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Czasopismo Polskiego Stowarzyszenia
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ENVIRONMENTAL POLICY AND MANAGEMENT

STUDIES AND MATERIALS

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ENVIRONMENTAL POLICY AND MANAGEMENT

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Agnieszka RZEŃCA

THE PERSPECTIVE OF LOCAL AUTHORITIES IN RESOURCE-EFFICIENT URBAN MANAGEMENT. THE CASE OF LODZ METROPOLITAN AREA

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ABSTRACT: The paper attempts to identify the scope of urban policy in the context of re-orientated responsibilities in the area of environmental protection and stimulating sustainable development in cities. At theoretical level, it makes references to urban regimes theory, the idea of urban resilience, paradigms of place-based development policy, and ecosystem-based management. The main objective of the paper is to identify the scope of urban policy and key areas for activities pursued by local authorities in the light of identified environmental threats and priority action areas. Cities and towns of the Lodz Metropolitan Area were selected for the case study.

KEY WORDS: resource-efficient management, sustainable development, city, urban functional area, urban policy

Introduction

As A. Karwińska writes "...in order to survive and develop cities needed innovative ideas of how to cope with subsequent challenges, outbreaks, invasions, fires, social conflicts, supplies of food, water..." (Karwińska, 2014, p. 8-9). Searches for an optimum model, a target hypothetical "ideal city", and ways (paths) to overcome barriers and adapt to the changing conditions are still going on. Natural environment, in particular in the context of available ecosystem services, quality of life and sustainability of economic processes are all important factors that determine the living conditions in the city. Environmental quality problems perceived as a nuisance (also shortages), which have been experienced since the first housing districts emerged, have got intensified and globalised in recent years. Increasing body of environmental tasks, mainly as a result of the development of environmental infrastructure, however justified, has proven insufficient in the context of accumulating negative phenomena, such as increased contamination, loss of biodiversity, chaotic de-urbanisation and appropriation of space (also public space). Environmental policy, understood in sectoral terms, has not produced expected outcomes and in the face of new challenges and threats previously unidentified in many cities (environmental poverty, floods and local flooding, smog, blackouts) it has proved ineffective.

Sustainable development paradigm adapted for the needs of cities has changed the urban perspective and clearly highlighted the relevance of a comprehensive approach, where a city is understood as a social, economic, and environmental system. This approach was reflected in the *Leipzig Charter* (2007), which delineates the path of sustainable development for cities and identifies the main priorities, such as economic prosperity, social balance, and healthy environment. Sustainable development of cities consists in activities integrated and synchronised around key areas, such as: the quality of life, innovative, knowledge-based, and low-emission economy, resource-efficient management, and adaptation to climate change. Programme (7.EAP) "Living well within the limits of our planet" (2013), where supporting sustainability of EU cities features as one of priority goals. The Programme advocates the implementation of sustainable urban planning and development policies, in particular in the field of urban collective transport and mobility, energy efficiency, resource-efficient management and protection of biodiversity in cities until 2020 in the majority of EU cities. Urban policy, articulated at the EU and national levels, has become one of the key public policies and an evidence of the EU being "city oriented".

The paper attempts to identify the scope of urban policy in the context of re-orientated tasks in the field of environmental protection and stimulating sustainable urban development. At theoretical level, it refers to the urban regimes theory, the idea of urban resilience, place based policy, and ecosystem-based management. Its principal goal is to specify the key activity areas for local authorities in the light of identified environmental threats and priority action areas. Case study is based on the Lodz Metropolitan Area (in Polish: Łódzki Obszar Metropolitalny) where pilot studies on resource-efficient management were conducted[1].

Urban policy: a response to contemporary challenges in cities

A shift from sectoral approach to an integrated territorial approach is one among processes observed for public policies across the world and in particular in Europe (including some EU Member States). Integrated territorial approach highlights the territory and territorial aspects of development. Cities and their functional areas are considered to be the key links of these processes. In Europe, there is general agreement over the key principles of future development of cities and territorial development, which should:

- be based on balanced economic growth and territorial organisation of activities, with a polycentric urban structure;
- build on strong metropolitan regions and other urban areas capable of ensuring good access to services of general economic interest;
- have compact settlement structure with limited uncontrolled urban sprawl;
- represent high level and quality of environmental protection in and around cities (*Cities of tomorrow: Challenges, visions, ways forward,* 2011).

Urban policy comes as a response to the above listed postulates as it is designed to exploit endogenous territorial potential (territorial capital) specified and identified by functional linkages, integration of public involvement in space and multilevel management system. Drafted by the government *National Urban Policy 2023* (Polish: *Krajowa Polityka Miejska 2023,* 2015) adopted in 2015 provides the framework for place-based activities of the state designed to support sustainable development of cities and their

[1] Pilot study: *"Zasobooszczędne gospodarowanie w miastach Łódzkiego Obszaru Metropolitalnego oraz wybranych innych miastach regionu łódzkiego"* (Resource-efficient management in cities and towns of the Lodz Metropolitan Area and in selected towns in the Lodz Region) based on a questionnaire-based interview conducted among the inhabitants of the LMA and representatives of local authorities and administration between March and June 2015.

functional areas[2] and to tap into their potential in growth of the country. The policy is drafted at national level and implemented through creating optimum conditions for the growth of cities, a well as through concentrating and integrating actions broken down by type and entities involved. It is a comprehensive and inter-territorial policy dedicated to cities.

The *National Urban Policy* has as its strategic goal to "enhance the capabilities of cities and urbanised areas to generate sustainable growth, create new jobs, and improve the quality of life of residents" through actions undertaken to shape the space, public involvement, transport, urban mobility, low-emission and energy efficiency, urban regeneration, investment policy, economic growth, environmental protection and adapting to climate change, demography, and urban management. Ecosystem-based management concept (*EBM*[3]) that stresses the importance of holistic approach to managing social-economic-environmental systems meets the needs of complex, comprehensive management in urban areas. Ecosystem-based management is the key element of an integrated approach that combines all individual characteristics of an urban system, such as, co-existence of closely intertwined environmental, social, and economic elements and processes. It differs from traditional approach as it does not address individual species, problems, sectors or activities. It focuses on a full array of interactions within urban ecosystem[4], where a man and effects of his activities feature as relevant compo-

2 In accordance with the National Spatial Development Perspective 2030 an urban functional area is defined as a settlement structure, spatially continuous and composed of separate administrative units. It covers a compact urban area and urbanised area functionally linked with it.

3 *Ecosystem-based management* (*EBM*) – "is a management approach that recognises (needs of) the ecosystem" it originates from natural sciences and is a response to the problems of endangered species, protection of land, water, etc. first formulated in the United States in the 1980s and 1990s connected with an integrated approach to management, where ecosystem is understood as a system of intertwined biological and physical elements, mechanisms and outcomes of human actions. It is based on the identification of interactions between biophysical, social, and economic spheres; it also seeks ways to manage multiple, diverse human interferences with the ecosystem. The substance of ecosystem-based management consists in the integration of marine ecosystems (species, materials and ocean currents), social and economic systems and institutional systems to conduct complex (holistic) actions aimed to improve the quality of ecosystems and services that they render (McLeod, Leslie (eds), 2009; Tallis et al., 2010). The term "ecosystem-based management" should be distinguished from the term "ecosystem management", which focuses on environmental interactions within the ecosystem rather than on the wide context of outcomes of human activity.

4 Specialist literature identifies two main strands of considerations concerning cities understood as ecosystems. One of them highlights the context of nature. City is interpreted as a collection of ecosystems, i.e., a structural and functional system that meets ecosystem criteria in biological sense. We are thus speaking of ecosystems in a city (ecosystem of a river valley, city park, etc.). The second, holistic approach focuses on a city as an entity and identifies close relations and interdependences between

nents. The approach is based on: ensuring sustainable use of ecosystem resources (1), cooperation and collaboration in implementing ecosystem-based management and planning (2), monitoring changes and effects, i.e., management effectiveness (3). Ecosystem-based management is a spatial approach, which recognises relationships (links), cumulated impact and multiplicity of goals within a given territory. The overarching objective is to maintain urban ecosystem in a healthy, clean, productive and resilient condition so that it could perform its functions and provide goods (including raw materials) and services that build up and maintain prosperity of its inhabitants and ensure efficient functioning of the city over a long period of time. It centres on enhancing the resilience of urban ecosystem and adaptation to change, improved efficiency of resources and higher social prosperity (McLeod, Leslie, 2009).

In an interdependent social, economic, and environmental system environmental resilience to pressure and adaptation are crucial for maintaining dynamic equilibrium necessary to uphold the continuity of environmental, social, and economic processes. In particular climate changes, their negative consequences and urban adaptation processes linked with them have produced the idea of urban resilience (Simmie, Martin, 2009), that has emerged in urban (but also regional) studies. Urban resilience is defined as a scope/scale of adaptation capabilities of a city to unexpected and unpredictable situations (e.g., natural disasters) or problems resulting from economic uncertainties, e.g., resource (water) or energy shortages (Barnett, 2001). Understanding of ecosystem resilience, i.e., to what extent it can maintain structures and functions in the light of distortions, is crucial for development planning. Against this background, urban policy is reactive and responds to current challenges in cities; it also favours integrated and flexible development planning.

