people is aimed at using provisional and cultural services. This remark is especially important in creating ecological politics on a local, regional and national scale. Services shall be protected, even though the demand for them is relatively low. It is indispensable for a very important, but relatively covert social and economic interest. Regulating and supporting services are a base for various process which are often the ground for the functioning of the whole socio-economic system. Attempts made in this field may remain unseen and unappreciated by society, but they must be taken in order to ensure security, even it if does not have a direct political effect.

Summary

Problematic aspects of ecosystem services, regardless of the region, shall be examined together with the anthropogenic factor. Human influence affects not only the functioning of the environment, but also the amount and quality of ecosystem services. It may be assumed that limited human pressure may cause the increase of service supply, and consequently the increase of their value. After exceeding a certain, maximum level, especially in degraded ecosystems, a gradual decrease of service quality shall appear.

The pressure-services relation (the intensity of pressure - the accessibility of services) cannot be described as a simple, linear dependence. It is shaped differently for a given category of service (provisional, regulating, cultural). Regulating services are the most important, and the most endangered by human pressure. The higher the pressure is, the weaker the ecosystem (threats, pests, lack of self-cleaning), and consequently people are provided with fewer regulating services, which prove to be the most difficult services to regenerate. People, due to their irrational use of the environment, put valuable ecosystems at a risk of degradation.

A degraded lake does not generate any profits, but only costs. The amount of money spend on re-cultivation is huge, and such activities are not always efficient enough. Together with the decrease of the amount and the quality of services, the declared willingness for financial support for a given ecosystem decreases as well. In order to keep ecosystem services on a proper level, various subjects which are responsible for environmental policy, must cooperate properly. Local authorities shall be encouraged to research into the relation between human pressure and the services level. Setting a level of supplied ecosystem products and services may help to utilize the most valuable, from the provided services' point of view, ecosystems.

Małgorzata Kowalczyk • Sylwia Kulczyk

ECOSYSTEM SERVICES IN TOURISM RESEARCH; CASE STUDY OF AQUATIC RECREATION

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ŚWIADCZENIA EKOSYSTEMOWE W BADANIACH NAD TURYSTYKĄ. PRZYPADEK REKREACJI WODNEJ

STRESZCZENIE: W artykule omówiono możliwości zastosowania koncepcji świadczeń ekosystemowych w badaniach nad turystyką i rekreacją. Głównym warunkiem jej wykorzystania w tym zakresie wydaje się jest klasyfikacja świadczeń ekosystemowych, która byłaby przydatna w omawianej dziedzinie. Na przykładzie dwóch form rekreacji wodnej (żeglarstwo i wędkarstwo) wyróżniono trzy podstawowe grupy świadczeń: materialne, estetyczne i duchowe. Ze względu na fakt, że wartości niematerialne są w dużym stopniu uwarunkowane kulturowo, co utrudnia podział świadczeń na „ekosystemowe" i pozostałe, należałoby rozważyć upowszechnienie pojęcia świadczenia krajobrazowe.

SŁOWA KLUCZOWE: świadczenia ekosystemowe, świadczenia krajobrazowe, klasyfikacja, rekreacja wodna

Introduction

Tourism and recreation are an important form of human activity. Economically they grow constantly – in 2011 international tourism receipts surpass USD 1 trillion[1]. Socially it is an indispensable part of life, especially in countries with a higher level of economic growth. Mutual interactions between tourism and recreation and environment are widely known, resulting in popularity of sustainable tourism, that respect environmental and social values. As mentioned above, tourism as a form of activity is of interest to a large part of society. The described phenomenon is highly interdisciplinary, remaining in the range of interest in the social sciences, economics and natural sciences. Undoubtedly, a tool which would allow to integrate various approaches and widely present research results is needed. It is believed, that the ecosystem services concept could be useful in this field. Some problems that concern the use of the concept within mentioned field are discussed in the presented article. These are:

- classification of ecosystem services for the purpose of tourism and recreation research;
- perspectives of integration social and ecological approaches within the concept of ecosystem services.

Two types of aquatic recreation: inshore sailing and angling have been selected as examples for discussed problems.

Tourism and recreation within the concept of ecosystem services

Recreational services are recognized by the most popular classifications[2,3,4,5,6,7] (see Table 1). However divisions applied suggest their independency, it seems to

[1] *International tourism receipts surpass USD 1 trillion in 2011,* UNWTO press release, http://media.unwto.org/en/press-release/2012-05-07/international-tourism-receipts-surpass-us-1-trillion-2011 [Date of entry: 30-09-2012].

[2] R. Constanza et al., *The value of the world's ecosystem services and natural capital*, "Nature" 1997, No. 387, p. 253-260.

[3] *The Millenium Ecosystem Assessment, Ecosystems and Human Well – being: Synthesis*, Island Press, Washington D.C. 2005.

[4] R.S. De Groot, M.A. Wilson, R.M.J., Boumans, *A typology for the classification, description and valuation of ecosystem functions, goods and services*, "Ecological Economics" 2002 No. 41, p. 393--408.

[5] K.J. Wallace, *Classification of ecosystem services: Problems and solutions*, "Biological Conservation" 2007, 139, p. 235-245.

[6] J. Boyd, S. Banzhaf, *What are ecosystem services? The need for standardized environmental accounting units*, "Ecological Economics" 2007, No. 63, p. 616-626.

[7] R. Haines-Young, M.Potchin, *Common International Classification of Ecosystem Services (CICES): 2011 Update,* http://unstats.un.org/unsd/envaccounting/seeaLES/egm/Issue8a.pdf [Date of entry: 30-09-2012].

be impossible to separate recreational and tourism from another types of services. For example, in "The Millenium Ecosystem Asessment" recreation is mentioned within "cultural services"[8]. This group is intentionally not directly related to the collection of material goods. Meanwhile, main threats to the environment from tourism correspond to direct, excessive use of resources. Environmental goods that support tourism can include both of benefits related to other cultural subgroups (especially aesthetical benefits) and to the group of provisioning services. For example, tourism is characterized by a large water holding capacity, both in terms of land use (eg. golf courses) and the individual behavior of tourists. The food supply is also important, with traditional farming as a basis of regional cuisine.

As it can clearly be seen, it would be very difficult to place all the phenomena related to tourism and recreation within one branch of the MEA (2005) classification; the same problem is observed with the other classifications mentioned above.

The attempt to simplify theoretical framework of ecosystem services concept was made by J. Boyd and S. Banzhaf[9], who propose to achieve the goal by omitting regulatory and supporting services. The same idea has been presented by K. Wallace[10]. However simplification of the concept could be useful for marketing or educational purposes, it does not represent the complexity of natural phenomena. According to R. Constanza[11] to oversimplify the concept of ecosystem services means to deprive it of much of the scientific potential. Alternatively he suggests to use various classifications of ecosystem services depending on research scope. Different divisions are needed for different subjects, but they are also scale dependent, with level of detail increasing proportionally to scale of research.

Probably the simplest way of classifying ecosystem services for tourism and recreation is to assign them to various types of activities. This allows to identify areas of potential conflicts. The number of services taken into consideration depends on the scope of research. J. Boyd and S. Banzhaf[12] underline, that final benefit which man obtains depends not only on the of the ecosystem, but also on infrastructure, equipment and personal skills. However, each of mentioned means depends, more or less, on environment. Thus, ecosystem services are needed to support the existence of means mentioned above. They could be called secondary services, in contrast to primary ones, that result in providing direct benefits. Primary services are always connected with the area, where activity is realized. This not apply to secondary services, because materials used for the equipment can be derived from far away. That makes problematic detailed identification of secondary services.

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[8] *The Millenium Ecosystem Assessment*, op. cit, p. 44.
[9] J. Boyd, S. Banzhaf, op. cit., p. 621.
[10] K.J. Wallace, op. cit., p. 235.
[11] R. Constanza, *Ecosystem services: Multiple classification systems are needed*, "Biological Conservation" 2008 No. 141, p. 350.
[12] J. Boyd, S. Banzhaf, op. cit., p. 621.

Table 1.
Tourism and Recreation within different classifications of ecosystem services

Classification	Position of tourism and recreaction	Recognizing of material aspects	Recognizing of nonmaterial aspects	Notes
Constanza et al.[a)]	One of 17 main categories	yes	no	Focus on eco-tourism and outdoor recreation.
De Groot, Wilson, Boumans[b)]	One of 23 ecosystem function (recognized as information function)	yes	yes	Function + process = services and goods. Classification of functions, but only examples of services provided.
Millenium Ecosystem Assessment[c)]	One of 4 subgroups of cultural ecosystem services	no	yes	
Wallace[d)]	One of 6 subgroups of category socio-cultural fulfillment	no	yes	
Boyd and Banzhaf[e)]	One of 6 benefits	yes	no	Recreation as a benefit not as a service
CICES[f)]	One of 23 service groups (within intellectual and experiential service class)	yes	no	Focus on use of resources (direct or indirect)

[a)] R. Constanza et al., op. cit., p. 254.
[b)] R.S. De Groot, M.A. Wilson, R.M.J. Boumans, op. cit., p. 396.
[c)] *The Millenium Ecosystem Assessment,* op. cit., p. 120.
[d)] K.J. Wallace, op. cit., p. 241.
[e)] J. Boyd., S. Banzhaf, op. cit., p. 623.
[f)] R. Haines-Young, M. Potchin, op. cit., p. 6.

The important feature of the ecosystem services' concept is that it joins two subjects – environment and its users. There is no service without demand. Diverse demand features could be the basis of ecosystem services' classification for tourism. However, description of demand is not easy, because tourism and recreation are very diversified. Detailed social research is necessary to describe which services and to which extent are needed. Concerning balance between material and nonmaterial features that are commonly described as important to tourism[13] three types of ecosystem services can be distinguished:

- Material services – support goods and means necessary for specified type of activity
- Aesthetical services – support contact with beautiful surrounding
- Spiritual services – support spiritual experience.

Depending on activity, but also on individual user's features, significance of every group changes. Every group distinguished above is different when the

[13] M. Kowalczyk, S. Kulczyk, *Krajobraz jako obiekt badań geografii turyzmu,* "Problemy Ekologii Krajobrazu" 2010 Vol. 27, p. 197-201.

problem of economic valuation is considered. Probably the easiest to sum up are material services. Various methods of tourist values economic assessment has been described by C. Tisdell[14]. However, significant lack of quantitative data on aesthetical and especially spiritual services is observed[15].

Case study – aquatic recreation at Great Masurian Lakes

The Great Masurian Lakes (Wielkie Jeziora Mazurskie) is a subregion within Masurian Lakeland (Pojezierze Mazurskie) in northeastern Poland. Water bodies make 7% of Masurian Lakeland area and 20% of Great Masurian Lakes[16]. Vast forest areas, extensive agriculture and relatively well preserved nature determine touristic and recreational values of the region, which is one of the favorites holidays destinations in Poland. Various forms of recreation and tourism are realized within the area – from typical leisure stays through different forms of active tourism. Popularity of aquatic tourism is logical consequence of area's natural characteristics. However aquatic recreation is widely recognized as regional brand[17], there are no data available on the number of people practicing it's different forms[18].

For further analysis sailing and angling have been selected. Sailing strongly influences the image of The Great Masuria Lakes. It has been remarked as a tourist product recommended for further development[19]. Whereas inshore sailing is the strong regional feature (thanks to relatively big lakes that are connected each to others), angling is popular all over the country, being one of the most common aquatic activities in Poland.

As far as preferences of tourist visiting area of Great Masurian Lakes are concerned, there are no data that focus on active recreation. P. Duczmal[20] in her research on preferences of leisure tourists within the area identified 3 main features important for tourist, that could be treated as ecosystem services. These

[14] C. Tisdell, *Valuation of Tourism's Natural Resources,* "Working Papers on Economics, Ecology and the Environment" 2003, No 81, http://ageconsearch.umn.edu/bitstream/48962/2/WP81.pdf [Date of entry: 30-09-2012].

[15] *The Millenniu Ecosystem Assessment*, op. cit., p. 120.

[16] J. Kondracki, *Geografia fizyczna Polski*, PWN, Warszawa 1988, p. 332.

[17] PART SA, Raport otwarcia marki Warmia i Mazury, http://mazury.travel/media/art/159/file/Raport_Otwarcia_Marki_Warmii_i_Mazur.pdf p.47 [Date of entry: 30-09-2012]

[18] M. Kozak, *Turystyka jako czynnik rozwoju regionów Polski Wschodniej*, http://www.mrr.gov.pl/rozwoj_regionalny/Polityka_regionalna/Strategia_rozwoju_polski_wschodniej_do_2020/Dokumenty/Documents/TURYSTYKA_PL_WSCH_18_10_2011.pdf, p. 56 [Date of entry: 27-09-2012].

