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ECOSYSTEM SERVICES AS A FACTOR STRENGTHENING REGIONAL DEVELOPMENT TRAJECTORY

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ŚWIADCZENIA EKOSYSTEMOWE JAKO CZYNNIK WZMACNIANIA TRAJEKTORII ROZWOJU REGIONU

STRESZCZENIE: Koncepcja świadczeń ekosystemowych i krajobrazowych jest obecnie szeroko dyskutowana w literaturze i ciągle pojawiają się mniej lub bardziej udane próby uwzględnienia koncepcji w działaniach praktycznych. Niestety wokół tego podejścia badawczego narosło wiele niejasności i nieporozumień, czego efektem jest między innymi nieporównywalność proponowanych rozwiązań i raczej tylko postulatywny charakter planowania rozwoju regionów oparty na świadczeniach ekosystemowych. Celem artykułu jest próba odpowiedzi na kilka podstawowych pytań dotyczących istoty świadczeń ekosystemów w kontekście aplikacyjnym.

SŁOWA KLUCZOWE: świadczenia ekosystemów, rozwój regionalny

Introduction

In regional development, the natural environment is increasingly being perceived as a factor capable of generating development trajectories. These trajectories may locally become dense, forming so-called attractors occupying a region referred to as the basin of attraction, which determines, among others, the viscosity of the region. One way to identify and then appraise the value of environmental potential that can influence the direction of development of regions is by analysing ecosystem services. They fit with the latest concepts of environmental management and environmental economics.

The concept of ecosystem and landscape services is currently being widely discussed in the literature, with repeated attempts, more or less successful, to incorporate this concept in practical action. Regrettably, this approach has accumulated a good deal of obscurity and misunderstanding, one of the consequences being the existence of non-comparable solutions and some wishful thinking, as opposed to detailed plans, in the planning of regional development based on ecosystem services.

The present article sets out to address several basic questions regarding the essence of the applicative dimension of ecosystem and landscape services in the local scale.

Theoretical foundations of modelling of reality vs. environmental resources

Spatial econometric models have been used with considerable success in the work on regional analyses[1]. These models more and more often incorporate the value of environmental resources[2]. Reality modelling is very often founded on the theory of chaos and based on non-linear system dynamics. It originated within the natural sciences, where it was observed that many interrelated elements influence the outcome of natural processes under investigation. Computer simulations have similarly shown that identical data input to the same system of equations may generate different results even with small changes of the degree of freedom. Thus, such procedures are founded on the theory of deterministic

[1] W. Ratajczak, *Modele ekonometrii przestrzennej w analizie regionalnej*, in: T. Stryjakiewicz, T. Czyż (eds.), *O nowy kształt badań regionalnych w geografii i gospodarce przestrzennej*, „Biuletyn Komitetu Przestrzennego Zagospodarowania Kraju Polskiej Akademii Nauk" 2008 no. 237, p. 186-202.

[2] M. Degórski, *Quality of life and ecosystem services in rural-urban regions. Europa XXI*, Warszawa 2012, p. 137-148.

chaos, which defines a property of equations or systems of equations consisting in high sensitivity of the solutions to an infinitesimally small disturbance of the parameters describing dynamic systems. Thus, small differences in input data generate a different series of solutions to non-linear equations. This property of non-linear equations exposes the sensitivity of final results to very small differences in initial conditions given a sufficient period, referred to as characteristic time. Thus, the amplification of minor changes of the initial conditions over a sufficiently long time may generate diametrically different outcomes[3]. In line with this assumption, it can be assumed that environmental resources as a significant element of sustainable development, barring substantial differences between socio-economic determinants, may or may not exert the same influence on regional development. Many researchers have also observed that predictions regarding unstable systems in time will not easily produce reliable results[4]. Nonetheless, searching for attractors is an important research direction in many fields of science. An attractor is a hidden, barely perceptible, ordering of a process. If an attractor is known, predictions can be made and the course of processes can be influenced, including the development of regions or supraregional units.

Assuming, in line with the premises of Lorenz's model[5], an emerging order, where a non-measurable and non-linear reality becomes comprehensible, it has to be stated that the direction of regional development becomes predictable too. Chaos transforms into order not only as described by the attractors of Lorenz or Henon, but also as described by strange attractors, such as solions, bifurcations or fractals, which can be regarded as mathematical models of the creation of order in nature.