Since cities differ and represent a variety of characteristics and typical problems, urban policy must be individualised. City provides space for clashes among coalitions, partnerships, interest groups, and stakeholders who represent diverse interests and needs (*urban regime theory)* (Stone,1989). Institutional framework that includes administration bodies, as well as interactions between central and local administration, sectors of the economy, civil society, but also the legal system, all of them determine urban policy. A city is a living lab where projects the best suited to local conditions and meeting local needs can be delivered in cooperation with many other partners. Thus, it is vital to expand and foster institutional collabora-

nature, social and economic sphere. As a result, the interest focuses on a city as a complex, multicomponent system. Under this approach, urban ecosystem provides the foundations for ecosystem-based management.

tion with a wide group of stakeholders, i.e., public institutions, NGOs, economic operators, and residents who exert real impact upon living conditions, as well as social and economic activities in cities. Social involvement is a valid argument for increasing the efficiency of urban policy and the purposefulness of co-managing the city.

Resource-efficient management – new dimension of environmental protection?

Rio Declaration (Principle 4) clearly stressed the role of environmental protection in attaining sustainable development as an integral part of the development process (Kozłowski, 1993). The role of material and energy savings together with the need to reduce the consumption of resources by reducing flows of materials in the economy, as well as efficient use of obtained resources have been highlighted on numerous occasions (Daly, 1990). As for raw materials we know that their increasing global consumption translates into overall increase in their prices, intensified volatility of prices and increasingly frequent cases of raw material shortages and distortions in ecosystems. Despite universally known premises and consequences, imbalanced consumption of resources continues.

Change dynamics, but first and foremost, the scale and intensity, with which natural resources are used up, force out re-orientation in the approach to environmental protection and focus on resource-efficient management. Resource-efficient management, i.e., resource-efficiency includes all efforts intended to conserve natural goods for future generations maintaining high living standard of society and efficient economic development. More environmentally-friendly economy that efficiently uses its resources is an important area of "new" EU engagement, which is clearly stressed in Europe 2020 Strategy. The flagship initiative "*Resource-efficient Europe"* adopted in 2010 is an integral part of "Europe 2020" Strategy within the pillar of "sustainable development". Its main axis links development with environmental protection and environmentally-friendly conduct of the users, in particular in the context of energy security, sustainable transport, economic and efficient use of natural resources, as well as building collaboration capabilities among various stakeholders. Long-term action plans that go on until 2050 relate to climate, energy, transport and resource-efficient.

Flagship initiative has been presented in greater details in the *"Roadmap to a Resource-Efficient Europe",* whose principle goals include:

- improved economic performance with simultaneous reduction of resource consumption;

- identification and generation of new opportunities for economic growth, boosting innovation and EU competitiveness;
- ensuring security of supplies of basic resources;
- counteracting climate change and reducing environmental impact of the use of resources.

The above goals will become operational through actions in the field of sustainable production and consumption, waste management (where waste is treated as potential resource), supporting innovation, and protection of natural capital. The key to successful resource-efficient management at local, regional and supranational level lies in minimisation of the use of resources, i.e., in saving and smaller consumption of resources as a result of improved productivity and efficiency or even rationing. Equally important are recycling as a solution promoting closed circuit circulation where resources get re-used and replacement meaning the use of substitutes or alternative innovative solutions.

Contrary to common beliefs, Poland is much more clearly lagging behind in the EU in water, waste, and air management with better performance reported for energy management (Blusz, Inderberg, Zerka (eds.), 2015). Responsibility for the implementation of saving-oriented, efficient solutions rests to a significant extent with authorities at lower levels. In this context, we need to reinterpret tasks facing local authorities and all environment users. Local authorities remain to be responsible for eliminating negative environmental impact of local communities, however, the accent is put on comprehensive design of development processes and engaging inhabitants in managing, and primarily protecting, environmental resources (figure 1).

At the local level resource-efficient management can be discussed from the point of view of living conditions, with respect to which local authorities strive for continuous improvement. Living conditions include the entirety of relationships between people and the environment and relate to social and economic conditions, quality of housing, services, and conditions determined by natural environment and local development (Markowski, 1999). An integrated approach creates conditions to focus activities around key city resources or/and problems and limiting sectoral, unilateral approach to development, which is fundamental in the context of resource-efficient management.

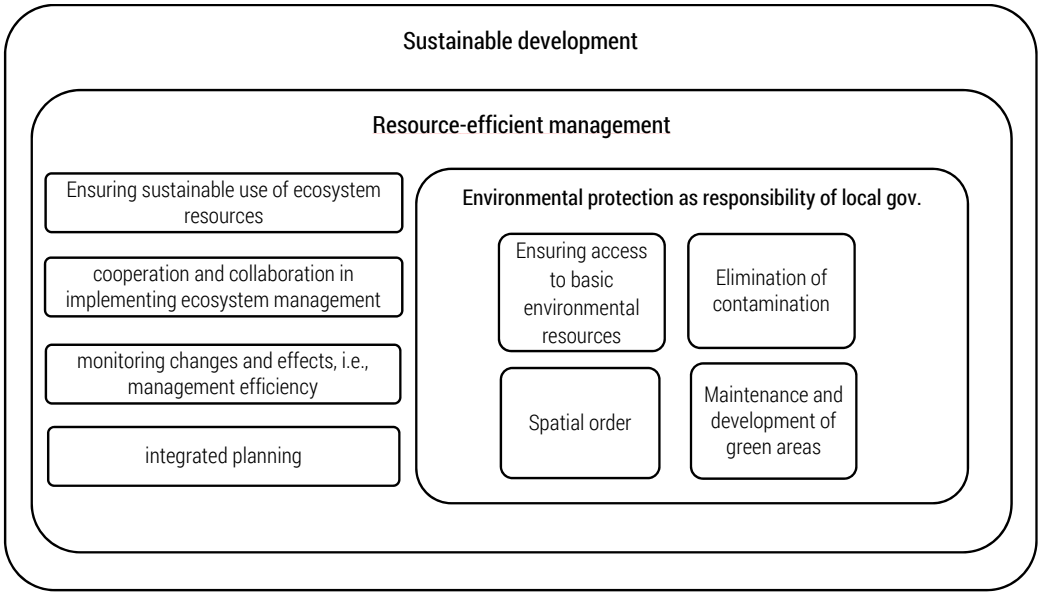

Figure 1. Essence of resource-efficient management. Local dimension

Source: author's own study.

Resource-efficient urban management: case of the Lodz Metropolitan Area

Redefinition of environmental goals and priorities that go much beyond the area of traditional environmental policy forces out integration of activities addressed to specific entities or actions. Local authorities face the challenge of supporting the efficiency of the use of natural resources, reducing emissions in the economy (increasing energy efficiency of the economy and energy generation from renewable energy sources, reducing emissions from transport in urban agglomerations), and improving adaptation capabilities to climate change. Nowadays, it is fundamental how cities perceive and identify environmental threats and problems of "little homelands" and what key challenges they face. The above issues provided an impulse for original studies conducted in towns and cities of the Lodz Metropolitan Area (LMA)[5].

[5] In the paper we present some results of a pilot study *„Zasobooszczędne gospodarowanie w miastach* Łódzkiego *Obszaru Metropolitalnego oraz wybranych innych miastach regionu łódzkiego"* (Resource effficient management in cities and towns of the Lodz Metropolitan Area and in selected towns in the Lodz Region) based on a questionnaire-based interview conducted among the inhabitants of the LMA and representatives of local authorities (mayors and councillors) and administration between March and June 2015.

The LMA includes regional capital Łódź and four counties (poviats) around it: brzeziński, łódzki wschodni, pabianicki, and zgierski; capital of the region, Łódź, and 11 satellite towns (including 5 towns, which are urban-rural communes). The LMA covers the area of 2,499 km^2, i.e. only 13.7% of the total area of the voivodeship (region); it is inhabited by 1,116 k people (44.0% of total population of the region), out of which 977 k live in towns and cities (60.2% of urban population in the region)[6]. The area has experienced common history, industrial development track, stormy flourishing and dramatic stagnation, as well as numerous functional links developed in the past and present times. Nowadays, these towns are seeking their own development paths, adopt new solutions, use their potential (human capital, location in the centre of the country, etc.), including post-industrial potential (Sokołowicz, Zasina, 2013; Rzeńca, Sokołowicz, 2017).