[19] W. Banasik, M. Bucholz, *Strategia rozwoju turystyki województwa warmińsko-mazurskiego,* http://wrota.warmia.mazury.pl/images/stories/file/Turystyka/strategia%20rozwoju%20turystyki.pdf p. 54 [Date of entry: 30-09-2012].

[20] P. Duczmal, *Ogólnodostępna baza noclegowa w Mazurskim Parku Krajobrazowym,* master thesis realized in the Department of Tourism Geography and Recreation, WGiSR UW, 2009, p. 106

are silence and peace, beautiful views and waterways availability. According to the classification proposed above, silence and peace respond to spiritual services, beautiful views represent aesthetical services and waterways availability is of material character. It is assumed, that same needs characterize most of activities realized within the area. However, details differ depending on activity. The attempt has been made to describe different groups of ecosystem services and their mutual relations. The presented analysis is of preliminary character. It focuses on methodology, that could be applied in future research.

Material Services

As mentioned above material services depend as well on quality of environment as on goods and means that are necessary for specified type of activity (e.g. equipment, dress etc.). For both activities taken into consideration availability of open water areas and properties of shoreline are recognized as primal services. It is possible to economically evaluate at least some of them. Basing on interviews with experts and taking into account own experience crucial conditions for both forms of recreation were specified (see Table 2).

Table 2
Conditions for sailing and angling

	Lake (open water)	Shoreline
Saling	• Area • Shoreline • Connections with other lakes	• Lack or reeds • Yachtports • Type of land use
Angling[1]	• Fish population • Shoreline • Volume of lake • No. of stocking spieces	• Low shore • Lack of reeds – accessibility of water • No. of recreational platforms and its area

Source: A. Skrzypczak, A. Mamcarz, *Zastosowanie wskaźników przydatności rekreacyjnej jezior w ocenie ich stanu ekologicznego*, www.icoz.uni.lodz.pl/prezentacje/sesja/sesja_V_A.Skrzypczak.pdf [Date of entry: 12.06.2012].

The conditions mentioned above can be divided in natural and anthropogenic (cultural). The second ones are important for angling in particular, because fish population is related to number of stocking species. Stocking has a very strong impact on fish population. However, it is very difficult to estimate fish population living/occurancing in the lake[21]. Despite mentioned difficulties, mayority of listed conditions could be easy presented in strict metrics and indexes, which are listed below (Table 3 and 4).

[21] J.C. Schneider, C. James, 1998, *Lake fish population estimates by mark-and-recapture methods*. Chapter 8 in: J.C. Schneider, C. James (ed.) 2000. *Manual of fisheries survey methods II: with periodic updates*. Michigan Department of Natural Resources, Fisheries Special Report 25, Ann Arbor, www.michigandnr.com/publications/pdfs/IFR/manual/SMII%20Chapter08.pdf [Date of entry: 04.10.2012].

Table 3
Evaluation of lakes suitability for angling

Natural conditions	Infrastructure and human activity
Shape of shoreline [shoreline development ratio]	Number of recreational platforms
Reeds occurence [width of reeds' belt along the shore in meters]	Area of recreational platforms
Area of forests and wetlands in direct cachment [till 100 m from shoreline]	Number of stocking species
Accesibility of water surface [linear, in meters]	Quantity of annual stocking

Source: A. Skrzypczak, A. Mamcarz, *Zastosowanie wskaźników przydatności rekreacyjnej jezior w ocenie ich stanu ekologicznego*, www.icoz.uni.lodz.pl/prezentacje/sesja/sesja_V_A.Skrzypczak.pdf [Date of entry: 12.06.2012].

Table 4
Evaluation of lakes suitability for sailing

Natural conditions	Infrastructure and human activity
Total length of shoreline	Number of marinas
Length of shoreline of different land use: favorable (forested), accesible (unbuilded, reed free)	Number of yachts
Lake's area (open water without reed and other obstacles)	
Connectivity to others lakes: free or with obstacles	
Weather conditions: length of summer period	

The metrics and indexes presented above can be divided in two groups: that of natural conditions and that of infrastructures development, which can be understood as cultural conditions. The same division can be applied in evaluation of lakes suitability for sailing. As it is stated above, there are some differences in needs of anglers and sailors. Metrics and indexes presented in Table 4. are proposed to evaluate lakes suitability for sailing.

The evaluation conducted for sailing[22] shows significant differences between lakes as well as the large gap between the valuation of the basin as a whole and its coastline. As far as pricing conditions for sailing depend on lakes's surface, the valuation assumptions highlight the diversity of the shorelines characteristics. Conducted economic evaluation of Great Masurian Lakes for sailing has revealed, that many simplifications and assumptions are needed to be made in order to present environment in economic values. The obtained results are of informative value. Therefore, the problem of complex economic evaluation of ecosystem services is still actual and need to be developed.

[22] M. Kowalczyk, S. Kulczyk, *Wycena potencjału rekreacyjnego w krajobrazie pojeziernym na przykładzie żeglarstwa*, "Problemy Ekologii Krajobrazu" 2012 Vol. 27, in print.

Aesthetical and spiritual services

Aesthetic preferences are very individual ones. However, some common patterns exist and their identification is scope of environmental psychologist and other research disciplines[23].

Thus it could be expected, that need of different material services would be connected with specific aesthetical preferences. Technical aspects of observation also seemed to be important; anglers usually stay close to the shore and their small boats are close to the water level, whereas sailors prefer open spaces and yachts decks are situated higher above water. Another parameter, that should be taken into consideration, is spatial and temporal dynamic of observation. Anglers stay longer in one point, whereas sailing means frequent change of viewpoints. Finally, there is a significant difference in a philosophy of both discussed activities. Angling is considered to be contemplative, and sailing active and dynamic.

As far as spiritual services are concerned, similar differences could be observed. Participant observation and conducted interviews with experts lead to statement, that inshore sailing is closer to cognitive tourism then to recreation; a yacht is often used as a mean of travel, whereas main goal of holidays is to visit tourist attractions ashore. Not only material aspects of visited places, but also legends, beliefs, history and other interesting "stories" draw attention of visitors[24]. In comparison to sailors, anglers are much more focused on material benefits – fishes.

Sailing is social activity, with lively culture and many links to global (or at least European) history and tradition. Meeting peoples, singing and playing musical instruments, organizing races and parties – all these events form a cultural image of discussed activity. In case of anglers remaining a part of social group is also important (otherwise it would be impossible to talk about fishing successes) but the social aspect of the activity is of less importance.

One could ask, if spiritual services, that are so strongly human oriented should be included in ecosystem ones? The answer should be positive. The basis of sailing culture phenomenon on Masuria is the presence of aquatic ecosystems; as generally human activity is based on environmental conditions.

Material, aesthetical and spiritual services are strongly connected. The last two groups are especially difficult to evaluate. Presented remarks are only general and require refinement. Implementing of social sciences methodology and tools would be very useful.

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[23] P.A. Bell, T.C. Greene, J.D. Fisher, A. Baum, *Environmental Psychology*, 5th Edition, Harcourt College Publishers, Fort Worth 2001.

[24] S. Kulczyk, *Znaczenie czynników kulturowych dla rozwoju ekoturystyki na przykładzie Wielkich Jezior Mazurskich*, in: *Turystyka kulturowa. Spojrzenie geograficzne*, ed. A. Kowalczyk, Uniwersytet Warszawski, Warszawa 2008.

Conclusions

The concept of ecosystem services could be very useful for tourism and recreations research. The crucial problems of its apply are the scale of conducted studies and the scope of the research. Tourism and recreation are types of human activity which take a place in landscape (that is understood as spatially related set of ecosystems) scale. Landscape's value is the main factor determining selection of area for active recreation. Therefore, in case of tourism and recreation use of term "landscape services' would be more adequate than "ecosystem services". It should be underlined, that however still rarely used, the integrative value of such an approach has been previously recognized. Termorshuizen and Opdam[25] have found "landscape services" concept suitable for interdisciplinary research and applicable in spatial planning practice. The importance of landscape approach has been mentioned also by A. Mizgajski[26].

The main problem that concerns the classification of ecosystem services for tourism and recreation is character of benefits obtained from environment. As well material, as nonmaterial benefits should be taken into account. Whereas material benefits mostly depend on environmental features, nonmaterial benefits are deeply connected to receiver's (human) characteristics, as cultural background and a system of values.

The strongest point of ecosystem services concept is that it is a way to evaluate and to present a value of environment. However, economical evaluation of environment is difficult process and it methods still need to be developed. This particularly concerned the evaluation of nonmaterial benefits.

Tourism and recreation are strongly human related, that makes difficult their placement within the concept of ecosystem services. Depending on classification they are treated as benefit, function or ecosystem service (see Table 1). Their complexity, that results in importance of as well material, and nonmaterial features is rarely recognized.

Due to diversity of tourism and recreation, the investigation on ecosystem services should always concern its specified form. As it is presented above, even relatively close types of activity, as sailing and angling, differ significantly. As far as nonmaterial aspects need to be taken into account, closer cooperation with social sciences would bring new solutions.

[25] J.W. Termorshuizen, P. Opdam, *Landscape Services as a bridge between landscape ecology and sustainable development,* "Landscape Ecology" 2009 Vol. 24, p. 1037-1052.

[26] A. Mizgajski, *Zarządzanie krajobrazem jako aspekt zarządzania środowiskiem*, „Problemy Ekologii Krajobrazu" 2008 Vol. 20, p. 147-152.

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ECOSYSTEMS' LOCAL RECREATIONAL SERVICES VALUATION. KRAJENKA MUNICIPALITY CASE STUDY

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WYCENA LOKALNYCH ŚWIADCZEŃ REKREACYJNYCH EKOSYSTEMÓW. PRZYKŁAD GMINY KRAJENKA

STRESZCZENIE: Przedmiotem badań zostały objęte świadczenia ekosystemów rozumiane jako materialne i niematerialne korzyści czerpane przez człowieka dzięki funkcjonowaniu układów przyrodniczych. Celem badań było oszacowanie wartości świadczeń związanych z wypoczynkiem i rekreacją na terenie gminy Krajenka, ze szczególnym uwzględnieniem lasów, jezior i rzek, oraz zaprezentowanie znaczenia koncepcji świadczeń ekosystemów przy ocenie oddziaływania na środowisko.

Obszarem badań objęto gminę miejsko-wiejską Krajenka położoną w północnej części województwa wielkopolskiego na pograniczu Pojezierza Krajeńskiego i Doliny Gwdy. Wycenie poddano lokalne walory rekreacyjne i wypoczynkowe środowiska przyrodniczego, które stanowią grupę świadczeń kulturowych. W postępowaniu badawczym wykorzystano dwie metody wyceny zasobów i walorów środowiska: metodę kosztów podróży (*Travel Cost Method* – TCM) oraz metodę wyceny warunkowej (*Contingent Valuation Method* – CVM) umożliwiającą oszacowanie gotowości do zapłaty (*Willingness To Pay* – WTP). Pierwsza z metod bazuje na ujawnionych preferencjach badanych osób, a podstawą wyceny warunkowej są potencjalne zachowania respondentów w stosunku do hipotetycznego scenariusza.

Zastosowanie wyceny świadczeń ekosystemów w ocenie oddziaływania na środowisko może zmniejszyć ryzyko podejmowania niewłaściwych decyzji wpływających na utrzymanie równowagi przyrodniczej na danym terenie.

SŁOWA KLUCZOWE: świadczenia rekreacyjne, koszty podróży, wycena warunkowa, zarządzanie środowiskiem

Introduction

Environmental resources and values, referred to as natural capital, are one of the human civilization development foundations. Exemplary use of those goods should therefore be targeted to meeting the needs of not only the present generation but also the needs of generations to come. This is the basis for sustainable development of the natural, economic and social areas harmonization in order to ensure the high quality of life. It is essential for this area to make the right decisions, concerning the environment's use, on the basis of quantitative and qualitative identification of the benefits derived by humans from the natural systems functioning. The ecosystem services' concept, which purpose is to identify and evaluate all humans benefits resulting from the ecosystems' metabolism, may prove helpful in carrying out this task.

The abovementioned benefits are increasingly becoming the subject of scientists' research around the world (e.g. initiatives such as MEA[1], NCP[2], TEEB[3], MAES[4]).