Domański[6] notes that the identification of attractors and their properties is a difficult mathematical problem. The difficulty stems from the non-linearity of systems of equations describing the behaviour of dynamic systems. For such systems, it is difficult to analytically introduce the properties of equilibrium systems. A characteristic trait of non-linear systems is the presence of simultaneous attractors[7]. Depending on the initial conditions and at given parameter values,

[3] R. Domański, *Przyczynek do modelowania rozwoju zrównoważonego w długim okresie*, in: T. Stryjakiewicz, T. Czyż (eds.), *O nowy kształt badań regionalnych w geografii i gospodarce przestrzennej*, „Biuletyn Komitetu Przestrzennego Zagospodarowania Kraju Polskiej Akademii Nauk" 2008 no. 237, p. 203-224; M. Degórski, *Wielofunkcyjność przestrzeni przyrodniczej szansą zwiększenia potencjału rozwoju regionów poprzez grawitację atraktorów i wzrost lepkości*, in: Z. Strzelecki, P. Legutko-Kobus (eds.), *Oblicza współczesnego kryzysu a polskie regiony*, Warszawa 2010, p. 280-287.

[4] K. Życzkowski, A. Łoziński, *Chaos, fraktale oraz euroatraktor*, „Foton 80" 2003, p. 4-9.

[5] M. Waszczyk, *Wpływ teorii chaosu na niektóre tradycyjne stanowiska ontologiczne oraz na spór o redukcjonizm*, „Zeszyty Naukowe Politechniki Gdańskiej. Filozofia VI" 2002 no. 589, p. 1-15.

[6] R. Domański, *Przyczynek do modelowania rozwoju zrównoważonego w długim okresie*, in: T. Stryjakiewicz, T. Czyż (eds.), *O nowy kształt badań regionalnych w geografii i gospodarce przestrzennej*, „Biuletyn Komitetu Przestrzennego Zagospodarowania Kraju Polskiej Akademii Nauk" 2008 no. 237, p. 203-224.

[7] T. Kapitaniak, *Niestabilne jak wahadło*, "Academia" 2006 no. 3(7), p. 109-114; R. Domański, op. cit.; M. Degórski, *Are environment conditions among factors behind new spatial pattern*, in:

a non-linear system may evolve towards different attractors. One parameter of importance for regional development comprises determinants related to environmental potential8 and social potential [Degórski 2012], construed as a generator of development, as well as those related to the system's resilience to external factors, such as those related to climatic change. This type of modelling is an ideal setting for the conception of ecosystem and landscape services. However, one methodological problem arises, namely, that there is no unity in the understanding and definition of ecosystem services as they are a conceptual entity.

The nature of ecosystem and landscape services

Even a brief review of the classic literature of the subject will reveal considerable chaos and variation in the scope of the concept of ecosystem services (Table 1).

As can be seen from the above listing of definitions, the term "ecosystem services" may refer to just about anything: from the physical goods produced by ecosystems, to components of nature or functions, conditions and processes, to the productive capacity of ecosystems. Against this background, the very general definitions proposed by TEEB, MEA and MAES seem to hold considerable promise, but do so only at first glance. According to these definitions, ecosystem services comprise everything of benefit to humans. It should be stressed at this point that such broad definitions allow for wholly subjective approaches to the issue and actually only make the identification and valuing of services more difficult.

In the light of our experiences to date, a sensible and effective application of the conception of ecosystem services to practical action and the comparability of the solutions suggested requires a sequence of at least four steps:

- providing much more precise definitions for individual terms and concepts;
- introducing appropriate procedures for the identification of services in specific areas and ecosystems;
- introducing appropriate standardised measures of services; and
- linking individual measures to practical activities, especially in the area of spatial planning.

With this approach, economic appraisal (valuing) is secondary to and entails directly from the adopted measures and indices defining the supply of and demand for ecosystem services.

A. Kovacs (ed.), *Old and new borderlines – frontiers – margins, Discussion Papers, Special Issue*, Pecs 2009, p. 29-39.

[8] J. Glasson*, Socio-economic impacts*, in: *Socio-economic impact assessment (SIA)*, London, New York, 2000, p. 20-41; P. Morris, R. Therivel, *Methods of environmental impact assessment*, London, New York 2000; B. Degórska, M. Degórski, *The environmental dimension of European space according to the concept of trajectory*, *Europa XXI*, Warszawa 2003, p. 37-44.

