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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 JEZIORNICH 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, że niewielka 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 services¹. 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 service³, 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

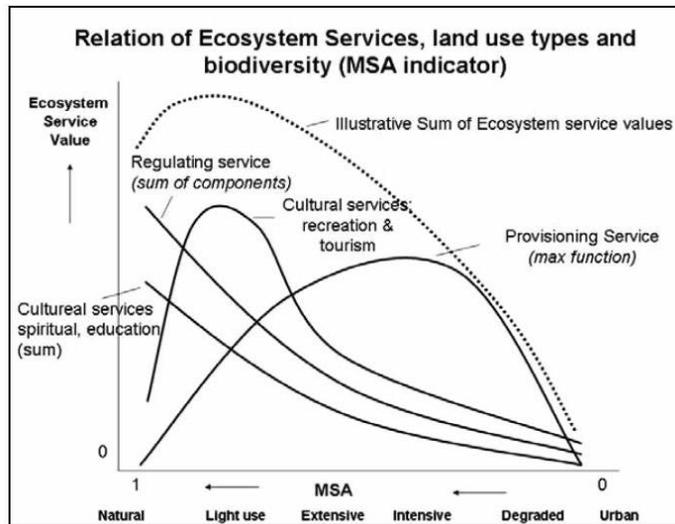
The research concerning changes in the levels of services, which are consequences of human pressure proves to be multi-level and extremely difficult. It demands a long cycle of observations, field measurements and good knowledge concerning the functioning of lake ecosystems. It was crucially important 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 recreation⁴. 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 area⁵. 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. Jękatyrczyk-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 coastline⁶.

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 Assessment⁷. 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 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.

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 than 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

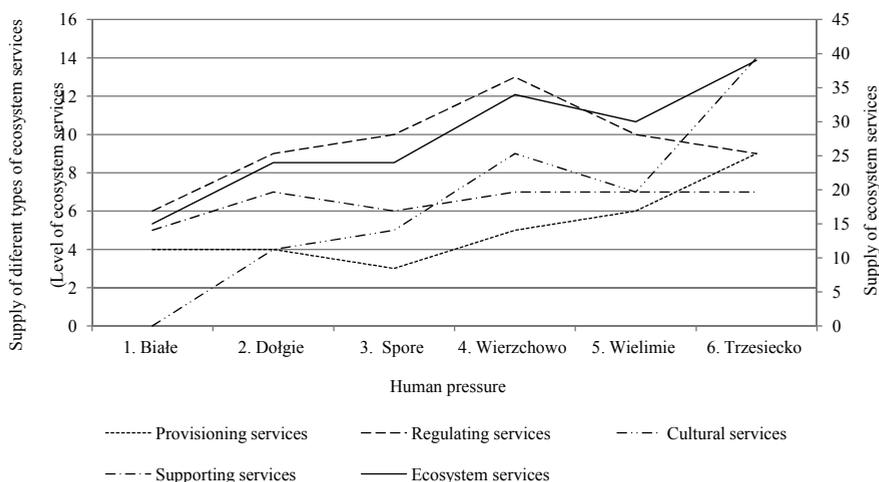
The research has shown that there is a relation between the level of human pressure and the range and intensity of services provided by lake ecosystems. Cultural services is the field in which it is possible to observe the biggest relation between the level of ecosystem change and quality and quantity 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.

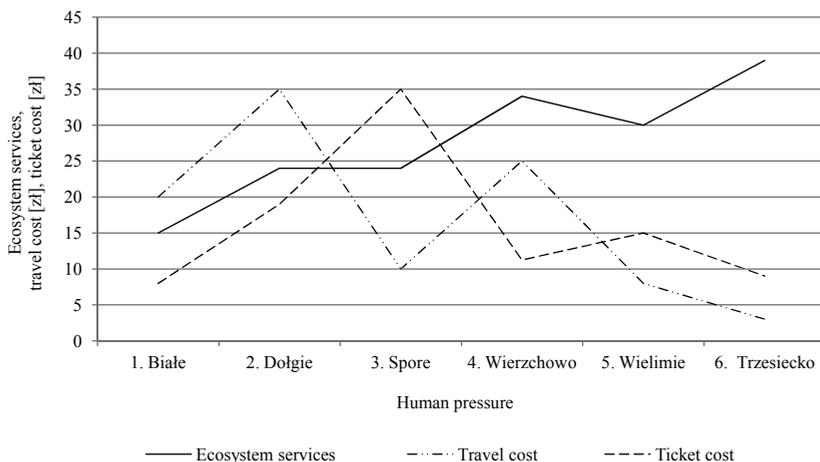
On the basis of the research, it has been stated that at the initial stage, the pressure increases the supply of services. The number of people using the ecosystem increases, and it becomes a subject of research interest, inspiration for artists, or a place for field classes. Together with the increasing 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 Trzeciecko 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 coefficient	
	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 if it 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.