The circle of researchers who saw this approach's attractiveness is widening in Poland as well[5] (e.g. Ryszkowski[6], Czajkowski[7], Mizgajski[8] i Stępniewska[9],

[1] Millennium Ecosystem Assessment (www.maweb.org) [Date of entry: 15-09-2012].
[2] The Natural Capital Project (www.naturalcapitalproject.org) [Date of entry: 15-09-2012].
[3] The Economics of Ecosystems & Biodiversity (www.teebweb.org) [Date of entry: 15-09-2012].
[4] The Mapping and Assessment of Ecosystems and their Services in Europe (www.biodiversity.europa.eu/ecosystem-assessments/european-level) [Date of entry: 15-09-2012].
[5] In 2010, Adam Mickiewicz University in Poznan, Department of Integrated Geography has organized the first symposium in Poland, devoted entirely to the issue of ecosystem services, Ecoserv2010: *Ecosystem services as a subject of transdisciplinary research*. The conference resulted in publication of Ekonomia i Środowisko (Economics and Environment) journal's issue No. 1(37), which presents the current scientific achievements of Polish researchers in the field of ecosystem services. In July 2011, at the University of Lodz, an international conference *Synthesizing different perspectives on the value of urban ecosystem services* was held. It was dedicated to the issue of assessment and valuation of ecosystem services in the city. Again, in 2012, in reference to the Ecoserv2010 symposium, the Department of Integrated Geography organized a second edition of Ecoserv2012 conference: Ecosystem services in transdisciplinary approach, which was dedicated to shaping the platform for cooperation between representatives of the natural sciences and economics in the field of research on ecosystem services. The special guest was Robert Costanza.
[6] L. Ryszkowski, *Adaptacja działalności ekonomicznej do procesu metabolizmu ekosystemów podstawą zrównoważonego rozwoju*, in: Prace Naukowe Akademii Ekonomicznej we Wrocławiu. Zrównoważony rozwój w teorii ekonomii i w praktyce, Graczyk A. [ed.], Wydawnictwo Akademii Ekonomicznej, Wrocław 2007, p. 186.
[7] M. Czajkowski, M. Buszko-Briggs, N. Hanley, *Valuing changes in forest biodiversity*, "Ecological Economics" 2009 No. 68, p. 2910-2917.
[8] A. Mizgajski, *Świadczenia ekosystemów jako rozwijające się pole badawcze i aplikacyjne*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 10-19.
[9] A. Mizgajski, M. Stępniewska, *Zastosowanie koncepcji świadczeń ekosystemów i koncepcji świadczeń infrastrukturalnych w programowaniu gospodarki ściekowej*, „Ekonomia i Środowisko" 2009 No. 1 (35), p. 125-139.

Zylicz[10], Lowicki[11], Kronenberg[12]).

This research's subject were the local recreational services associated with the natural environment functions of Krajenka municipality, located in the northern part of the Wielkopolska district in the confines of Gwda Valley and Krajeńskie Lakeland. The study area is characterized by high natural values associated with numerous forests and bodies of water together with the small pressure from industry. In socio-economic terms, the municipality has one of the highest shares of unemployed people in the working-age population group in the district[13].

The study's nature was methodological and diagnostic. Its purpose was to estimate the recreation and leisure cultural services value in the Krajenka municipality, including economic valuation methods. In terms of diagnostics the study examined the vacationing people's preferences in relation to chosen natural qualities, while as in methodological terms it assessed the appropriateness of the valuation methods used. The author's intention was for the study's results to become premises for the environment's protection and management at the local level and that it can be used in cost-benefit analyzes for projects which are likely to have significant effects on the environment.

Methods and assumptions

The survey's design

Data necessary to carry out the statistical analyzes have been obtained through surveys on randomly selected municipality resident's groups, who were delivered the questionnaires. The various stages of research, including the survey, were designed in account with the experience gained during the pilot study, conducted in late July and early August 2011, which was related to the valuation of Wapieńskie Lake recreational services[14].

The survey's questionnaire was divided into three main modules: introductory (formal), stated preferences with the description of a hypothetical scenario, and socio-economic module. The introductory part identifies the study's organizer and provides information about the purpose and nature of the research. The stated preferences module included questions about the views on natural values,

[10] T. Żylicz, *Wycena usług ekosystemów. Przegląd wyników badań światowych*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 31-45.

[11] D. Łowicki, *Wartość krajobrazu w świetle cen terenów pod zabudowę w latach 1995-2000*, „Ekonomia i Środowisko" 2010 No. 1(37), p. 146-156.

[12] J. Kronenberg, *Usługi ekosystemów w miastach*, „Zrównoważony rozwój – zastosowania" 2012 No. 3, p. 11-26.

[13] Local Data Bank, Central Statistical Office, 2010, http://www.stat.gov.pl/bdl [Date of entry: 15-09-2012].

[14] P. Lupa, *Wartość rekreacyjna zbiorników wodnych w koncepcji świadczeń ekosystemów*, in: *Współczesne zagadnienia, problemy i wyzwania w badaniach geograficznych*, Wydawnictwo Uniwersytetu Gdańskiego, Gdańsk 2012 [in press].

travel costs (including the means of transport, the time needed to reach the holiday destinations, frequency of visits per year), followed by a hypothetical scenario concluded with a question about the willingness to pay (*WTP*). The scenario assumes that the Krajenka municipality's natural environment which was always characterized as high-quality would experience degradation as a result of a potential investment's implementation. At the same time, it would lose all of its recreational values. With reference to that information the respondents had to declare the monthly cost's size they could incur in exchange for preventing the situation described and the possibility of continuing the recreational services use. The socio-economic module included questions designed to determine the respondents' social and economic status. It related to the following characteristics: gender, respondent's age, their place of residence, education, occupational status and income.

In most cases, the questions prepared had a combined nature, i.e., the respondent, at the same time, could answer using the selected item/s from a defined set, as well as put an individual response in a designated place.

Contingent valuation method – CVM

The contingent valuation method is based on the people's views and their contingent markets preferences (not necessarily existing in reality) study. Respondents are informed about a hypothetical (less often real) situation of the environment's deterioration and respond to questions about their willingness to pay (*WTP*) for preventing environmental degradation, or the willingness to accept (*WTA*) monetary compensation for the loss in this environment[15,16]. As pointed out by Żylicz[17,18], the development of CVM was initially very slow, but after validation of this method in the USA in 1993, the frequency of its use has increased considerably.

The study analyzed respondents' willingness to pay for preventing a potential ecosystem degradation and loss of its recreational values. The respondents could answer by:

1) selecting one of seven amounts in the range of 0-100 PLN/month in total,
2) entering their own amount, or
3) selecting the answer „I would not pay".

[15] J. T. Winpenny, *Wartość środowiska. Metody wyceny ekonomicznej*, PWN, Warszawa 1995, p. 91-97.
[16] J. Famielec, *Straty i korzyści ekologiczne w gospodarce narodowej*, PWN, Warszawa-Kraków 1999, p. 154-157.
[17] T. Żylicz, *Ekonomia środowiska i zasobów naturalnych*, PWE Warszawa 2004, p. 41.
[18] T. Żylicz, *Wycena usług* ..., op. cit., p. 31-45.

Travel Cost Method – TCM

The analyzed method is the most common of all the environmental resources and qualities valuation methods [19]. The method's aim is to estimate the value of ecosystem services from the perspective of costs incurred by people, in order to reach the high natural value places, taking into account the cost of lost time. In other words, the benefits derived by the person in the recreational area depends on the distance that they are willing to travel in order to reach that area, and therefore of the direct value of money spent and the indirect value of travel time[20]. As stressed by Winpenny[21], the particular advantage of TCM is its reliance on actual observed people's behavior, which makes it more reliable in comparison with the stated preference methods.

In this paper, the travel cost method is used to valuate the recreational services associated with the municipality residents recreation within the lake's, river's and forest's ecosystems.

While interpreting the amounts obtained by this method, they should be understood as the lower estimations of the sought value[22,23]. Thus, it was assumed that the minimum value that respondents attach to the given ecosystems group corresponds with the sum of their travel costs and the loss of time (equation 1).

$$\overline{x_w} = \frac{\sum_{i=1}^{n} F_i[\frac{(2 * S_i * CS_i)}{3} + (t_i * Ct_i)]}{\sum_{i=1}^{n} F_i} \quad (1)$$

$\bar{x}_w$ – weighted average value of a travel to the place of recreation [PLN/visit]
F_i – frequency of travels [number of visits/year]
S_i – distance from respondents' place of residence to the leisure site [km]
CS_i – unit cost of 1 km run over by car (0,43 PLN/km)
t_i – time spent in travel [h]
Ct_i – unit cost of lost time (21 PLN/h)

During the fieldwork, it was noted that an average of three people travelled in one car, hence, in the equation, the direct costs of a route were divided by three. While estimating the unit cost of lost time, Bartczak's[24], studies results were included. In 2002, she calculated the value of personal travel time in Poland at 16 PLN/h using the stated preference methods. For the purpose of this study, this ratio was realigned accordingly with the inflation over the period of

[19] J. Famielec, op. cit., p. 147-154.
[20] Ibidem, p. 148.
[21] J. T. Winpenny, op. cit., p. 90.
[22] T. Żylicz, *Ekonomia środowiska ...,* op. cit., p. 39.
[23] M. Czajkowski, *Nierynkowe metody wyceny*, in: *Wyzwania zrównoważonego rozwoju w Polsce*, ed. J. Kronenberg, T. Bergier, Kraków 2010, p. 15.
[24] A. Bartczak, *Wartość czasu podróży prywatnych w Polsce*, „Ekonomia" 2003 No. 7, p. 100-121.

2003-2012 (based on NBP data). In some studies, the given person's rate of pay that reflects the lost wage was assumed as the measurement unit for the time spent travelling, but this approach is not very objective in most cases[25].

Results

The respondents' characteristics and their preferences

The survey was conducted in the period from 21 to 30 May 2012, and concerned the residents' population in Krajenka municipality. In terms of questions related to the contingent valuation, the study group was limited only to adult residents of the municipality. Random selection was used while determining the research sample. Total of 350 questionnaires were distributed, and 63,4%, i.e. 222 surveys, were returned. To test the distribution of examined qualitative (nominal) variables hypotheses, Pearson's chi-square test (χ^2) was used. The value of $p \leqslant 0,05$ was accepted as the level of the statistical significance.

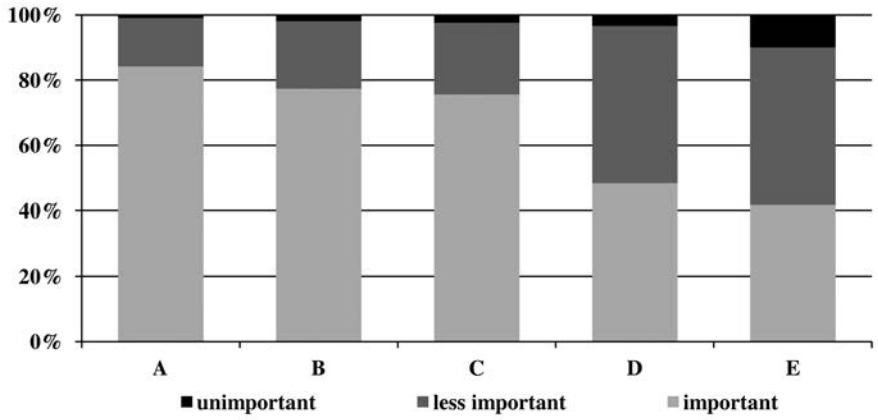
Most respondents taking part in the study were women (65%). 52% of the respondents were in their middle age (31-60 years), the least frequently represented (14%) age group were the elderly people (61 years and more). Over 23% of the respondents had lower education, almost 44% had secondary education, and nearly 33% had higher education. Most of the respondents were city residents (58%). More than 50% of the respondents were characterized by the highest income per one person in the household (> 1000 PLN/month), 34% of respondents found themselves in the group of middle-income ratio (500-1000 PLN/month), and almost 16% were in the group with low income (<500 PLN/month).

The analysis of the responses' number showed that, for most of the respondents, the most important natural advantage of the studied area was the clean air and favorable climatic conditions. Calmness as well as purity and availability of water also proved very important for the residents' relaxation and recreation. Flora and fauna, together with its diversity, was considered to be less attractive, and the lowest importance was attributed by the respondents to the local landscape and relief (Figure 1).