Table 1
Different conceptualisations of ecosystem services

Ecosystem services – definition	Ecosystem attribute	Social perspective
The capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly[a]	the **capacity** … to provide goods and services	to satisfy human needs
The set of ecosystem functions that is useful to humans[b]	set of **functions**	useful to humans
Conditions and processes through which ecosystems and species sustain and fulfill human life[c]	**conditions** and **processes**	to sustain and fulfill human life
A collective term for the goods and services produced by ecosystems that benefit humankind[d]	**goods and services** produced	benefit humankind
Components of nature, directly enjoyed, consumed or used yield human well-being[e]	**components** of nature	enjoyed, consumed or used for human well-being
The direct and indirect contributions of ecosystems to human well-being[f]	**ecosystems**	contributions to human well-being
The benefits that people obtain from ecosystems[g]	**ecosystems**	benefits to people

[a] C. Kremen, Managing ecosystem services: what do we need to know about their ecology?, "Ecology Letters" 2005 no. 8, p. 468-479.
[b] G.C. Daily (ed.), *Nature's services: societal dependence on natural ecosystems*, Washington D.C. 1997.
[c] W.A. Jenkins, B.C. Murray, R.A. Kramer, S.P. Faulkner, *Valuing eco-system services from wetlands restoration in the Mississippi Alluvial Valley*, "Ecological Economics" 2010 no. 69, p. 1051-1061.
[d] J. Boyd, p. Banzhaf, *What are ecosystem services? The need for standardized environmental accounting units*, "Ecological Economics" 2007 no. 63, p. 616-626.
[e] TEEB,*The economics of ecosystems and biodiversity*. *Mainstreaming the economics of nature: a synthesis of the approach*, conclusions and recommendations of TEEB, 2010; MAES, *Mapping and assessment of ecosystems and their services*. An analytical framework for ecosystem assessments under Action 5 of the EU Biodiversity Strategy to 2020. Discussion paper – Final, European Union 2013.
[f] MEA, *Millennium ecosystem assessment, Ecosystems and human well-being*, Summary for decision makers, Washington D.C. 2005; TEEB,*The economics of ecosystems…*, op. cit.; *Mapping and assessment…*, op. cit.

Source: authors' own compilation based on different sources.

The above postulates are consistent with the list of tasks named by de Groot et al.[9], who state that the integration of ecosystem services into landscape planning, management and decision-making requires a detailed investigation of the following topics:

- Understanding and quantifying how ecosystems provide services
- Valuing ecosystem services
- Use of ecosystem services in trade-off analysis and decision making
- Use of ecosystem services in Planning and Management
- Financing sustainable use of ecosystem services.

[9] R. S. de Groot et al., *Challenges in integrating the concept of ecosystem services and values in landscape planning, management and decision making*, "Ecological Complexity" 2010 no. 7, p. 260-272.

The quest for appropriate methodology

In the light of our experience to date, it appears clear that the methodologies employed for identifying ecosystem services and then for determining their resources and value should match particular spatial scales and analytical objectives. Methodologies based mainly on assessing the value of biodiversity (TEEB) or aiming to produce all-European comparison maps (MAES) are of no use for analyses of individual administrative districts (Table 2). Furthermore, if automatically applied for regional and local spatial planning purposes, they may clearly do more harm than good.

Table 2
Place and role of ecosystem services in planning development

Scale	Importance of ecosystem services	Detail level	Place of ecosystem services	Methodological platforms for evaluation
Household	no	no	no	no
Local (e.g. village)	medium	high	landscape gardening, planning of activities	lack of general approach
Subregional (e.g. commune)	high	high	spatial planning, planning of activities	lack of general approach
Regional (e.g. province)	medium	medium	spatial planning	MAES (doubtful)
National	low	low	strategies, programs, politics	TEEB, MAES
International	low	low	strategies, programs, politics	TEEB, MAES

Source: authors' own compilation based on different sources.

Of particular importance for practical applications, especially at the level of regional and subregional analyses, is conceptual precision and identification of the spatial extension of validity of individual concepts. In particular, the following should be determined:

(a) The provider of service – is it a specific narrowly-defined ecosystem, an ecosystem type not tied to a specific spatial location, a demarcated fragment of the Earth's surface that supports a diversity of ecosystems, or, finally, "nature" in general, whose territorial extension cannot be specified unambiguously;
(b) The natural resource (that is, an existing resource/state of the service provider) and its resultant natural potential (defining the service-providing capacity, which is determined not only by resource size, but also by other factors, such as ease of access). It is the potential rather than the resource that influences the potential and actual supply of ecosystem services.