Conducted studies show that in cities and towns in the LMA main environmental threats are connected with low emissions (furnaces at individual households that use coal, coal dust, and wood), contamination deriving from intensified car traffic (including noise), and lack of care of inhabitants for the environment. Characteristically, in towns and cities that experienced extreme weather conditions (e.g., rainstorm, droughts) these phenomena were listed as serious threats. It demonstrates the change in perception of environmental burden and threats in cities through short-term, episodic (e.g., droughts, water shortages) and/or permanent (e.g., power outages in the times of heat) difficulties. Excess water or energy consumption or changes in space including suburbanisation were not listed as threats. The major challenges enumerated by respondents included:

- building up environmental awareness and environmental approaches among residents,
- increased use of renewable energy sources,
- better energy efficiency performance,
- low emission and resource saving transport,
- better use and management of space,
- more efficient use of resources (water, energy, space),
- the highest rate of recycling possible ("zero" waste economy).

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6 Lodz Metropolitan Area, which currently consists of 31 units was established in 2014. Its major goals are, inter alia, to support the idea of local authorities; to protect common interests of the members of the Association; to support cooperation and integration of local self-government units of the Lodz Metropolitan Area; to promote partnership-based model of cooperation and to pursue joint policy in associated units of local self-government. Stress is placed on the integration of local community and joint planning of comprehensive or complementary actions. The cooperation resulted in the drafting and adoption of the Development Strategy for Lodz Metropolitan Area 2020. For more see: www.lom.lodz.pl.

The majority of respondents stressed the importance of improved energy efficiency but at the same time they did not perceive excess energy consumption as a threat. In some towns involved in regeneration projects better use and management of space was mentioned as a challenge. Unfortunately, no-one commented on suburbanisation. Neither has cooperation been identified as a threat or key to the success of implemented activities. Only 4 towns considered cooperation with neighbouring communes an important issue. As shown by earlier studies on metropolitan relationships within the LMA, so far institutional linkages and relationships among individual territorial units have played a minor role. Also the level of cooperation among territorial self-government units is perceived as low (for more see: *Strategia Łódzkiego Obszaru Metropolitalnego 2020+ Część I....*; *Studium rozwoju Łódzkiego Obszaru Metropolitalnego*). Local authorities, especially in smaller towns, may also have insufficient specialist knowledge on available solutions and on the efficiency of such activities.

Conclusion

Urban policy is one among the key public policies and its importance is increasing. On the one hand, place based policy fosters the role of local communities, in particular cities and towns and their functional linkages. On the other hand, the idea of ecosystem-based management and urban resilience exposes the role of interdisciplinary approach and the ability to pursue integrated management and control over sustainable development. The above conditions open up possibilities to practice resource-efficient management at the local level. Self-governments and local communities in towns and cities may become the forerunners of changes that will further get promulgated in other territorial systems.

The studies clearly suggest that in the near future gravity of environmental actions at the local level will shift its focus to low emission economy and improved energy efficiency. The new programming period favours cities and their functional areas, which become the major beneficiaries of EU assistance, hence the opportunity to efficiently implement new solutions or new models of urban development planning becomes more real.

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THE APPLICATION OF THE PROMETHEE METHOD IN EVALUATION OF SUSTAINABLE DEVELOPMENT OF THE SELECTED CITIES IN POLAND

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ABSTRACT: The priority objective of the article is the valuation of the selected Polish cities in the light of the sustainable development indicators, which have been developed by Central Statistical Office of Poland. Several dozens of indicators have been included in the study, which are grouped according to the four domains: social, economic, environmental, and institutional-political. It is worth mentioning, that the selected multicriteria decision aid method was used (the PROMETHEE method). The multicriteria analysis enabled to indicate the strengths and weaknesses of cities in the light of the idea of sustainable development. Moreover, the research has shown that the selected method is useful in solving the issues of contemporary urbanism.

KEY WORDS: the sustainable development, ranking, the PROMETHEE method

JEL: C49, C88, Q01

Introduction

In the age of contemporary problems and urban trends the principle of sustainable development plays more and more important role. The principle of sustainable development assumes "such a socio-economic development in which occurs the process of integration of political, economic and social activities with the preservation of the natural balance and the sustainability of basic natural processes in order to guarantee. In order to ensure the possibility to meet the basic needs of individual communities or citizens of both the present and future generations" (Prawo ochrony środowiska).

The implementation of the concept of sustainable urban development is often seen as an opportunity to improve living conditions and the urban environment (Barełkowski, 2012, p. 760). Furthermore, as A. Rzeńca notes: "In the face the process of globalization, metropolization and unification processes, cities are looking for their individual development paths which can meet the contemporary demands and expectations. In this context, the implementation of the concept of sustainable development and ecosystem approach to the city management could be a factor in building a competitive advantage and creating a positive image" (Rzeńca, 2016, p. 53).

Therefore, it is important to assess the city's current level of sustainable development. Firstly, this evaluation provides the multifaceted diagnosis of cities (in terms of social, economic, environmental, and institutional-political domains). Secondly, it is easier to identify potential problems of cities, as well as, it will be a starting point for defining strategies to facilitate the development of a sustainable city.

The important source of information is a publicly accessible application called sustainable Development Indicators, which contains a database of indicators to monitor the sustainable development at the national level (including the European Union and EU Member States), regional level (concerns both regions and voivodships) and powiat levels (Sustainable Development Indicators).

In this article evaluation four selected Polish cities: Bialystok, Lublin, Chorzow and Czestochowa were evaluated in terms of available indicators of the sustainable development[1]. The ranking was drawn up using the selected multicriteria method – PROMETHEE (*Preference Organization METHod Ranking for Enrichment Evaluations*). The main part of the research had been preceded by literature review of theory and the implementation of the PROMETHEE method.

[1] The selected cities were a case studies in the Author's PhD thesis, in which the evaluation these cities were made in the light of the idea of a compact city.

The literature reviews

The PROMETHEE method was developed in 1982 by Professor J. P. Brans. Then Professor B. Mareschal joined the study (Mareschal, 2017, p. 1).

Nowadays the PROMETHEE method is used worldwide to solve complex decision-making problems in various areas of life. Already in 2010 a group of scientists reviewed works on the theory and applications of the PROMETHEE method. Among the main areas of application, there were such areas as: environment management, hydrology and water management, business and financial management, chemistry, logistics and transportation (Behzadian et al. 2010, p. 208).

Moreover, a comprehensive review of the PROMETHEE method is regularly published on the Visual PROMETHEE website. The current database includes as many as 1570 various positions (situation on 11 June 2017), showing the popularity and the versatility of the PROMETHEE method (PROMETHEE-GAIA).

Based on the literature review, it can be noted, that multicriteria decision aid methods, including the PROMETHEE method, are becoming increasingly popular in analyses and the decision-making problems concerning the sustainable development. So far, the PROMETHEE method has been applied, inter alia, to issues such as:

- the management of natural resources:
  - water (Raju, Duckstein, Arondel, 2000; Mutikanga, Sharma, Vairavamoorthy, 2011),
  - energy (Doukas, Patlitzianas, Psarras, 2006; Tsoutsos et al., 2009; Bagheri Moghaddam, Nasiri, Mousavi, 2011),
  - air (Lim, Ayoko, Morawska, 2005; Nikolić et al., 2010);
- transport systems:
  - intelligent transport systems (Brucker, Verbeke, Macharis, 2004),
  - the management of urban road infrastructure (Jajac, Knezic, Babic, 2012),
  - the implementation of sustainable parking development projects (Jajac, Marovic, Mladineo, 2014);
- waste management, for instance:
  - municipal solid waste management (Vego, Kucar-Dragicevic, Koprivanac, 2008),
  - solid waste disposal (Arikan, Simsit, Vayvay, 2017);
- spatial and urban planning:
  - the implementation of development strategy (Ergazakis et al., 2007),
  - the selection of an investment site (Sriniketha, Diwakar Reddy, Naga Phaneendra, 2014; Simic et al., 2015).

However, above mentioned issues and works do not cover the topic, but they show point to current research problems that can be solved by the PROMETHEE method. It is worth adding that multicriteria methods are commonly used for spatial planning issues, including urban planning. A very popular research area is a multicriteria location analysis. In this article, the new problem of urban planning has been proposed, that is, the application of the PROMETHEE method in the evaluation of the sustainable development of cities.

To conclude, it might also be useful to refer to the sustainable urban development and the sustainable development indicators. In Poland, the work on the sustainable development indicators started in the 1990s, then research team was established, which was headed by Professor Borys (Borys, 2005, p. 10). It is important to note, that developed indicators are the basis of the previously mentioned the application called Sustainable Development Indicators available by the Central Statistical Office of Poland.