Statistically significant ($p \leqslant 0,05$) differences in the responses distribution were noted for the two combinations of variables: „climate and air quality – age" and „landscape and relief – education" (Table 1). Climatic conditions and air quality were more frequently described as important by the group of middle aged and older people (90% and 82%). For most of the younger respondents (almost 76%) those values were also important, however, in comparison to people in other age groups, they attributed average weight (24%) to the climatic conditions statistically more often. Every second respondent in the lower education group attributed the highest rank to landscape and relief, while every fifth

[25] J. T. Winpenny, op. cit., p. 89; J. Famielec, op. cit., p. 152-153; A. Bartczak, op. cit., p. 106.

Figure 1
Importance assigned to natural advantages of Krajenka municipality



A) climate and air quality (n = 215), B) calmness (n = 212), C) water quality and availability (n = 209), D) flora and fauna, biodiversity (n = 209), E) landscape and relief (n = 211)

Source: Own study.

believed these qualities are unattractive. Distribution of answers in groups of people with secondary and higher education were very similar. Most of them, described these values as having average importance (by 58% and 51% of people with secondary and higher education accordingly).

Willingness to pay

The data on the amounts declared by the respondents, acquired during the survey, was analyzed in terms of credibility and errors. As a result of further study 27 cases were excluded from the total of 222 (n = 195). The next step concerned the normality of residual distribution test for the declared amounts. Shapiro-Wilk test was used. In each of the examined cases, the residual distribution differed significantly from the normal distribution, which prevented the use of standard parametric methods. Cases were decided to be organized into four WTP groups: lack of willingness to pay (WTP = 0), low annual WTP value ($\bar{x}$ = 101), average annual WTP value ($\bar{x}$ = 278) and high annual WTP value ($\bar{x}$ = 788). This allowed the use of Pearson's chi-square test (χ^2) and to analyze the differences in respondents' answers distributions.

Based on the analysis of multi-way tables (crosstabulation tables), statistically significant ($p \leqslant 0{,}05$) differences in the respondents' answers distributions on the declared WTP value were noted for three classification groups: household income, place of residence and level of education (Table 2).

Table 1
Significant differences in the distribution of importance assigned to the natural environment advantages

No.	Group	Sample size n	Importance of advantages [%]			Sum [%]
			important	less important	unimportant	
climate and air quality – age						
1.	chi-square test (χ^2) = 10,1854, df = 4, p = 0,0374					
	young respondents	n = 70	75,71	24,29	0,00	100
	middle aged respondents	n = 108	89,81	8,33	1,85	100
	older respondents	n = 28	82,14	17,86	0,00	100
	total	n = 206	83,98	15,05	0,97	100
landscape and relief – education						
2.	chi-square test (χ^2) = 16,1559, df = 4, p = 0,0028					
	primary education (lower)	n = 45	55,56	24,44	20,00	100
	secondary education	n = 92	36,96	57,61	5,43	100
	higher education	n = 70	38,57	51,43	10,00	100
	total	n = 207	41,55	48,31	10,14	100

Source: Own study.

Table 2
Significant differences in the WTP distribution depending on the respondents' characteristics

No.	Group	Sample size n	Willingness to pay (*WTP*) [%]				Sum [%]
			lack	low	average	high	
household income							
1.	chi-square test (χ^2) = 48,7864, df = 6, p = 0,0000						
	<500 PLN	n = 31	58,06	32,26	6,45	3,23	100
	500-1000 PLN	n = 66	9,09	50,00	30,30	10,61	100
	>1000 PLN	n = 98	11,22	38,78	25,51	24,49	100
	total	n = 195	17,95	41,54	24,10	16,41	100
place of residence							
2.	chi-square test (χ^2) = 15,4574, df = 3, p = 0,0015						
	town area	n = 119	10,08	42,02	26,89	21,01	100
	rural area	n = 76	30,26	40,79	19,74	9,21	100
	total	n = 195	17,95	41,54	24,10	16,41	100
level of education							
3.	chi-square test (χ^2) = 12,8680, df = 6, p = 0,0452						
	primary education (lower)	n = 42	33,33	38,10	19,05	9,52	100
	secondary education	n = 84	14,29	47,62	23,81	14,29	100
	higher education	n = 68	13,24	35,29	27,94	23,53	100
	total	n = 194	18,04	41,24	24,23	16,49	100

Source: Own study.

Accordingly with the earlier assumptions, household income proved to be an important variable that affected the amounts declared by the respondents. People with higher incomes were more likely to be willing to pay more than those with the lowest incomes, who often declared unwillingness to pay. In other words, with an increase in the wealth level of the respondents, the percentage of people willing to pay higher amounts for the offered goods also increased. Expected correlation was also noted in the case of the residence place impact on the WTP amount. Respondents living in rural areas usually declared small amounts (<41%) or lack of willingness to pay (>30%), while residents of the city declared accordingly: small (>42%), followed by medium-sized (<27%) and a large WTP amounts (>21%) (therefore they were more willing to pay higher amounts). It was connected with the interaction observed between the place of residence and the respondent's income amount. In the group of city residents, higher income was indicated more often in comparison with the respondents living in rural areas (χ^2 = 19,4212, df = 2, p = 0,0001). In the case of „education" variable a positive relation was found as well. With the increase in the respondents' education level, the percentage of people, declaring a higher willingness to pay, also increased. However, the strength of this relation was much lower than in the case of the previously described interactions.

In order to verify the research results, a log-linear analysis[26], which examined the relations of individual variables (WTP, income, place of residence, education), was carried out. As a result, the direct effect of education on the declared amounts was ruled out (Figure 2), hence the extrapolation of results to the whole population included only the effects connected with the household income amount and respondents place of residence (Table 3).

Table 3
Willingness to pay – test results

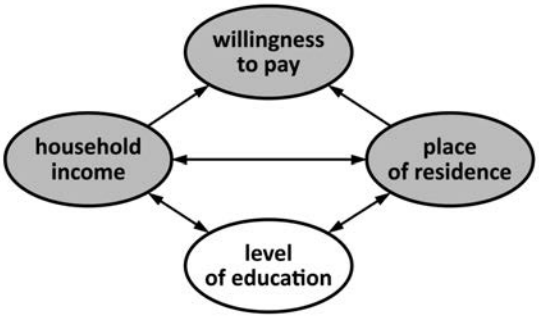
Place of residence	Survey results, n = 195				Extrapolated results	
	WTP [PLN/person/year]				population[a)]	WTP [thous. PLN/year]
	low income	average income	high income	total		
town area	128,6	189,6	400,0	264,9	2004	530,8
rural area	210,0	280,8	322,9	302,8	2745	831,2
municipality	158,5	234,0	347,5	286,8	4749	1362,0

[a)] population of adult residents announcing their willingness to pay (based on Registry Office in Krajenka data, 2012)

Source: Own study.

[26] Log-linear analysis provides a „sophisticated" way of looking at crosstabulation tables (to explore the data or verify specific hypotheses). Specifically, it allows the user to test the different factors that are used in the crosstabulation (e.g., gender, region, etc.) and their interactions for statistical significance (see A. Stanisz, Podstawy statystyki dla prowadzących badania naukowe. Odcinek 36: Analiza log-liniowa, „Medycyna Praktyczna" 2002/07, http://www.mp.pl/artykuly/?aid = 13111 [Date of entry: 07.09.2012].

Figure 2
Model of WTP dependency on respondents selected features based on the log-linear analysis



Source: Own study.

Travel costs

Before moving on to the actual calculations, the data from 222 forms was analyzed in detail in terms of containing relevant information and verifying their credibility. In each group of ecosystems, a number of questionnaires, which did not meet the formal conditions, was rejected (lakes – 5, rivers – 10, forests – 8).

Availability of various leisure areas, in terms of distance that needed to be covered by the respondent in order to reach them, had a significant impact on the range of travel costs. Therefore, spatial diversity of municipality's land use structure, especially the configuration of built-up areas in regard to recreation sites, was meaningful. Hence sections of rivers and forest complexes, which distribution was more even in regard to built-up areas, were more accessible to tourists than the lakes, focused solely on the southern border of the municipality. It needs to be kept in mind, of course, that, in addition to the distance criterion, other factors, such as the quality of the environment, were used to decide on the choice of a particular leisure area.

Among the analyzed ecosystems' groups, the forests and lakes enjoyed the greatest interest among respondents. The respondents most frequently choose the municipality's forest areas (21 visits per year), followed by lakes and rivers (17 visits a year for each). The highest average estimated value of a single visit was calculated for trips to the lakes (10,1 PLN). For trips to the forests this value was calculated at 6,1 PLN level, and for visits to the river at the level of 3,4 PLN. The annual average level of travel costs per one travelling respondent was estimated at 175 PLN for visits to the lakes, 129 PLN for visit to the forests and just 59 PLN for visits by the rivers (table 4). The calculated costs are also considered as the lower estimate of the local cultural services value associated with the conditions for leisure and recreation created by the environment.

Table 4
Travel cost method – test results

Group of ecosystems	Share of travelers in the sample	Number of travelers in the population[a]	Average number of visits per year for a single traveler	Value of a single visit	Travel and lost time costs for a single traveler[b]	Total recreational value[c]
	[%]	[No. of people]	[No. of visits]	[PLN]	[PLN/year]	[thous. PLN/year]
Lakes	74,6	5 620	17	10,1	174,9	983,0
Rivers	49,6	3 735	17	3,4	58,7	219,2
Forests	91,8	6 911	21	6,1	129,1	892,4
					SUM	2094,6

[a] extrapolated taking into account the share of travelers in the sample and the Registry Office data
[b] weighted average value
[c] extrapolated taking into account number of travelers in the population

Source: Own study.

Discussion

The results fit into the research on the natural environment's advantages and resources valuation. From Żylicz's[27] review on the ecosystem services valuation research's results comes a conclusion that both of the used methods have been successfully implemented around the world and tested by Polish researchers as well.

An example of contingent valuation method application is a study, conducted in the mid-90's, as a part of the international protection of the Baltic Sea[28] research project. At that time, an adult Pole's willingness to pay for the purification of the Baltic Sea was calculated as 169 PLN/year. The modified method was also used in the international studies on recreation by the lakes in Poland, Czech Republic and Norway[29]. The researchers asked respondents about their willingness to pay for improved water quality in the lakes, firstly by one, and then by two purity classes. In the Lake Łęgowskie case, average WTP amounts were estimated at USD 13 (improvement by one class) and USD 18 (improvement by two classes). The results were the lowest among all surveyed lakes (maximum WTP = 401 USD for lake Orre in Norway for improving the water quality by two classes, price level from the year 2005). In 2007, in Poland, a study was conducted to determine the willingness to pay for improving the tap water (drinking

[27] T. Żylicz, *Wycena usług ...*, op. cit., s. 31-45.
[28] A. Markowska, T. Żylicz, *Costing an international public good: the case of the Baltic Sea,* "Ecological Economics" 1999 No. 30, s. 301-316.
[29] M. Czajkowski et al., *Lake water quality valuation – benefit transfer approach vs. emperical evidence*, "Ekonomia" 2007 No. 19, p. 156-183.

water) and surface water quality. In the first case, the respondents were willing to pay an average of 21 PLN/month, while in the second, an average of 14 PLN/month[30]. The study also showed that the average annual rate for holidays by the water in adult urban population was formulated on the level of 16 visits. It is worth noting that the frequency of leisure travels for the lakes and rivers located in the Krajenka municipality was estimated at a similar level of 17 visits per year.

Due to the different nature of research (scale, object, aims) the results obtained by the mentioned authors are difficult to be compared with the results of research on Krajenka municipality. Their study involved the willingness to pay for improving the quality of one good, whereas in this study, the question concerned the declaration of payment for the possibility of using all recreational values of the municipality's natural environment and the prevention of their degradation. This could be the direct cause for the higher average *WTP* value.

Panasiuk[31], who in 2000 valued the recreational value of Pieniny National Park, conducted interesting study regarding TCM. He estimated the cost of a one-day trip to the PNP at the level of 16 PLN/visit, and of 215 PLN/visit for trips including an overnight stay. In 2003, a modified travel costs method was used to estimate the economic value of Elblag Canal[32]. The average cost for a Polish tourists visit ranged between 33-38 PLN, while in the foreign tourists' case it ranged between 147-155 PLN. At the turn of 2005 and 2006, Bartczak[33] estimated the value of a single recreational trip to Polish forests at an average level of 26,92 PLN/person with an average 41 visits a year. Giergiczny's[34] research with the use of TCM proved in turn, that the benefits provided by the Bialowieza Forest can be almost three times greater than the revenue from sales of wood harvested in the area. In reference to the Giergiczny's research's results, the estimated recreational value of the Krajenka municipality's forests was compared with the potential revenue from the harvested wood sales[35]. As a result, the average recreational value of forests in the whole municipality accounted for only 7% of the timber sales revenue. At the same time, large local variations, which ranged between 5% and over 40%, were noted for this share.