Table 3
Sample detailed indices of selected ecosystem services

Ecosystem Service	Category of ecosystem service	Indicator		Type of indicator		Service provider (reference unit)
		name	formula / unit	direct / indirect	supply / flow / demand	
Timber	provisioning	standing timber stock	[m^3] or [m^3/ha]	indirect	potential supply	forest district
Timber	provisioning	sales of timber by auction	[m^3] or [m^3/ha]	direct	flow	forest district
Mushrooms	provisioning	area of mixed and coniferous forests	[ha]	indirect	potential supply	ecosystem
Mushrooms	provisioning	mushrooms gathered at, delivery points	[Ton]	indirect	flow	village
Game	provisioning	population of wild game	[piece]	indirect	potential supply	hunting circuit
Game	provisioning	number of hunting permits	[piece]	indirect	demand	hunting circuit
Game	provisioning	game weight	[Kg]	direct	flow	hunting circuit
Cereal production	provisioning	sown area (with respect to soil class)	[sum (soil class * area)]	indirect	potential supply	municipality, village or single field
Cereal production	provisioning	cereal yields	[ton] or [ton/ha]	direct	flow	municipality, village or single field
Honey	provisioning	number of hives	[piece]	indirect	supply / flow	municipality or village
Water supply	provisioning	the number of intakes in lakes and rivers	[piece]	indirect	supply	municipality or village
Water supply	provisioning	number of groundwater intakes	[piece]	indirect	supply	municipality or village

Water supply	provisioning	the amount of water taken from lakes and rivers	[m^3/year]	direct	flow	municipality or village
Water supply	provisioning	the amount of water abstracted from groundwater	[m^3/year]	direct	flow	municipality or village
Water supply	provisioning	number of operated wells	[piece]	indirect	flow	municipality or village
Parasites and pathogens	regulating	share of linear and other small habitats	[% of area] or [km^2/km^2]	indirect	flow	landscape
Pollination	regulating	share of habitats good for pollinators	[% of area] or [km^2/km^2]	indirect	flow	landscape
Water quality	regulating	chemical composition at the outlet of the catchment		direct	flow	catchment
Water quality	regulating	land cover pattern in the catchment		indirect	flow	catchment
Biodiversity	supporting	number of plant species		indirect	flow	ecosystem
Biodiversity	supporting	field fragmentation/ length of field margins		indirect	flow	landscape
Biodiversity	supporting	number of nests of white storks		indirect	flow	landscape
Biodiversity	supporting	conservation status of habitats N2000		indirect	flow	ecosystem

Source: authors' own compilation based on different sources.

(c) The potential and actual supply of services, which depends not only on the potential, but also on the needs and other conditions, including formal and legal ones. The separation of these categories is important insofar as the size of each of them can be determined using different indices (direct and surrogate) that are not wholly mutually exchangeable;
(d) The recipient of services (an individual or a social group), the demand for services, the preferences and needs hierarchy.

Only such defined conceptual framework will make it possible to unambiguously specify the size of services actually provided (as relations/ transactions between the provider and the recipient).

Only within relations so defined is it possible to juxtapose the measures and indices relating to the quantity of services available. It is also important to distinguish indices of supply and demand and direct vs. indirect indices, as exemplified in table 3.

Service-related information as a tool supporting regional development

Appropriately collected and processed information on ecosystem services can be used to strengthen the trajectory of regional development. Importantly, it is not service resources as such, but service-related information and ideas on how to utilise these resources that is conducive to development. Otherwise, the state of the natural environment (including potential ecosystem services) may be seen as a barrier to development, examples of which can often be witnessed, especially in areas occupied by national parks and large-area refuges within the Natura 2000 network.

Any deliberations and plans for the utilisation and amplification of the supply of ecosystem services should, however, take into account the fact that it is principally impossible to maximise all services and, consequently, it is necessary to choose a selection of objectives and ways to use them, taking into account societal preferences and financial possibilities. On the other hand, there is also the danger of fetishisation of particular services (for example, the regulatory role of biodiversity). A preference for such services at the local level may cause a marked reduction in the supply of other services that are considered locally more important and more valuable.

Conclusion

Preliminary data indicate that the use of well-defined concepts and appropriate measures/indices facilitates discussion with local communities, which constitutes an important precondition for the effective implementation of the participatory approach in planning. Planning is to be understood broadly in this context, embracing both classic spatial planning, the result of which is the local land-use plan, as well as conservation plans for protected areas (national parks and Natura 2000 zones).

The issue of scale of analyses and their measurability remains an open question for future research. Reality modelling efforts, i.e. works in the realm of spatial planning, will benefit from clearly defining the area of interest for measurable (empirical) and non-measurable (complementary) research. Providing precise definitions may be decisive for the success of ecosystem services in spatial management.

Analysis of these issues constitutes the topic of the research project "Ecosystem services in a young glacial landscape – an assessment of resources, threats and use", funded by the National Science Centre (NCN) and carried out by a team of researchers from the Polish Academy of Sciences Institute of Geography and Spatial Organisation (ST10/04344).