In view of the development of various databases, recently an attempt of the evaluation of the sustainable development of Polish cities has been made. The results were published in the report "Sustainable Urban Development" which was prepared for the Polish Robert Schuman Foundation and the Konrad Adenauer Foundation by the INSIGHT Policy (www.europolis.schuman.pl). Authors of the report applied 71 indicators from various databases (for example databases of the Central Statistical Office of Poland, databases of the Ministry of Finance, databases of the Ministry of Digitalization and others). The zero unitarization method was used to determinate the value of group of indicators (relating to 4 dimensions of the sustainable development: environment, economy, society and politics). The final indicator of the sustainable urban development was calculated as the average of each group of indicators (Arak, Kusterka-Jefmańska, 2016, p. 38). The first place in the ranking was taken by Warszawa. Sopot came second. The third place was taken by Bielsko-Biala. It is worth noting that Bialystok was ranked 17th on the list. Lublin and Czestochowa were in the first thirty and Czestochowa was in the first fifty (Arak, Kusterka-Jefmańska, 2016, p. 16).

In this work, the 66 sustainable development indicators, available on the website of Central Statistical Office of Poland were used to assess the sustainability development of the selected cities. The calculations were made in Visual PROMETHEE software, based on algorithm of the PROMETHEE method.

Algorithm of the multicriteria analysis

Below are presented the stages of the multicriteria analysis and the main assumptions of the PROMETHEE method:

- Step 1. Define alternatives and criteria. This multicriteria analysis includes 4 alternatives (Bialystok, Lublin, Chorzow, Czestochowa) and 66 criteria, that is the sustainable development indicators available on the website of the Central Statistical Office of Poland.
- Step 2. Define the evaluation of the alternatives in the light of the criteria. Tables from 1 to 4 present general data.
- Step 3. Define the properties of criteria. First, the following information should be defined:
  - character (stimulant/destimulant),
  - weight (in the analysis criteria have the same weight, but in the software sensitivity analysis is available),
  - preference function (in the PROMETHEE method considers the differences between the evaluations of the decision options in the light of each criterion. What is important, the characteristic feature of the selected method is the preference function, which is used to measure a power of preference and takes values from the interval from 0 to 1, where 0 means no preference and 1 means a full preference. There are six types of preference functions: usual, U-shape, V-shape, level, linear and Gaussian preference function. The choice of the preference function depends on the decision-maker, although the authors of the method have developed some instructions. For example, both usual and level preference functions are recommended for qualitative criteria. The linear preference function and V-shape, which is one of linear preference functions, are used for quantitative criteria (Trzaskalik, 2014, p. 245; Instruction of PROMETHEE method, 2013, p. 145-146].
- Step 4. The final ranking. In the selected method, there are two rankings: partial and complete. The rankings are based on the preference flows, which "*are computed to consolidate the results of the pairwise comparisons of the actions and to rank all the actions from the best to the worst one*" (Instruction of the PROMETHEE method, 2013, p. 149). There are: the positive preference flow (Phi+), the negative preference flow (Phi-) and the net preference flow (Phi). The positive preference flow illustrates the power of exceeding one action over another. On the other hand, the negative preference flow shows to what extent the variant is overridden by other actions. The basis for the final ranking is the value of the net preference flow. The higher is the indicator, the better the action. (Trzas-

kalik, 2014, p. 245-246; Instruction of the PROMETHEE method, 2013, p. 149-150).

- Step 5. The additional analyses. The available software (for example Visual PROMETHEE) both makes calculations easier and allows for a variety analysis (for instance sensitivity analysis) which allows better understanding and helps to solve a given decision problem.

It should be emphasized, that the main steps of multicriteria analysis using the PROMETHEE method are outlined above. The complete description of this method can be found, for example, in the following publications (especially Brans and Mareschal, 2005, p. 163-195; Instruction of the PROMETHEE method, 2013, p. 143-151).

In the next part of the article, both the necessary data (the value of the sustainable development indicators of the four cities which were the case studies) and the results of the multicriteria analysis are presented.

Multicriteria analysis of the selected Polish cities in the light of the sustainable development

The tables below show the evaluation of the selected cities (Bialystok, Lublin, Chorzow and Czestochowa) in the light of 66 indicators of the sustainable development broken down into domains. Table 1 applies to social domain, table 2 refers to economic domain, table 3 environmental domain and table 4 refers to institutional-political domain. Moreover, the category of indicators has been included within the domains. Next to the name and the value of the indicators, the number, unit and the quality of each indicators are given in the tables. All data come from the Sustainable Development Indicators available by the Central Statistical Office of Poland (Sustainable Development Indicators).

Table 1. Social domain

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
Demographic changes							
1	Natural increase per 1000 population	-	↑	1,60	0,40	-3,70	-4,10
2	Ratio of balance of permanent migration person at working age	[person]	↑	7,10	-22,50	-7,80	-42,20
3	Demographic dependency ratio: post-working age population per 100 persons of working age	[person]	↓	29,00	34,00	35,40	36,50
4	Demographic dependency ratio: non-working age population per 100 persons of working age	[person]	↓	55,30	60,20	63,00	60,80
5	Demographic dependency ratio: post-working age population per 100 persons of pre-working age	[person]	↓	110,40	129,70	128,50	149,80
Public health							
6	Infant deaths per 1000 live births	[per mil]	↓	3,50	2,70	7,60	5,60
7	Deaths by selected causes of death in percentage of total: diseases of the circulatory system	[%]	↓	42,70	44,70	43,50	47,60
8	Deaths by selected causes of death in percentage of total: tumors	[%]	↓	24,60	26,70	27,70	26,30
9	Deaths by selected causes of death in percentage of total: diseases of the respiratory system	[%]	↓	6,60	6,20	2,80	3,80
10	Deaths of people aged up to 65 years per 1000 population at this age	-	↓	2,40	2,90	4,90	4,10
Poverty and living conditions							
11	People in households benefiting from the social assistance at their households in percentage of the total population	[%]	↓	5,90	5,40	8,00	5,00
12	Average monthly gross wages and salaries (economic entities which employ more than 9 persons)	[PLN]	↑	3706,73	3955,65	3638,84	3526,81
13	Average useful floor area of dwelling per capita	[m^2]	↑	25,60	25,50	24,80	26,30
Education							
14	Children covered by pre-school education in percentage of the total number of children at the age 3-5 (total)	[%]	↑	94,80	96,80	79,10	87,90

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
15	Ratios the quality of education and the level of students' knowledge: passing the exam maturity examination in the vocational upper secondary schools	[%]	↑	74,30	78,50	64,70	68,20
16	Ratios the quality of education and the level of students' knowledge: passing the final examinations in upper secondary vocational schools	[%]	↑	89,30	89,30	87,40	89,40
Access to labour market							
17	Long-term unemployed persons in registered unemployed persons total	[%]	↓	48,50	51,30	38,20	45,20
18	Registered unemployed persons in relation to persons of working age: unemployed persons, females	[%]	↓	7,20	6,80	6,80	8,80
19	Registered unemployed persons in relation to persons of working age: unemployed persons with tertiary education, total	[%]	↓	1,70	1,60	0,40	1,60
20	Job offers for disabled people in 1000 disabled unemployed	-	↑	39,00	74,00	28,00	2,00
21	Graduates – registered unemployed people (yet not working) in percentage of the total registered unemployed people	[%]	↓	4,50	4,00	2,10	3,10
22	Graduates – registered unemployed people (yet not working) in percentage of the total registered unemployed people: graduates – females	[%]	↓	5,80	5,00	2,20	3,90
23	Registered unemployment rate	[%]	↓	11,90	8,60	10,10	11,20
Sustainable consumption patterns							
24	The number of cars per 1000 people	[pcs]	↓	377,30	463,40	399,20	478,90
25	The consumption of water, electricity and gas in households during a year per capita: electricity	[kWh]	↓	609,70	695,40	780,20	704,80
26	The consumption of water, electricity and gas in households during a year per capita: gas	[m^3]	↓	103,60	143,20	111,10	124,40
27	Consumption of water, electricity and gas in households during the year per capita: water	[m^3]	↓	32,70	35,00	29,20	37,00
Old-age income adequacy							
28	Long-term unemployed people aged 55-64 in relation to registered unemployed people aged 55-64 total	[%]	↓	64,90	61,80	52,70	56,90

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
29	Persons at post-working age in households benefiting from social assistance at their households in percentage of the total number of people at this age	[%]	↓	2,00	3,30	3,00	1,50
Determinants of health							
30	People injured in accidents at work per 1000 employed persons	[person]	↓	6,86	8,25	8,17	4,89
31	Health clinics per 10 000 people	[facilities]	↑	10,00	9,00	6,00	7,00
Criminality							
32	Rate of detectability of the delinquents of identified crimes	[%]	↑	56,00	59,00	67,00	71,00
33	Identified crimes total per 1000 population	-	↓	17,76	28,34	42,09	24,61
Road accidents							
34	Victims of road accidents per 100 000 registered motor vehicles: injured	[person]	↓	111,93	128,25	114,47	432,49
35	The victims of road accidents per 100 000 registered motor vehivles: fatal accidents	[person]	↓	5,60	7,89	1,94	2,89

Source: author's own work based on www.wskaznikizrp.stat.gov.pl [30-06-2017].