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[30] A. Bartczak, *Wycena korzyści z poprawy jakości wody kranowej I powierzchniowej w Polsce*, „Ekonomia i Środowisko" 2010 No. 2 (38), p. 123-141.

[31] D. Panasiuk, *Problemy wartościowania środowiska w ocenie zbiornikowych inwestycji gospodarki wodnej*, Ph.D. Thesis, Politechnika Warszawska, Warszawa 2002.

[32] T. Liziński, M. Bukowski, *Wycena wartości ekonomicznej zasobów przyrodniczo-kulturowych na przykładzie Kanału Elbląskiego*, „Woda. Środowisko. Obszary wiejskie" 2008 vol. 8 No. 1(22).

[33] A. Bartczak, *Wartość funkcji rekreacyjnej lasów w Polsce*, „Ekonomia i Środowisko" 2006 No. 2 (30), p. 23-41.

[34] M. Giergiczny, *Rekreacyjna wartość Białowieskiego Parku Narodowego*, „Ekonomia i Środowisko" 2009 No. 2 (36), p. 116-128.

[35] Studies on the production of wood in the forests of the municipality were carried out in 2011 using one of the InVEST models (managed timber production model) and data obtained from The State Forests National Forest Holding (see: P. Lupa, *Zastosowanie narzędzi InVEST do wyceny produkcji drewna jako świadczenia ekosystemów leśnych. Przykład Nadleśnictwa Złotów*, „Badania Fizjograficzne" 2012, R. III A – Geografia Fizyczna (A61) [in press]).

Krajenka municipality's natural environment's recreational value's research results obtained using the travel costs method are lower compared to the results of mentioned authors' analyzes. This is probably caused by the significant differences in the touristic and recreational rank of the individual research areas. Pieniny National Park, Bialowieza Forest or Elblag Canal are nationally and internationally important tourist destinations, while the analyzed municipality is characterized by local recreational values (less travel costs associated with travelling short distances from place of residence to the leisure area). The respondents' population, limited to residents of the selected municipality, used in this study, was also a factor which determined the results. Therefore, the recreational value, which is assigned to the municipality's natural environment by persons who are not its citizens, was not taken into account (underestimation).

Conclusion

In accordance with the stated research objective, the cultural services value of the Krajenka municipality's natural environment, connected with the possibility of leisure and recreation was calculated. In the case of contingent valuation method, the local recreational benefits value has been calculated as less than 1,36 million PLN. In the case of travel costs method, total recreational value of three ecosystem groups: forests, lakes and rivers, was calculated as about 2,1 million PLN. The results obtained through the travel costs method should be interpreted more as a lower estimate of the desired goods value, therefore the lower estimated WTP value is puzzling. This discrepancy could be caused by using different populations in the surveys, depending on the economic valuation method used. In addition, the hypothetical scenario presented in the study could be too general and unrealistic for the respondents, which in turn could lead to the insincere responses. It is worth noting at this point that the travel costs method is applicable to revealed (actual) respondents' preferences, which may make it more reliable in comparison to the contingent valuation method based on the subjects' potential behaviours in relation to a hypothetical scenario.

The results obtained during the study confirmed the author's initial assumptions, connected inter alia with the declared WTP level. There was a relation between the level of the declared amount and the household income, which, in the examined case, varied depending on the respondents' place of residence. Declaring higher amounts more frequently by residents of the city resulted probably not only from their high income. It could also be related with the availability of land valuable in terms of nature and recreation. Availability is usually lower for town residents than for people living in rural areas, therefore the former can place higher value on the cultural benefits, connected with the possibility of leisure and recreation in open areas, which are less available for them.

The results of this study characterize the natural environment's recreational services' value in the Krajenka municipality, and pose as premises for the protection and rational use of its assets. They can be used in the assessment of environmental impact in order to reduce the risk of making wrong decisions which could affect maintaining the analyzed area's natural balance.

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SUSTAINABILITY OF HUMAN DEVELOPMENT. ASSESSMENT ON THE BASIS OF SELECTED INDICATORS

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TRWAŁOŚĆ ROZWOJU SPOŁECZNEGO. OCENA NA PODSTAWIE WYBRANYCH WSKAŹNIKÓW

STRESZCZENIE: Współczesne badania nad problematyką rozwoju są w dużej mierze zdominowane przez dwie koncepcje: rozwoju społecznego (*human development*) oraz rozwoju trwałego (*sustainable development*), przy czym często poszczególni autorzy koncentrują się wyłącznie na jednym zagadnieniu. Zwraca się jednak uwagę, że obie te koncepcje są wzajemnie powiązane na kilka różnych sposobów. Trwałość jest uwarunkowana poziomem osiągniętego rozwoju społecznego oraz jednocześnie brak trwałości w postaci nadmiernej degradacji środowiska może być barierą w rozwoju społecznym. Celem niniejszego opracowanie jest integracja obu koncepcji, jak również ocena rozwoju poszczególnych krajów poprzez zestawienie wskaźnika rozwoju społecznego z wybranymi wskaźnikami trwałości: skorygowanych oszczędności netto oraz śladu ekologicznego.

SŁOWA KLUCZOWE: rozwój społeczny, rozwój trwały i zrównoważony, ślad ekologiczny, wskaźniki trwałego rozwoju

Introduction

The concept of sustainable development is currently one of the main concepts of the long-term strategy of economic and social growth. It is understood as the need to preserve three types of capital, i.e., man-made, human and natural, treated as production factors forming the basis of human well-being for future generations (in accordance with the principle of intergenerational equity). At the same time, many authors point out that the concepts of well-being, quality of life and social justice need to be revised. One of the most important modern proposals is A. Sen's concept of human development. The purpose of this paper is to integrate these two concepts and to assess the sustainability of the achieved level of development of selected countries based on the indicators of Human Development Index (HDI), Adjusted Net Savings and Ecological Footprint.

The concept of human development

On the basis of economic sciences the category of development is generally understood quite narrowly by identifying it with economic growth and the improvement of material well-being. Development economics as a separate discipline of economics, was founded in the late 1950s. The purpose of development economics is primarily the search for the answer to the fundamental question, why have some countries become rich while others remained poor[1]. The seriousness of these problems meant that in mainstream economics the issue of development is to a large extent reduced to the attempts to explain the sources and mechanisms of economic growth as measured by GDP.

Starting from the 1990s, a gradual evolution of the concept of „development" took place. According to R. Piasecki the contribution of the United Nations, which several prominent economists were linked to should be appreciated. The most important achievements of the United Nations in formulating development strategies may include strengthening the awareness that development cannot be limited only to economic growth, noticing the weight of social and environmental problems; noticing the negative role of poverty and misery, which, among others, are the elements of destabilization and base for terrorism[2] development. All of these lead to the paradigm of economic development being gradually replaced by the so-called human development paradigm.

[1] *Ekonomia rozwoju*, scientific editor R. Piasecki, Polskie Wydawnictwo Ekonomiczne, Warszawa 2011, p. 15-16.
[2] Ibidem, p. 30.

The concept of human development is largely based on the ideas of A. Sen, a prominent economist and philosopher[3], concerning equality, distributive justice and egalitarianism of human capabilities, as a measure of justice.

According to A. Sen the key is to distinguish between the results achieved from the ability to achieve itself. A person's social status may be assessed either by the reference to their actual achievements or to the freedom of being able to achieve. Achievements describe what we were able to come to, but the freedom to achieve involves our realistic chances of getting what we considered to be valuable[4].

The concept of capability was used by A. Sen to create a more comprehensive theory of development, which was presented in his work *Development as Freedom*[5]. Development is primarily understood as a process of expanding freedom enjoyed by people, which contrasts with narrower approaches likening growth to GDP increase, industrialization, technological development and modernization of social life. The goal of this approach is to improve people's lives by broadening the scope of what people can do and who they can be, for instance, be healthy, well-nourished, educated, actively participate in community life. From this perspective, the development is the removal of obstacles such as illiteracy, poor health, lack of access to resources, or lack of civil and political freedom[6]. There is no denying that economic growth is important, however, development cannot be assessed solely on the basis of aggregated indicators of national income[7].

A sizeable contribution to the concept of social development was also made by M. Nussbaum. In her works she refers to Aristotle's thought, including Aristotle's essentialism, by which we mean the notion that human beings have certain solid and common to all properties[8].

M. Nussbaum is also critical of the dominant approach to the assessment of development measured on the basis of GDP per capita and utility theory only.

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[3] For his achievements in the field of economics, and in particular the theory of social choice, welfare economics and poverty research, he has received the Nobel Prize in 1998. The importance of A. Sen's concept for the development of economics has been presented in the article by S. Pressman and G. Summerfielda, *The Economic Contributions of Amartya Sen*, „Review of Political Economy" 2000 Vol. 12, No. 1. quotation: T. Kwarciński, *RównośćiI korzyść. Amartyi Kumar Sena koncepcja sprawiedliwości dystrybutywnej*, Uniwersytet Ekonomiczny, Kraków 2011, p. 8.

[4] A. Sen, *Nierówności. Dalsze rozwiązania*, Społeczny Instytut Wydawniczy Znak, Kraków 2000, p. 46.

[5] A. Sen, *Development as Freedom*, Random House, Inc., New York 1999. Polskie wydanie: A. Sen, *Rozwój i wolność*, Wydawnictwo Zysk i S-ka, Poznań 2002.

[6] Por. S. Anand, A. Sen, *Human Development and Economic Sustainability*, "World Development" 2008 Vol. 28 No. 12, p. 2030-2033.

[7] Por. ibidem.

[8] M. Nussbaum, *Human Functioning and Social Justice: In Defense of Aristotelian Essentialism*, „Political Theory" 1992 Vol. 20 No. 2, p. 202-246, quotation: A. Głąb, *Rozum w świecie praktyki. Poglądy filozoficzne Marthy C. Nussbaum*, Wydawnictwa Akademickie i Profesjonalne, Warszawa 2010, p. 165.

In addition to lack of information about the distribution of income, there is also no information about goods, which are not always correlated with high levels of income, such as life expectancy, infant mortality, education, employment opportunities, political freedom, racial, and gender relations. South Africa in the apartheid era and Singapore governed by strict political regime could be suitable examples here. Countries such as Pakistan, Zimbabwe, Honduras had similar levels of GDP per capita (in 1997), but differed significantly in the level of illiteracy among women and their participation in income[9]. Also utility (expressed satisfaction) may not be an appropriate measure of development, as subjective feelings of people can be determined by social membership and inability to see other opportunities.

It is necessary to clarify the exact meaning of the concept of „cability". M. Nussbaum believes that the starting point is the concept of human dignity and a life that is worthy of dignity – i.e. a life enabling a „truly human functioning" in the sense described e.g. by Karl Marx in his *Economic and Philosophical Manuscripts* (1844). M. Nussbaum tried to create a list of ten basic and universal human capabilities (central human capabilities) as a dignified life conditions[10], however, it should be emphasized that each listed capability is a separate component and the lack of one cannot be compensated by the bigger amount of the other. According to M. Nussbaum capabilities are an adequate criterion of quality of life. Providing all people with at least the basic level of their fulfillment should be the main objective of government politics.

It is noteworthy that the list of central human capabilities of Nussbaum was also the subject of empirical research[11]. The results obtained have confirmed that capabilities have a significant influence on the subjectively perceived state of well-being. The introduction of control variables related to personality (personality has an impact on the perceived well-being), did not affect the main conclusions of the analysis[12].