Table 2. Economic domain

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
Economic development							
36	New-registered entities of the national economy recorded in the REGON register per 10 000 population at the working age	-	↑	164,00	170,00	136,0	165,00
37	Value of share capital of companies per 1 person on at the working age	[PLN]	↑	546,00	2145,00	25 817,00	3 772,00
38	Expenditure on innovation activities in enterprises by group of sections in percentage of the total expenditure on innovation activities in enterprises (up to 9 employees): industry and construction	[%]	↑	63,90	43,70	26,30	51,80

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
39	Expenditure on innovation activities in enterprises by group of sections in percentage of the total expenditure on innovation activities in enterprises (up to 9 employees): trade; repair of motor vehicles; transportation and storage; accommodation and catering; information and communication	[%]	↑	17,30	33,30	64,80	43,70
40	Expenditure on innovation activities in enterprises by group of sections in percentage of the total expenditure on innovation activities in enterprises (up to 9 employees): financial and insurance activities; real estate activities	[%]	↑	3,90	3,80	0,80	1,40
41	Expenditure on innovation activities in enterprises by group of sections in percentage of the total expenditure on innovation activities in enterprises (up to 9 employees): other services	[%]	↑	14,90	19,10	8,10	3,10
Employment							
42	Natural persons conducting economic activity per 100 persons of working age	-	↑	13,30	14,30	11,80	13,80
43	Entities by size classes per 10 000 population at the working age	-	↑	1773,50	2037,00	1657,10	1863,80
Transport							
44	The length of bicycle lane: per 10 000 km^2	[km]	↑	10 378,90	7432,00	4994,00	3 193,30
45	The length of bicycle lane: per 10 000 population	[km]	↑	3,60	3,20	1,50	2,20
46	The length of local public roads per 100 km^2: surfaced	[km]	↑	319,70	279,20	390,80	246,50
47	The length of local public roads per 100 km^2: unsurfaced	[km]	↑	52,10	52,80	5,40	118,60
48	The expenditures of gminas on public roads in percentage of their total expenditure	[%]	↑	12,20	13,60	6,10	14,60

Source: author's own work based on www.wskaznikizrp.stat.gov.pl [30-06-2017].

Table 3. Environmental domain

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
Climate change							
49	Emissions of carbon dioxide from plants especially noxious to air purity	[t/y]	↓	906 416,00	591 829,00	1 447 572,00	824 415,00
Energy							
50	Electricity consumption per capita: total	[kWh]	↓	609,70	695,40	780,20	704,80
Air protection							
51	The emissions of air pollutants from plants especially noxious to air purity: gases	[t/y]	↓	909 274,00	595 194,00	1 452 059,00	829 145,00
52	The emissions of air pollutants from plants especially noxious to air purity: particulates	[t/y]	↓	113,00	236,00	96,00	255,00
53	Pollutants retained or neutralized in pollutant reduction systems in polluting plants especially noxious to air purity in percentage of the generated: gases (excluding carbon dioxide)	[%]	↑	16,40	1,00	74,30	0,80
54	Pollutants retained or neutralized in pollutant reduction systems in polluting plants especially noxious to air purity in percentage of the generated: of dust	[%]	↑	99,60	98,70	99,90	99,10
Land use							
55	Forest cover	[%]	↑	17,90	11,10	6,90	4,00
Biodiversity							
56	Legal protected area in percentage of the total area	[%]	↑	1,02	17,16	8,51	6,34
57	Green belts in percentage of the total area	[%]	↑	5,00	5,70	22,20	3,10
Waste management							
58	Mixed municipal waste from household collected during a year per capita	[kg]	↓	186,20	173,00	216,80	192,50
59	Treated industrial and municipal wastewater in percentage of the total value of the industrial and municipal wastewater requiring treatment	[%]	↑	100,00	100,00	100,00	99,29

Source: author's own work based on www.wskaznikizrp.stat.gov.pl [30-06-2017].

Table 4. Institutional-political domain

No	The name of indicator	Unit	Quality	Białystok	Lublin	Chorzów	Częstochowa
Openness and participation							
60	Foundations, associations and social organizations per 10 000 population	-	↑	40,00	50,00	22,00	36,00
61	The structure of councilors in the authorities (legislative bodies) in gminas and poviats: females	[%]	↑	17,90	19,40	32,00	25,00
62	The structure of councilors in the authorities (legislative bodies) in gminas and poviats: people with higher education	[%]	↑	96,40	93,50	72,00	85,70
Economic instruments							
63	European Union funds for the financing of EU programs and projects acquired by the gminas and poviats in per capita	[PLN]	↑	4,30	11,00	12,90	6,60
64	Expenditure from the budgets of gminas and poviats on public debt in 1000 PLN per total revenue budgets of gminas and poviats	[PLN]	↓	17,80	15,00	5,80	11,10
65	The investment expenditures of gminas and poviats in percentage of their total expenditure	[%]	↑	20,00	30,80	13,60	14,70
66	The area covered by the local spatial development plans in percentage of the total area	[%]	↑	45,00	47,00	101,10	17,50

Source: author's own work based on www.wskaznikizrp.stat.gov.pl [30-06-2017].

The calculations were performed using the Visual PROMETHEE software. Both, the preference flows and the final ranking and are presented in table 5. In addition, the partial rankings were prepared in the light of individual domains, see table 6.

Table 5. The preference flows and the final ranking of cities

City	Phi	Phi+	Phi-	The place in the final ranking
Bialystok	0,1506	0,3619	0,2112	1
Lublin	0,0877	0,3204	0,2327	2
Chorzow	-0,0973	0,3043	0,4016	3
Czestochowa	-0,1410	0,2153	0,3563	4

Sour: author's own work.

Table 6. The partial rankings of the cities in the light of each domain

City	SOCIAL DOMAIN		ECONOMIC DOMAIN		ENVIRONMENTAL DOMAIN		INSTITUTIONAL-POLITICAL DOMAIN	
	Phi	The place in the ranking	Phi	The place in the ranking	Phi	The place in the ranking	Phi	The place in the ranking
Bialystok	0,2125	1	0,1648	2	0,1568	1	-0,1943	4
Lublin	-0,0031	2	0,2326	1	0,1234	2	0,2165	1
Chorzow	-0,0675	3	-0,3464	4	-0,0559	3	0,1513	2
Czestochowa	-0,1418	4	-0,0509	3	-0,2243	4	-0,1735	3

Source: author's own work.

Bialystok is characterized by positive demographic trends (for example natural increase or relatively low demographic dependency ratio). Also noteworthy are sustainable consumption patterns, expressed by relatively small number of private cars per 1000 people or low consumption of water, electricity and gas in households during a year per capita. Another distinctive feature of the capital of Podlasie is the transport system, especially the highly developed network of bicycle lanes. The weak points of the city are related to the socio-economic sphere, including situation on the local labor market, as well as, the selected economic instruments in the institutional-political domain.

In Lublin, high values of indicators from the categories: "poverty and living conditions" and "education" were recorded. Lublin is the city with the best situation in terms of the economic domain and the institutional-political domain (see table 6). Among the indicators which need improvement, the sustainable consumption patterns and some indicators of the environment domain should be indicated first.

Both Chorzow and Czestochowa to a lesser extent meet the principle of the sustainable development. The main weak point of Chorzow is level of education, the level of entrepreneurship of the inhabitants, as well as, the selected indicators of the environmental domain. The indicators relating to the labor market in Chorzow and economic instruments fared much better.

In Czestochowa, there are mainly adverse demographic trends, improper sustainable consumption patterns, and some disturbances of the environmental domain and the institutional-political domain. Among the indicators that received positive evaluations, should be mentioned, for example indicators that refer to old-age income adequacy or the selected indicators concerning the system of transport.

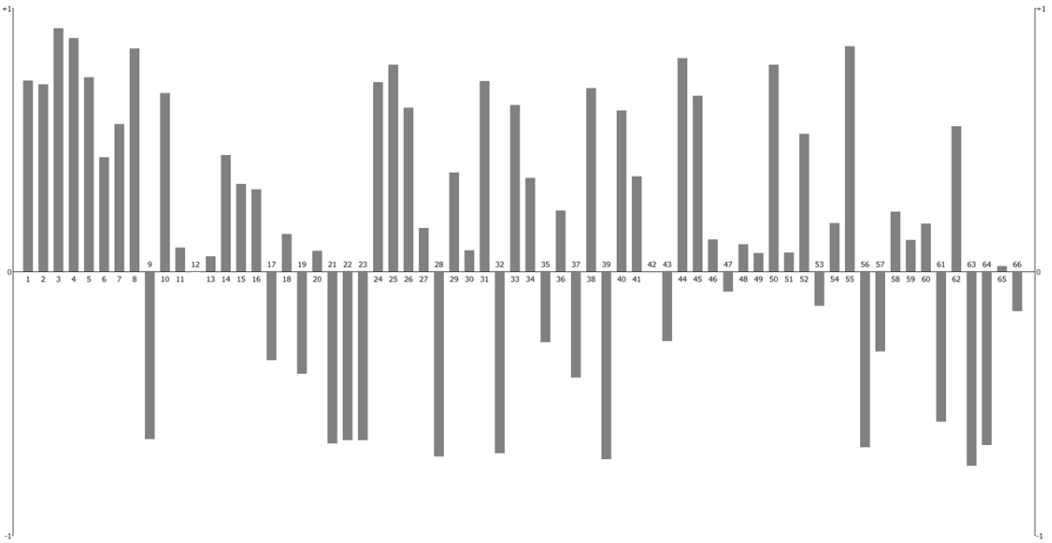

Figure 1. Profile of Bialystok

Source: author's own work based on Visual PROMETHEE software.

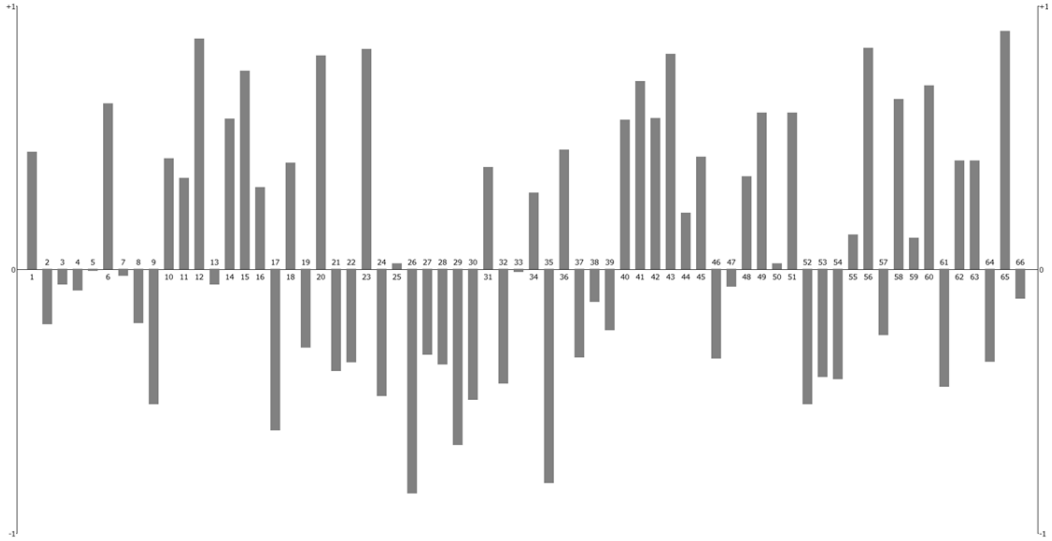

Figure 2. Profile of Lublin

Source: author's own work based on Visual PROMETHEE software.

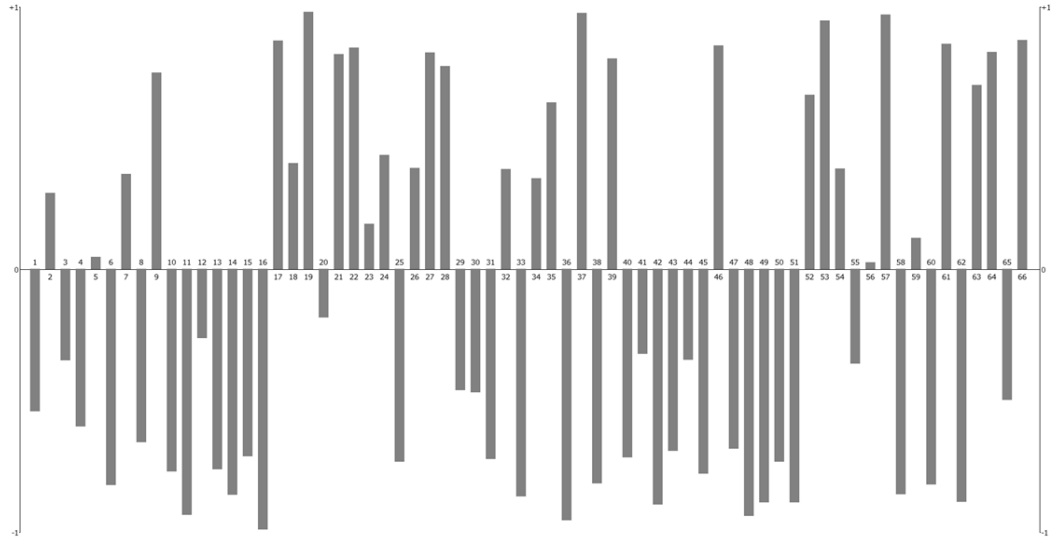

Figure 3. Profile of Chorzow

Source: author's own work based on Visual PROMETHEE software.

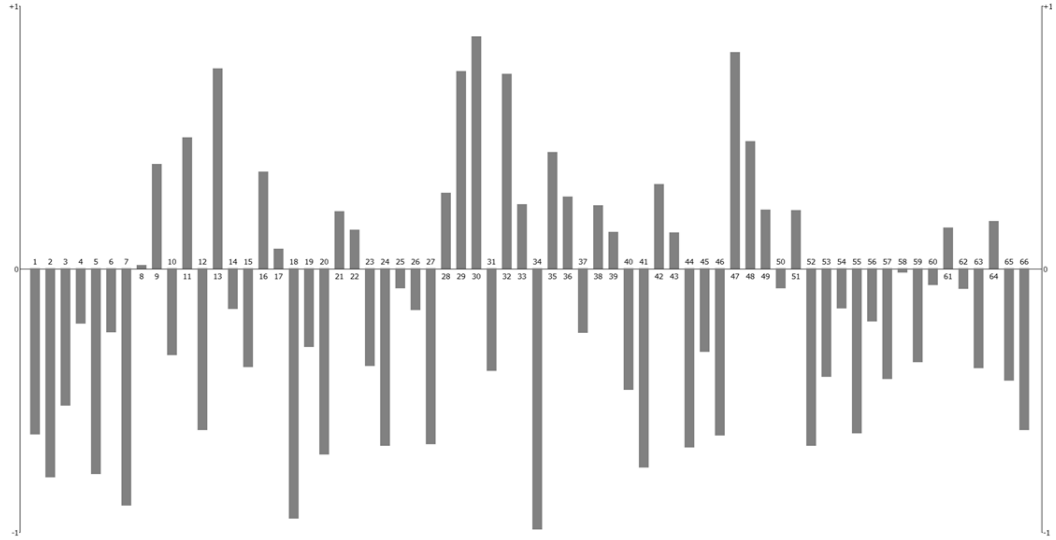

Figure 4. Profile of Czestochowa

Source: author's own work based on Visual PROMETHEE software.

Figures 1-4 show "profile of actions" then profile of the selected cities. It shows strengths and weaknesses in the light of the sustainable development. The function "*Action Profiles*" which is available in Visual PROMETHEE software was used. What is important, the bars show the net flows of each criterion. The upper bars indicate advantages, while the lower ones indicate the criteria which require corrective action to ensure that the city's development is sustainable (Instruction of PROMETHEE method, 2013, p. 119).

Conclusions

Based on the literature review and the results of multicriteria analysis the following conclusions were drawn:

- the principle of the sustainable development plays a significant role in the context of contemporary problems and urban trends, focusing primarily on the phenomenon of urban sprawl, the unfavorable demographic trends and problems of urban management;
- for years multicriteria decision aid methods have been used in many fields around the world, including the topic of the sustainable development;
- the selected multicriteria decision aid method might be a useful instrument for evaluation the sustainability development of cities, as well as, in the light of other, well known concepts (for instance: smart cities, compact cities, etc.);
- multicriteria analysis makes it possible to identify the elements which need corrective action plans, this is particularly important at the stage of creating and updating urban development strategies and plans.

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Karol MROZIK • Piotr IDCZAK

THE CAPACITY OF ECOSYSTEM SERVICES IN SMALL WATER RETENTION MEASURES

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ABSTRCT: This study identifies and analyses ecosystem services (ES) in the context of their applicability for drought and flood prevention measures planning undertaken within the framework of small water retention. The results illustrate that ES classified as regulation and maintenance are the most significant because they, one the one hand, contribute the most to improving the flood retention capacity of river catchment areas, whilst on the other hand they provide desirable values that people derive from nature. Furthermore, we also find that the small water retention reservoir is a solution which assures both the best weather hazard prevention as well as the greatest number of benefits.