Sen's concept of human development is the basis for the definition of development adopted by the United Nations Development Programme (UNDP)[13]. UNDP has been preparing the annual Human Development Report (HDR) since 1990. The major HDR tool is the Human Development Index (HDI), which consists of sub-indices covering the three basic dimensions: a long and healthy

[9] M. Nussbaum, *Women and Human Development*, Cambridge University Press, 2001, p. 61.
[10] M. Nussbaum, *Capabilities as Fundamental Entitlements: Sen and Social Justice*, "Feminist Economics" 2003 No. 9(2-3), p. 40-41.
[11] P. Anand et al., *Capabilities and well-being: evidence based one the Sen-Nussbaum approach to welfare*, Social Indicators Research 2005 Vol. 74 No. 1, p. 9-55.
[12] Ibidem, p. 42.
[13] Human development is the expansion of people's freedoms and capabilities to lead lives that they value and have reason to value. It is about expanding choices. Freedoms and capabilities are a more expansive notion than basic needs. Many ends are necessary for a "good life," ends that can be intrinsically as well as instrumentally valuable – we may value biodiversity, for example, or natural beauty, independently of its contribution to our living standards. UNDP, Human Development Report 2011, http://hdr.undp.org/ [Date of entry: 15-08-2012].

life (measured by the ratio of the expected average life expectancy at birth), access to knowledge and education (measured by the average and expected number of years of education), and the standard of living (gross national income per capita at purchasing power parity), thus directly relating to the idea of A. Sen and M. Nussbaum's proposals.

The problem of human development sustainability

It has been noted that the research on human development and the research on the sustainability of development are often intertwined. However, according to E. Neumayer, at a very basic level, human development is exactly what the proponents of sustainable and balanced development want to maintain[14].

S. Anand and A. Sen noted the following in this connection: „*This has a terribly hollow ring if it is not accompanied by a moral obligation to protect and enhance the well-being of present people who are poor and deprived. If one thinks that people will be deprived in the future unless different policies are followed, then one is morally obliged to ask whether people are deprived right now. It would be a gross violation of the universalist principle if we were to be obsessed about intergenerational equity without at the same seizing the problem of intragenerational equity: the ethic of universalism certainly demands such impartiality*"[15].

It should be noted that the Human Development Report 2011 is largely devoted to the problems of reconciling human development with the need to preserve and protect the environment. The report mentions the notion of sustainable human development, similar to that of A. Sen, understood as the expansion of significant freedoms of the present generation and attempting, at the same time, to avoid serious breach of freedoms of future generations[16].

However, it should be noted that the concern for future generations can be a hindrance to prosperity of those living today. On one hand, the increase in consumption today, poses a threat for future generations meeting their needs and aspirations. On the other hand, social development by improving health, nutrition, education, etc. contributes to the development of the so-called human capital. This will have its impact also in the future, for example through increased productivity and people's ability to generate bigger income. Therefore, human development can be an important means of ensuring sustainability. It is important to note that this is consistent with the modern theory of endogenous economical growth. The complicated relationship between the diversity of human development (at the international level and within the country) and sustainabil-

[14] E. Neumayer, *Human Developement and Sustainability*, Human Development Research Paper 2010/5, UNDP, http://hdr.undp.org/ [Date of entry: 15-08-2012].

[15] S. Anand, A. Sen, *Human Development and Economic Sustainability*, "World Development" 2008 Vol. 28 No. 12, p. 2038.

[16] *Sustainable human development is the expansion of the substantive freedoms of people today while making reasonable efforts to avoid seriously compromising those of future generations.*

ity were also analyzed by other authors[17]. It was found that there might be a reciprocal relationship between them – inequalities in human development cause lack of sustainability. At the same time lack of sustainability may contribute to an increase in inequalities. It is believed that these relationships are nonlinear. The narrow scope of this study does not allow for a broader discussion of the nature of these relationships.

It is important to note that the majority of these observations is not based on empirical studies, therefore they are of speculative nature. Empirical research is needed in this area.

Research also shows a clear correlation between the level of development (measured by HDI) and the so-called Index of Climate Hazard covering the risk of the sea levels rise and storm waves, extreme weather phenomena, and reduced productivity in agriculture. This means that countries with a low level of development will be the most affected by climate changes[18].

The potential impact of environmental destruction on the issues of gender equality and women's rights should also be mentioned. Research shows a strong correlation between high levels of deforestation and the weakening of women's health, more housework and a reduced level of income. At the same time, it is acknowledged that there is a link between women's stronger position and reduced fertility in urban areas and a more sustainable use of resources in rural areas[19]. The weight of the problem is emphasized by the European Parliament draft resolution on women and climate change, which states that „in addition to other disastrous effects, climate change intensifies discrimination on grounds of sex."[20]. As a justification, it was stated, among others, that women account for 80% of refugees and displaced persons, and their mortality rate in the case of a natural disaster is five times higher than for men.

Human development in relation to selected indicators of sustainability

At operational level, the relationship between human development measured by HDI index and selected indicators of sustainability, especially *adjusted net savings*[21] and *ecological footprint*[22] is analyzed most often. It can be assumed that the adjusted net savings rate is an indicator of weak sustainability (allows

[17] E. Neumayer, *Sustainability and Inequality in Human Development*, Human Development Research Paper 2011/4, UNDP, http://hdr.undp.org/ [Date of entry: 15-08-2012].
[18] P. E. Ehrlich et al., *Securing natural capital and expanding equity to rescale civilization*, "Nature" 2012 Vol. 486, p. 69.
[19] Ibidem, s. 71.
[20] http://www.europarl.europa.eu [Date of entry: 10-09-2012].
[21] Bank Światowy, http://www.worldbank.org [Date of entry: 10-09-2012].
[22] Global Footprint Network, http://www.footprintnetwork.org [Date of entry: 10-09-2012].

substitutions between different forms of capital), whereas ecological footprint is an indicator of strong sustainability.

According to E. Neumayer sustainability indicators should not be combined with development indicators (for example, by modifying HDI) so as to create a single indicator. Instead, they should be used complementarily to assess whether the achieved level of human development is sustainable[23]. Comparing the value of HDI and real net savings of selected countries, it was found that in 1998 countries with low and medium levels of human development were particularly vulnerable to the potential lack of sustainability. This does not only mean that it is likely that they will not be able to achieve a greater level of social development, but also will not be able to maintain it in the future[24]. New research confirms this conclusion[25]. In 2007, the countries with a very high level of human development met the condition of weak sustainability (positive value of genuine savings), primarily because of high investment in manufactured and human capital. On the contrary, lack of weak sustainability was characteristic for countries with medium or low levels of social development, especially the ones dependent on the extraction of their natural resources. In addition, all countries with a very high level of development did not meet the condition of strong sustainability (a given country's ecological footprint indicator per capita is higher than the world average value of biocapacity per capita)[26].

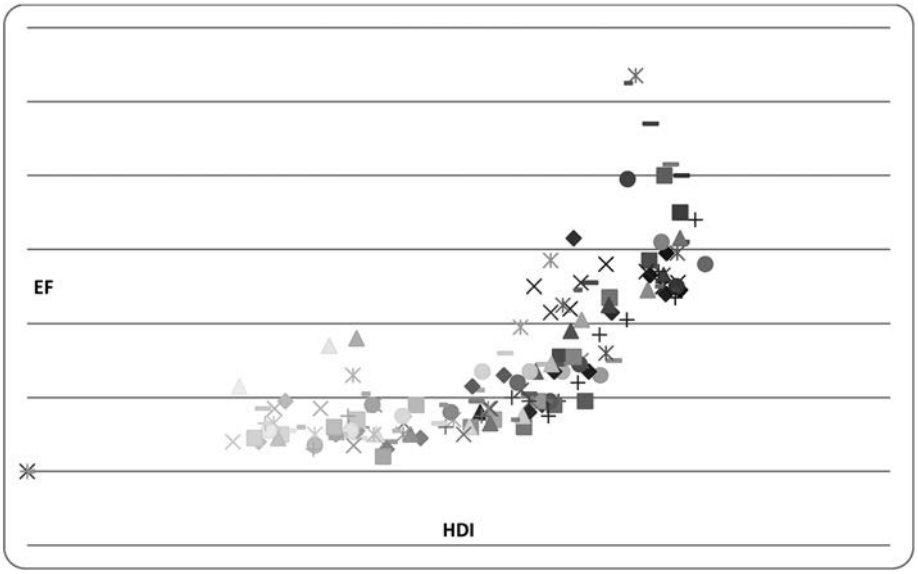
In another study, a clear correlation between the increase of HDI and the increase of pressure on the environment was found by analyzing changes in HDI indicators and ecological footprint in the years 1975 – 2003[27]. As a necessary (but not sufficient) condition of sustainability of certain countries HDI $\geqslant 0.8$ was adopted and the value of the ecological footprint to biocapacity ratio $\leqslant 1$. In 2003 out of 93 countries, only Cuba met both conditions.

Changes in the methodology of calculating HDI index[28] (since 2010) as well as new calculations of adjusted net savings (2009) and the Ecological Footprint (2007) provide an opportunity to reassess the sustainability of countries with different levels of development, as well as the relation between the indicators. Annex 1 shows the values of HDI, ANS (*adjusted net savings*), EF (*ecological footprint*) and the difference between the value of the ecological footprint of individual countries and the world average biocapacity per capita being equal to 1.8 of global hectares (EF-BC). Assessing the correlation between indicators a

[23] E. Neumayer, *The human development index and sustainability – a constructive proposal,* "Ecological Economics" 2001 Vol. 39, p. 102.
[24] Ibidem, p. 111.
[25] E. Neumayer, *Sustainability and Well-being Indicators*, UNU-WIDER Research Paper No. 2004/23, http://www.wider.unu.edu/ [Date of entry: 15-08-2012].
[26] E. Neumayer, Human Developement and Sustainability, Human Development Research Paper 2010/5, UNDP, http://hdr.undp.org/ [Date of entry: 15-08-2012], p. 13.
[27] D. Moran et al., *Measuring sustainable development – Nation by nation*, "Ecological Economics" 2008, Vol. 64, p. 470-474.
[28] http://hdr.undp.org/en/statistics/hdi [Date of entry: 15-08-2012].

Pearson's correlation coefficient was calculated which is 0,126 for HDI and ANS; 0,751 for HDI and EF. The values of HDI and EF are presented in Figure 1.

Figure. 1.Correlations between human development and pressures on the environment



Source: independent work based on: Program Narodów Zjednoczonych do spraw Rozwoju, http://hdrstats.undp.org/ [Date of entry: 15-08-2012].

It can be concluded that there is a strong correlation between the level of human development and environmental pressure measured with the ecological footprint indicator. This relation is (roughly) exponential – HDI index increments result in an increasing demand for environmental goods. Simultaneously, there is no correlation between human development and the value of ANS.

Assuming that the necessary condition for strong sustainability is a positive value of EF-BC, whereas the condition for weak sustainability is a positive value of ANS, it can be said that almost all the countries included in the group of very high and high levels of human development do not meet the condition of strong sustainability, i.e. the demand for environmental goods exceeds regenerative capacity of the environment. At the same time, most countries in the group of medium and low human development level meet the condition of strong sustainability. The argument that the condition of weak sustainability is not met mostly in countries with a low level of development has not been proven. It is worth to note that several countries (United States, Ireland, Greece, Portugal) from the group of a very high level of human development do not meet the condition of weak sustainability. Probably the cause is the global financial crisis causing a significant decline in savings and investment. It is worth noting that these

countries do not meet the condition of strong sustainability either. Among other countries which do not fulfill both criteria are: Saudi Arabia, Trinidad and Tobago, Russia, Kazakhstan and Oman. All of them are characterized by the dependence on the exploitation of natural resources.

Conclusion

The arbitrariness of the adopted indicators and their specific values is debatable, however, it clearly shows that progress in human development is made through greater use of natural resources, often greater than the ability of the environment to regenerate, thereby causing the degradation of the environment. The main challenge in the field of development policy is to break the relationship between the progress in human development and the use of the environment.

Two-sided nature of the relationship between human development and sustainability causes the need for these problems to be solved together. Actions directed exclusively on one of those areas may not be effective.

A promising direction of research would be the attempt to assess the correlation between the level of human development and the indicators used in the determination of the so-called *planetary bounderies*[29]. This will determine the extent to which human development of countries takes place within the so-called critical thresholds. Correlations in groups of countries with different levels of development may prove interesting.

[29] J. Foley, *Bilans zdrowia Ziemi*, „Świat Nauki" 2010, No. 5, p. 50-53.