KEY WORDS: ecosystem services, small water retention, river catchment, AHP

JEL: Q25, Q57, O22

Introduction

The measures related to small water retention enable to increase the retention capacity of river areas. Their main aim is to improve the water balance of the catchment, including preventing drought and flood (Mrozik, 2012). However, for most measures it is almost impossible to determine their real impact and (in particular) the effectiveness of their impact on the volume of flow rate during a flood. Hence, from the viewpoint of flood protection, the it is small water retention reservoirs that seem to be more useful to in limited the flooding[1]. It should be also noted that besides the already mentioned regulatory and maintenance services, the small water retention also provides other valuable ecosystem services which may contribute not only to better water management and reduction of flood and drought risks but also to delivering the most beneficial outcomes of high value to society (Wagner et al. 2013). Thus, it has been necessary to shed more light on these issues in respect of a concrete river catchment.

The key questions addressed in the paper are: What kind of ecosystem services can be considered in the planning of raising the retention capacity of the river catchment? To what extent particular ecosystem services can affect the retention capacity of the river catchment and, at the same time, yield measurable social and business benefits, when implementing different measures? In order to provide answers to these questions, the authors analysed the concept of ecosystem services for Poland with a view to their possible application for measures contributing to improving the retention capacity of the river catchment.

An ecosystem approach to IWRM

Recently observed climate fluctuations coupled with such processes as urbanization and suburbanization (urban sprawl) imply an urgent need for action to maintain a balance between natural resources use and territorial development. Extreme weather conditions such as irregular and heavy rainfall patterns and intensifying droughts often result in local flooding and flash floods (Mrozik, Przybyła 2013). These intensifying events, on the one hand, constitute frequently a serious barrier to the social and economic development of communities, and on the other, seen as a result of human action, may exacerbate a the pressure on the environment, giving rise to the disappearance of ecosystems, loss of biodiversity, reduction of soil water retention

[1] According to the classification proposed by W. Mioduszewski, this group includes reservoirs with a capacity of up to 0.5 million m^3 and a damming height up to 5 m. (Mioduszewski, 2014, p. 19-29 and 2014b, p. 41-51).

capacity, soil degradation etc. In order to protect regions and localities from floods while also preserving biodiversity, sustaining natural resources and providing opportunities for human development, the combination of comprehensive mitigation and adaptation measures is needed to counteract the already emerging effects of climate change and protect against the climate change that is predicted to occur in the future. The rationale behind this is the Integrated Water Resources Management (IWRM) which is applied as a tool assuring solutions to the water crisis under conditions of human interventions as a basis for sustainable development (Mrozik et al., 2014). IWRM is defined as a process that "promotes the co-ordinated development and management of water, land and related resources, in order to maximise the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" (Handbook…, 2009). It follows that all measures aimed at improving the management of water should integrate ecological, social and economic factors in an equitable way.

Bearing in mind the above-mentioned scope of matters and the objective of this study, it is argued that IWRM should focus on safeguarding and enhancing the water storage potential of a particular area by the use of various solutions which as far as possible take account of ecosystem services. Such an ecologically orientated approach is very crucial and beneficial because places emphasis on the key role of ecosystem functions[2]. A relevant aspect of this approach is that the maintenance of diversity in ecosystems builds "resilience against large disturbances". To put it another way it might be said that the ecosystem needs an integrity understood as an ability to work further in a natural way. Measures of human action have to be taken in an adaptive manner. This means that stakeholders are aware of the fact that ecosystems are complex systems, which are "adaptive" or "self-organising" and that management systems must be able to adapt to change in the system (Jewitt, 2002).

Coming back to the matter of ecosystem functions on water, it is noted that the two basic functions can be considered which provide specific services, i.e. water regulation and water supply (Groot 2002). The former function refers to the impact of natural systems on the regulation of hydrological flows at the earth's surface. The available services offered by this function are, for example, maintenance of natural irrigation and drainage, buffering of extremes in discharge of rivers, regulation of channel flow, and provision of a medium for transportation. The letter function deals with the filtering, retention and storage of water in streams, lakes and aquifers. It is worth

2 De Groot defines ecosystem functions as "*the capacity of natural processes and components to provide goods and services that satisfy human needs, directly or indirectly*" (Groot, 1992).

mentioning that the retention and storage capacity depends on the topography and sub-surface characteristics of the involved ecosystem. Ecosystem services resulting from the supply function of water are directly related to the consumptive use of water by, for instance, households, agriculture and industry. Although these services provide vital benefits, it should not be overlooked that they are a part of the hydrological cycle. The traditional approach to water management focuses on a few selected elements of this complex system (including the control of the hydrological cycle) and, consequently, provide specific artificial services. The movement to IWRM enables to consider the complexity of the hydrological cycle more accurately (Jewitt, 2002). This is particularly important while considering the fact that the possibility of natural landscapes to mitigate the negative effects of hazardous weather events is usually neglected (Nedkov, Burkhard, 2012). Thus, the planning and management of retention areas taking into consideration the ecosystem services require a good understanding of the relationships that exist between their function and designs (Reckendorfer et al., 2013). The decision-making process should incorporate nature conservation into water retention designs. Only such an approach makes it possible to sustain the functional and vital values of nature.

Methodology

This paper provides further evidence for the debate on ecosystems services and their utility to assist flood prevention and mitigation measures, in particular as far as the small water retention is concerned. To this end, it was used a methodology that bases substantially on an qualitative the approach but elements of quantitative approach are also included. It comprises an extended literature review on ecosystems services and the application of the AHP method (*analytic hierarchy process*). This means that the approach applied in the work is twofold. Firstly, we identified those ecosystems services which can be recognized, with regard to analysed measures, as appropriate for enhancing the water retention capacity of the river catchment. To do this we used in particular the concept of ecosystem services for Poland (Mizgajski, Stępniewska, 2012). To the best of our knowledge, the ecosystems services useful for the analysed small water retention measures are presented in table 1. A prominent feature of the study is the belief that ecosystems services can be applied while planning small water retention and choosing the best actions.

Secondly, what follows, we had to examine the range of selected ecosystem services to influence the retention capacity of the river catchment and, at the same time, their impact on socio-economic well-being. All ecosystem ser-

vices and measures were considered from the main objective point of view, which was maximising the positive impact of ecosystem services in the prevention of drought and flooding. Such a complex problem needs to be addressed through the use of the multi-criteria decision making approach proposed by Saaty. AHP is a very flexible and powerful tool because combines elements of mathematics and psychology. It enables to solve the problems of decision-making which are multi-faceted and described by quantitative and qualitative elements.

AHP is based on a symbolic model that uses a multi-level hierarchical structure of objectives, criteria and alternatives. The design of the structure consists in determining the components (elements) of a problem and grouping them into homogeneous sets. Then, taking into consideration interdependencies existing between them, they are allocated and organized at appropriate levels of the hierarchical structure. In this way, a simplified model of the reality is constructed in which the individual elements of the decision problem are organised separately but at the same time in an inter-related way according to the relationships existing between them (Prusak, Stefanów, 2014). Analysis of the decision-making problem by AHP in the paper was carried out with the following steps:

- creation of multi-level hierarchical structure of the problem – at the highest level an overall objective was determined, at the lowest level alternatives (type of solutions) for reaching the objective were clarified, and at the intermediate level the decision criteria (here ES) affecting the degree of fulfilment of the objective,
- pairwise comparisons of various criteria and alternatives – data were collected from experts[3] which pointed their decision based on the Saaty's scale,
- calculations and generating results by using the software *Super Decision*,
- rating of each alternative (solutions) – classification of particular solutions in the light of the adopted criteria in terms of their contribution to achieving the overall objective and indicating the best solution.

Description of the research area

A research area allowing the application of AHP and enabling to make the brest decision was the Skórzynka river catchment. It is located within the administrative borders of two rural communes Dopiewo and Tarnowo

[3] In the analysis the opinions of six experts (specialists in the field of water management, environmental engineering, environment protection and development, spatial planning and economics and management) were used. The aggregation of the results was based on behavioural methods (Prusak, Stefanów, 2014, p. 212-217).

Podgórne and the city of Poznań. The Skórzynka river catchment (of 10 km^2 total area) covering 21% of the area of its recipient – the Potok Junikowski – is characterised by an intensive suburbanization manifested by, among others, a dynamic increase of built-up and urban areas at the expense of agricultural land. Residential areas with industrial, service development and transport areas occupy 54%, and agricultural land only 31% of the catchment area. Skórzynka is a tributary of Potok Junikowski which is a surface water body (code PLRW60001718576) in the Warta water region. In turn, Potok Junikowski is defined a heavily modified water body and its state was assessed as bad. Moreover, it is at risk of failing to achieve environmental objectives set out in the Water Framework Directive. In addition, the Skórzynka river catchment is located within a region with the highest needs of developing water retention and the greatest need for irrigation. On the other hand, flooding and droughts are here common natural disasters (Mrozik, 2016, Mrozik et al., 2015).