Mieczysław Gruda • Mariola Kwasek • Włodzimierz Rembisz

MACROECONOMIC EVALUATION OF SUSTAINABILITY IN THE AGRICULTURAL SECTOR WITH USE THE STRUCTURAL EQUATIONS MODELING (SEM)

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MAKROEKONOMICZNA OCENA ZRÓWNOWAŻENIA SEKTORA ROLNICZEGO Z WYKORZYSTANIEM MODELOWANIA RÓWNAŃ STRUKTURALNYCH (SEM)

STRESZCZENIE: Modelowanie równań strukturalnych to klasa wielowymiarowych, parametrycznych modeli statystycznych pozwalających na testowanie hipotez badawczych o dużej złożoności relacji pomiędzy zmiennymi. Klasyczne zastosowania modelowania równań strukturalnych to (1) analiza ścieżek, która może być traktowana jak rozszerzenie analizy regresji o możliwość kształtowania relacji o dowolnym układzie zależności (możliwość łącznego ujmowania zależności dla wielu powiązanych równań regresji) lub (2) konfirmacyjna analiza czynnikowa (CFA – *confirmatory factor analysis*), która pozwala na kierowaną teorię analizy struktury relacji między wieloma zmiennymi. Modele SEM (*structural equations modeling*) w pracy wykorzystane są do opisu zależności między trzema makroagregatami, jakie występują w układzie zrównoważonym: zrównoważenie ekonomiczne, zrównoważenie środowiskowe i zrównoważenie społeczne.

SŁOWA KLUCZOWE: komputerowe wspomaganie decyzji, inżynieria środowiskowa, produkcja, ekonomika środowiska, sektor rolniczy, rolnictwo zrównoważone (sustainable agriculture), modelowanie równań strukturalnych, model rozwoju

Introduction

The study aims at determining the long-term relation between the agricultural sector and the national economy and the environment, i.e. the so called sustainable growth. The growth analysis was conducted on the basis of the Dynamic Sustainable Growth Model and the Structural Equations Modeling. Determination of the impact of factor groups: economic, environmental and social on the development of the agricultural sector (factor relations). Variant determination of the trajectory of the agricultural sector production process, gross added agriculture value (WDBR), food consumption, pace of changes of the environmental progress factor and the emission of pollution connected with food (*ex-ante*). Assessment of the degree of sustainability of the agricultural sector and environmental areas vs. the agricultural and environmental subsidies from the EU budget.

The Essence of Sustainable Growth

1. Constancy of needs satisfaction in inter-generational dimension.
2. Generational perception of the needs-satisfaction problem.
3. Environmental resources and values are of economical meaning (so called natural capital).

Fundamental Aims of Sustainable Growth

1. Inter-generational justice consists in aiming at reducing the developmental disproportions between rich and poor regions, as well as decreasing the developmental disproportions in a given country (aiming at satisfying the basic needs of the population (including needs connected with food).
2. Reducing income stratification within the population (GINI = 35; 2009).
3. Necessity to retain the natural capital for future generations by means of economical management of natural resources;
4. Recycling of resources and observing the traditional economic rationale of the economic growth.
5. Maintaining dynamic environmental balance.
6. Maintaining suitable proportion between the consumption and the investments (at macro level) and maintaining demographic constancy.

Aspects of Sustainable Growth

The sustainable growth category (constant growth) is nowadays an integral element of not only the environmental policy as well as social and economic policy but also different strategies of social and economic growth at particular stages of responsibility and management. Macroeconomic sustainability of the agricultural sector is important due to the following reasons:

- analysis of the flow of the economic surplus between agriculture and the other sectors of economy (problem connected with retransferring of the surplus);
- evaluation of the process of redistribution of income and relocation of resources by means of price diversification (price scissors), tax regulations and trade policy tools;
- request of macroeconomic environment impact on the agricultural and food sector (through the economic policy options, exchange rates and trade), as well as agricultural and food impact on macroeconomic environment.

Assessment of the sustainability of the agricultural sector

Sustainable Agriculture

1. Sustainable agriculture is an alternative concept for the intensive agricultural growth model, basing on performing all activities within agriculture taking into account welfare of the future generations. The principles of sustainable growth are examined in micro-scale (household) and macro-scale (country, region).
2. Sustainable agriculture is considered to be one that conjoins its production targets with environmental requirements (so called eco-growth), which requires significant state's interference with the economy. In such a case, the state's role should be increased with regard to its proprietary character towards environmental goods and natural resources. The state should coordinate the environmental activities in micro and macro terms.
3. It is becoming more and more common to think that it is not consumption and increasing economic development which is the substance of the new order and the foundation of the future but the quality of life with keeping the natural goods.
4. The scope of socially sustained agriculture encompasses, apart from the environmental factor, the economic and social factors which significantly influence the rate of sustainability in the agricultural sector.
5. Sustainable agriculture offers food produced with the use of minimum amounts of fertilizers and plant protection agents, and it is directed at such use of the earth resources which does not damage natural sources but allows satisfying the needs of next generations of producers and consumers[1].

The concept of the sustainable model of agricultural growth assumes collision-free fulfilment of various agricultural and non-agricultural functions by agriculture and rural areas. The following functions should be regarded as most important:

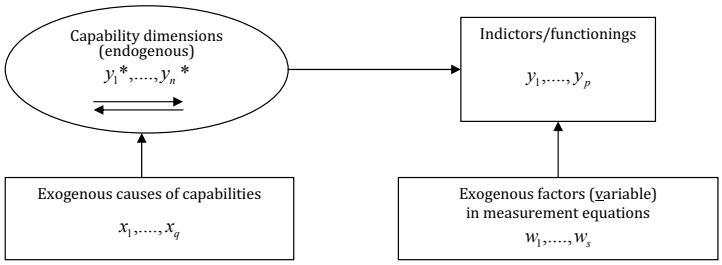
[1] J. Zegar, *Z badań nad rolnictwem społecznie zrównoważonym*, IERiGŻ PJB, Warszawa 2009.

1. Production of food and non-food products in a specified quality and quantity, guaranteeing food safety of farmers and consumers as well as ensuring well-being of the household animals.
2. Providing suitable standard of life to the inhabitants of rural areas.
3. Protecting natural environment in agricultural and rural areas.
4. Preserving and developing aesthetic and recreational values of rural areas.
5. Preserving the cultural heritage of the countryside.

Structual Equations Modeling

In general, the structure of the SEM can be presented as follows:

Figure 1
General structure theoretical framework of the SEM model



Structural Equations Modeling is a class of multi-dimensional and parametrical static models enabling testing of research hypotheses having a significant possibility to reach complexity of relations between the variables. The strengths of the model approach are as follows:

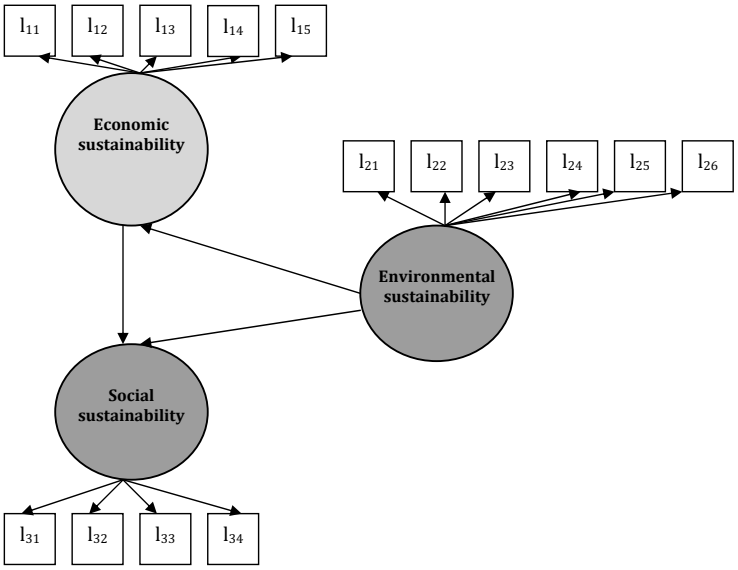
- possibilities to freely reflect the paths of dependencies between the variables,
- possibility to reflect the theoretical construct as a delayed variable.

Classic application of the structural modeling includes:

- Analysis of paths which can be treated as extension of the regression analysis with the possibility to shape the relations in chosen possibility pattern (possibility to jointly find matches for many correlated regression equations),
- **Confirmatory Factor Analysis (CFA)** which allows directing the analysis of relation structure between many variables.

The following variables were accepted during the study of economic sustainability: Gross Added Value of Agriculture (in milliards of PLN), agricultural income (in PLN per household), possibility of export (in %), heath expenditure (in millions of PLN) and charges for using the environment (in millions of PLN). In Table 1 there is presented the rate of sustainability of the agricultural sector according to 16 voivodships in Poland with economic factors describing them.

Figure 2
Factor structure of the Structural Equation Model



Source: Own study.

The following variables were accepted during the study of environmental sustainability: (1) areas protected by law (% of the area in general), (2) use of pollution (% of the population in general), (3) emission of CO_2 (in tonnes per 1 inhabitant), (4) use of water in agriculture (in millions of m^3), (5) balance of the used nitrogen (in kg N/ha) and (6) household animals stock (per 100 arable plots). In Table 2 there is presented the rate of sustainability of the agricultural sector according to 16 voivodships in Poland with the environmental factors describing them.

The following variables were accepted during the study of social sustainability: (1) employed in agriculture (in thousands of AWU), (2) working occasionally and as hired workers (in thousands of AWU), (3) social work efficiency (in thousands of PLN) and (4) private property in the sector (in %). In Table 3 there is presented the rate of sustainability of the agricultural sector according to 16 provinces in Poland with the social factors describing them.

Figure 3 presents the average rate of development of the examined entities (provinces) in Poland per capita from 2007-2010. The highest rate of economic growth can be observed in the following voivodships: Mazowieckie, Dolnośląskie, Wielkopolskie and Śląskie. Whereas, the highest dynamics of the GDP growth per capita (in economy) occurs in Świętokrzyskie, Małopolskie, Łódzkie and Opolskie. On the other hand, the agricultural sector has the largest growth potential (the Gross Added Value of Agriculture – milliards of PLN – and agricul-

Table 1.
Level of Sustainability of the Agricultural Sector in Poland According to Voivodships – Economic Factors

Specification	Gross Added Value of Agriculture (milliards PLN)	Agricultural income per household (PLN)	Possibility of export (PL = 100)	Health expenditure (millions PLN)	Charges for using the environment (millions PLN)
	2008	2007-2009	2007	2011	2009
	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}
1.Dolnośląskie	1.666	23 970	8.9	4 403	157.3
2. Kujawsko-Pomorskie	2.713	41 398	4.8	3 067	99.4
3. Lubelskie	2.923	18 181	2.5	3 237	67.1
4. Lubuskie	0.903	24 410	3.8	1 478	34.3
5. Łódzkie	3.876	24 109	4.3	3 956	204.3
6. Małopolskie	2.129	31 729	4.8	4 747	147.8
7. Mazowieckie	8.617	53 596	18.2	8 923	240.8
8. Opolskie	1.107	15 928	2.0	1 448	63.1
9. Podkarpackie	1.246	18 570	4.0	2 974	52.1
10. Podlaskie	2.438	15 164	1.3	1 746	26.6
11. Pomorskie	1.540	10 742	7.7	3 378	106.8
12. Śląskie	1.491	22 221	16.2	7 121	378.1
13. Świętokrzyskie	1.596	23 786	1.0	1 941	59.1
14. Warmińsko-Mazurskie	2.045	14 264	2.0	2 022	42.1
15. Wielkopolskie	5.316	76 487	11.7	4 986	165.0
16. Zachodniopomorskie	1.609	11 233	6.0	2 553	100.3
POLAND	41.215	31 378	347.6 mld	68 100	1 944

Source: Prepared on the basis of: *Environmental Protection. Environment 2011*, GUS, Warsaw 2011; *Agricultural Statistical Yearbook from 2010*, GUS, Warsaw 2011; *Poland Report 2011*: *Economy – Society – Regions*, MRR 2011].

Table 2.
Level of Sustainability of the Agricultural Sector in Poland According to Voivodships – Environmental Factors

Specification	Areas protected by law % of area in general	Use of pollution % of population in general	Emission of CO_2 per inhabitant (tonnes)	Use of water in agriculture (millions of m_3)	Balance of the used nitrogen (kg N/ha)	Animal stock per 100 arable plots LU/ UAA
	2007	2007	2009	2008	Average from 2007-2010	2009
	x_{21}	x_{22}	x_{23}	x_{24}	x_{25}	x_{26}
1.Dolnośląskie	18.2	77.1	7.1	184.7	78.1	0,25
2. Kujawsko-Pomorskie	31.3	70.8	4.1	52.1	85.3	1.00
3. Lubelskie	22.7	53.7	4.9	168.0	65.6	0.49
4. Lubuskie	38.9	68.4	2.1	40.0	61.5	0.28
5. Łódzkie	18.8	66.2	6.4	75.1	72.1	0.85
6. Małopolskie	52.1	55.9	19.2	76.5	71.8	0.59
7. Mazowieckie	29.7	53.2	9.3	89.9	71.1	0.79
8. Opolskie	27.3	65.8	5.7	32.0	95.8	0.56
9. Podkarpackie	44.5	64.1	7.0	59.4	64.6	0.39
10. Podlaskie	32.0	63.3	1.5	21.2	86.8	1.20
11. Pomorskie	32.7	80.5	3.8	9.0	74.2	0.62
12. Śląskie	22.1	72.0	44.0	74.4	75.8	0.57
13. Świętokrzyskie	64.6	49.5	5.2	75.0	67.2	0.60
14. Warmińsko-Mazurskie	46.5	72.1	1.3	46.3	82.2	0.79
15. Wielkopolskie	31.8	63.0	7.3	115.5	86.2	1.22
16. Zachodnio-Pomorskie	21.1	79.7	2.3	34.2	68.5	0.24
POLANG	28.1	65.2	8.2	1 153.3	75.9	0.72

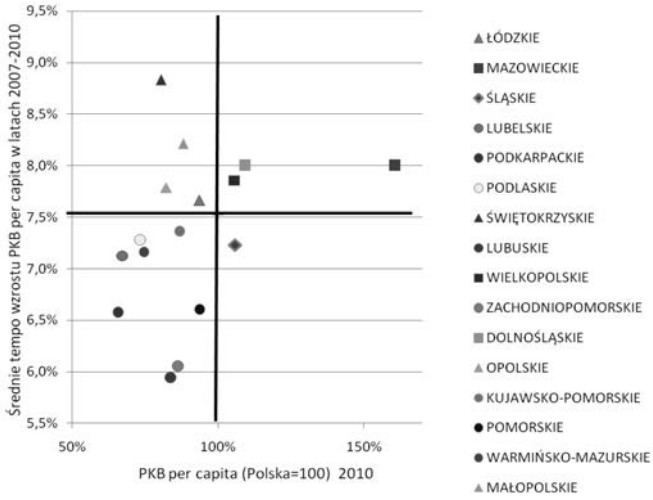
LU – Livestock Unit; UAA – Utilized Agricultural Area
Source: Ibidem.

Table 3.
Rate of Sustainability of the Agricultural Sector in Poland According to Voivodships – Social Factors

Specification	Working in agriculture (thousands of AWU)	Occasional and hired workers in agriculture (thousands AWU)	Social work Efficiency (thousands of PLN)	Private property in the sector (in %)
	2009			
	X_{31}	x_{32}	x_{33}	x_{34}
1. Dolnośląskie	86.5	4.5	19.260	77.9
2. Kujawsko-Pomorskie	106.6	7.1	25.450	90.7
3. Lubelskie	282.1	9.5	10.362	96.6
4. Lubuskie	28.7	2.0	31.463	81.2
5. Łódzkie	192.8	8.1	20.104	97.7
6. Małopolskie	252.7	2.4	8.425	97.0
7. Mazowieckie	351.0	18.3	24.550	98.2
8. Opolskie	48.7	0.9	22.731	74.2
9. Podkarpackie	219.1	2.1	5.687	94.7
10. Podlaskie	117.8	2.0	20.697	97.9
11. Pomorskie	62.2	4.6	24.759	81.1
12. Śląskie	95.1	1.7	15.678	90.9
13. Świętokrzyskie	138.4	3.8	11.532	97.4
14. Warmińsko-Mazurskie	66.2	5.2	30.891	85.0
15. Wielkopolskie	208.2	11.6	25.533	85.6
16. Zachodnio-Pomorskie	43.3	4.2	37.160	70.2
POLAND	2 299.3	88.1	17.925	89.7

AWU – Annual Work Unit
Source: Ibidem.

Figure 3
GDB growth and its rate per capita in the voivodships in 2007-2010



Source: Own study.

tural income – PLN per household) in Mazowsze (PLN 8.6 mld, PLN 53.6 k) and Wielkopolska (PLN 5.3 mld, PLN 76.5 k).

Agricultural and environmental support in Poland compared with EU-27

Agricultural and environmental programmes are important instruments of promoting sustainable agriculture and rural areas. The basic aim of the agricultural and environmental programmes is the promotion of environmentally-friendly agricultural production systems and protection of natural and cultural values of rural areas.

Agricultural and environmental activities are related to the following subjects: (1) protection or enhancing biological bio-diversity of farmland, (2) protection of household animal breeds and diversity of the grown plants, (3) protection of water and soil quality, (4) protection and improvement of water resources and (5) preserving and improvement of rural areas. In Table 4 there are presented agricultural and environmental subsidies in Poland compared with the EU Member States (EU-27).

In the two financial periods, EU 2004-2006 and 2007-2013, the Polish agriculture used limited financial support. The average direct subsidies (Table 4) per household in Poland were almost 4 times lower than their average amounts

Table 4.
Agricultural and Environmental Support in Poland and EU-27 – in EUR in 2007

Specification	Subsidy per household	Subsidy per hectare of arable plot	Subsidy per EUR 1000 of production	Subsidy per 1 ESU of agricultural growth	Amount of agricultural and environmental support per annum	Agriculture and Environment/Gross Added Value of Agriculture ratio [%]
Polska	228	13.57	8.34	24.00	250.5 mln	0.82
UE-27	844	27.68	19.97	29.62	4.319 mld	2.76
Max[a)]	8303 (LU)	197.6 (AT)	82.4 (IRL)	199.9 (AT)	x	x

[a)] the highest value for a given country in a selected group of EU economy: LU (Luxembourg), AT (Austria), IRL (Iralndia).

Source: Prepared by the Author on the basis of the data from FADN Poland and the European Union.

in the EU-27. In relation to 1 ha, the direct subsidies were 2 times lower and in relation to the produced agricultural income they were almost at the same level. On the contrary, the agricultural and environmental expenditure in Poland was, on average, three times lower than in the EU-27. In 2007, Poland used 5.8% of the EU expenditure allocated to environmental activities.

Research method and results

To study the development of the agriculture sector was used macroeconomic dynamic model in conjunction with natural resources and environmental resources in the form of:

$$G(Q, W, A, R, N, t), \quad (1)$$

where:
Q – production of goods, W – waste production, A – expenditure, R – natural resources, t – time.

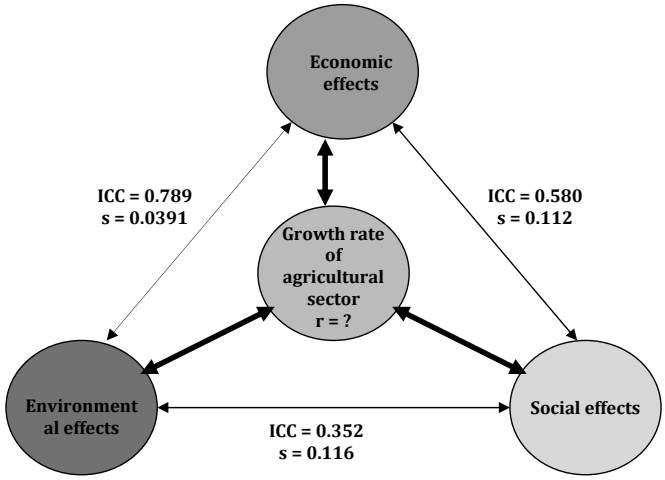
The function of production with technological transformation (recycling and optimizing) is usually presented as follows:

$$F(A,R,t) = T\text{-}1(\min \{T(G(A,R,t), a(t)*R\},t), \quad (2)$$

where:
T – technological transformation, A – expenditure.
$0 < a(t) \leqslant 1$ coefficient of technological effectiveness.

For the assessment of the sustainability of the agricultural sector in the form of three data groups describing the status of the sustainability in the agricultural sector there was used the statistical package for construction and analysis of structural equations and for estimation of the description of statistical dependencies – Lisrel 8.8 (Linear Structural Relationship).

Figure 4.
Correlation between the Environment, Economic and Social Effects and the Growth of the Sustainable Agricultural Sector in Poland (ICC – interclass correlations, s – standard error of the estimation)



Source: Prepared by the Author.

Table 5.
Structural Parameters of Group Variables of the Sustainability Model

Hypotheses		Estimated parameters	Average from subtrial	Standard error	t-Statistic
Environmental sustainability →	Economic sustainability	0.789	0.8036	0.0391	20.4321
Economic sustainability →	Social sustainability	0.580	0.5803	0.1121	5.1652
Environmental sustainability →	Social sustainability	0.352	0.354	0.116	3.043

Source: Author's calculations on the basis of data from Central Statistical Office (GUS) and FADN.

Table 6.
Correlation of Hidden Variables

Specification	Economic sustainability	Environmental sustainability	Social sustainability
Economic sustainability	1.00	x	x
Environmental sustainability	0.80	1.00	x
Social sustainability	0.86	0.82	1.00

Source: Author's calculations, Lisrel 8.8.

Table 7.
Statistical Elements of the Model

Specification	Variables	Estimated parameters	Average from subtrial	Standard error	t-Statistic
Economic sustainability	l_{11} l_{12} l_{13} l_{14} l_{15}	0.2836 0.2431 0.2603 0.2863 0.1252	0.2833	0.0092	30.9389
Environmental sustainability	l_{21} l_{22} l_{23} l_{24} l_{25} l_{26}	0.4810 0.4452 0.3029 0.1432 0.3245 0.1872	0.476	0.0384	12.531
Social sustainability	l_{31} l_{32} l_{33} l_{34}	0.3264 0.2749 0.2837 0.2587	0.324	0.0197	16.544

Source: Author's calculations, Lisrel 8.8.

Table 8.
Structural Parameters of the Model

Hypotheses		Estimated parameters	Average from subtrial	Standard error	t-Statistic
Environmental sustainability →	Economic sustainability	0.800	0.804	0.030	20.43
Economic sustainability →	Social sustainability	0.580	0.585	0.112	5.165
Environmental sustainability →	Social sustainability	0.350	0.352	0.116	3.043

Source: Author's calculations, Lisrel 8.8.

Conclusion

In many developed countries within the EU there is currently implemented the stage of the so called sustainable agricultural and rural areas growth. The study of the rate of sustainability is analysed both in terms of a household (micro-approach) and in macroeconomic terms. Nowadays, the assessment of the agricultural sustainability at the household level is necessary, and in particular as a response to the demand of the agricultural, economic or social practices.

At present, the key issues to be solved are related to the macroeconomic assessment at the level of agricultural and environmental sector. The key approaches to the sustainability assessment are (1) scope of the definition of sustainability agriculture and (2) selection of diagnostic (model) tools. The largest

difficulties include the selection of parameters, their number, reciprocal relations, normalisation of indicators, setting minimum and maximum thresholds, objectivity when grading the assessment and changing the indicator measurement to synthetic measurement units. The Lisrel 8.8 package was used for structural equations modeling. It is a good tool to use in structural modeling, similarly as the SPSS & AMOS package. For the assessment of macroeconomic degree of sustainability there are used, *inter alia*, such indicators as ICC (intercorrelational), factor estimation parameters and analysis of the set paths on the basis of regression equations. The following results were obtained for more important obtained inter-correlations: (1) economic vs. environmental effects at the level of 0.789, (2) economic vs. social effects at 0.580, (3) environmental vs. social effects at 0.353. The statistical results included in Table 5 enable verification of hypotheses of structural parameters of the model representing strength of the inter-correlation between the leading effects.

The utilised developmental models for the agricultural sector (data from 2000-2010) make it possible to estimate the important developmental indicators for the agricultural sector. It is estimated that the agricultural production will increase at the average level of 1.2% per annum, the Gross Added Value of Agriculture at 1.8% and the demand for food at 1.5%[2].

There have been obtained average forecasts regarding the sustainable growth of the agricultural sector until 2020 in two variants: moderate and optimistic. The Gross Added Value of Agriculture is to increase at the level of 1.84 and 4.1 per cent, the demand for food at 1.50 and 3.90 per cent, the environmental progress at -0.52 and 4.4 per cent and gaining pollution (waste per inhabitant) at 1.06 and 3.1 per cent annually. The presented statistical instruments for the assessment of the sustainability in the agricultural sector make it possible to obtain interesting practical results.

[2] M. Gruda, M. Kwasek, *Dynamic Macroeconomic Modeling vs. the Sustainable Development of Agricultural Sector in Poland*. VI Conference Professor Aleksander Zelias on Modeling and Forecasting of Socio-Economic Phenomena. Zakopane 15-18 May 2012.

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