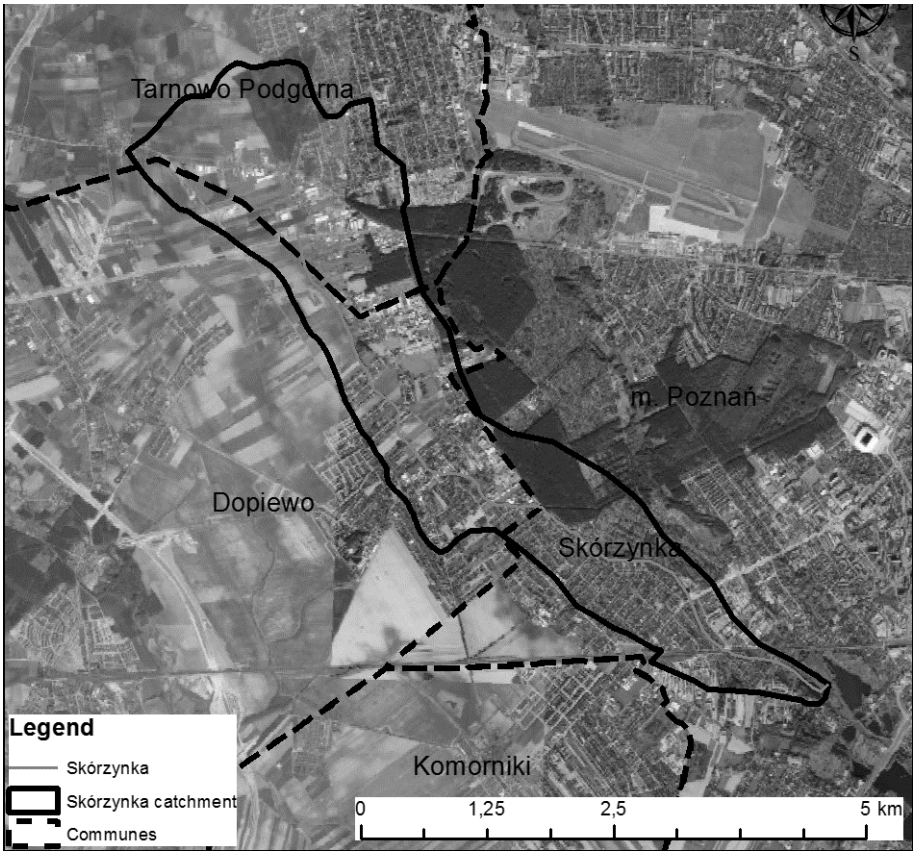

Figure 1. Location of Skórzynka catchment

Source: author's own work.

Results and discussion

In the paper three types of actions (measures) in a small water retention area were constructing: constricting a small water retention reservoir (V=15000 m^3), agrotechnical measures (72 ha) and rainwater harvesting systems (total volume = 15000 m^3) (Idczak, Mrozik, 2015). These solutions were analysed in the context of ecosystem services that are adequate to deal with small water retention measures, as shown in table 1.

Table 1. Ecosystem services related to small water retention measures*

	Ecosystem services	Small water retention reservoir	Agrotechnical measures	Rainwater harvesting systems
Provisioning	Fish (wild populations)	1	0	0
	Aquaculture products	1	0	0
	Drinking water	0	0	0
	Domestic water use	0	0	2
	Irrigation water (consumptive)	2	0	0
	Cooling water (non consumptive)	1	0	0
	Genetic resources	1	0	0
Regulation & Maintenance	Dilution, decomposition, remineralisation and recycling	1	1	0
	Attenuation of runoff and discharge rates	1	2	1
	Water storage for flow regulation	2	1	1
	Local & Regional climate regulation	2	1	1
	Water purification and oxygenation	1	1	0
	Biological control mechanisms	1	1	0
	Maintaining nursery populations	1	1	0
Cultural	Landscape character	2	1	0
	Cultural landscapes	2	1	0
	Wilderness, naturalness	1	1	0
	Charismatic or iconic wildlife or habitats	1		0
	Prey for hunting, fishing or collecting	1	0	0
	Scientific	1	0	0
	Educational	1	0	0

* relevance degree of ES to be considered in small water retention measures: 0 – none, 1 – low, 2 – high
Source: author's own work.

The main aim is, certainly, increasing the retention which should contribute to a reduction of the risk of flood or drought, and the improvement of water balance in the catchment. However, other services provided by the examined measures cannot be overlooked.

The aim of soil retention is possibly the permanent stoppage of the rain water in the soil and sustaining and enhancing local water balance. Infiltration of rain water is a significant factor in shaping the surface of ground water. A longer staying of water in soil causes, in turn, a better cleansing of the waters. Additionally, if infiltration is increased, evapotranspiration will be increased. Since evapotranspiration is connected to retention, it has an impact on the bioclimatic equalising functions of the landscape and balances the mesoclimate (Mrozik, Przybyła, 2013).

What clearly emerges from table 1 are the differences between the agrotechnical measures and the small water retention reservoir and also the rain water harvesting system. A possibility of the development of tourism and, especially, recreation on and around small reservoirs is crucial from the ecosystem services point of view. A landscape which lacked lakes, is enriched. The reservoir enables also fishing. In the case of rain water harvesting systems these are noteworthy seen as water resources to be used for household purposes.

In the second step the procedure based on AHP was applied to choose those ecosystem services as well as those measures which in the best possible way contribute to the achievement of the objective set in the study. To put it in other words, the objective was to determine the kind of measures enhancing the retention capacities of the Skórzynka river catchment which enable society to maximise the benefits provided by the ecosystem services. However, in order to make a complex decision, it needs to structure the decision hierarchy descending from the overall objective of the decision, through the various criteria on which subsequent elements depend to the lowest level, setting out all the alternatives concerned, as shown in Figure 2. Categories of ES were used as criteria (attributes) represented at the intermediate level which were to determine the decision. In turn, measures referring of the alternatives of a decision were laid down at the last level of the hierarchy.

Once the hierarchy was structured, the pairwise comparisons of various criteria and alternatives were taken to determine the relative importance of each alternative in terms of each criterion. In such a way the weights for the different criteria as well as alternatives were computed. These actions consisted in quantifying the linguistic choices of the decision makers by using Saaty's scale and in determining the priority vectors. Finally, the rating of each alternative was multiplied by the weights of the criteria and aggregated to get the final ratings. The results are displayed in table 2.

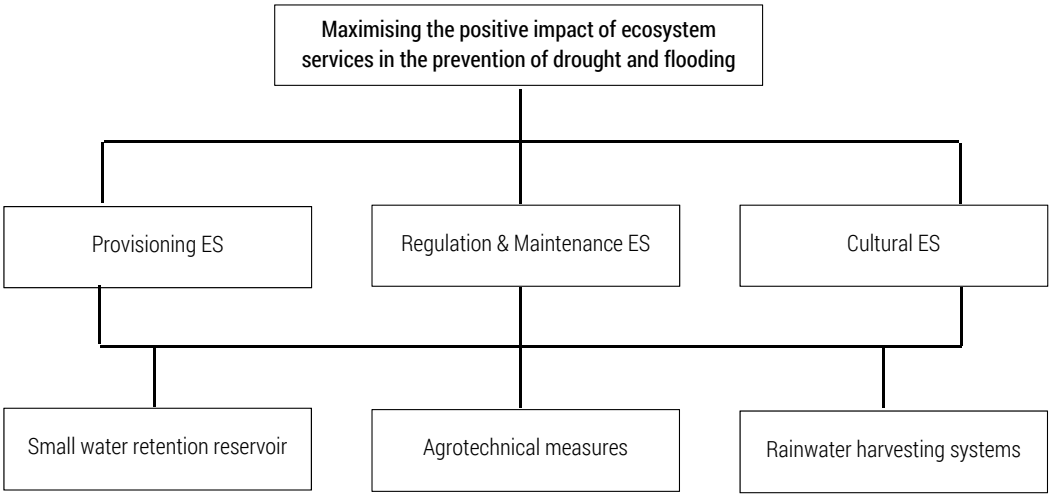

Figure 2. A hierarchical structure of the decision problem

Source: author's own work.

Table 2. Synthetic indicators of the AHP analysis

Name of solutions	Ideal indicator	Weight indicator	Rank
Small water retention reservoir (SWRR)	1,0000	0,6802	1
Agrotechnical measures	0,2855	0,1942	2
Rainwater harvesting systems	0,1846	0,1256	3

Source: author's own work.

The evidence provided by the AHP analysis show that the solution with the highest priority in the light of the adopted criteria is the small water retention reservoir. This also implies that the SWRR compared with the other technically feasible alternatives has the highest contribution to the achievement of the objective pursued, i.e. reaping the greatest benefits from the ES taken within actions against the drought and flooding in the Skórzynka river catchment. To some extent, this might point out that a technical measure such as SWRR counted among the elements of the hydro-technical system, i.e. caused by human activities, can provide, in the case at hand, the most benefits that people derive from nature. However, this should come as no surprise because nowadays actions taken by humans are designed with the highest respect for the environment to restore the natural and water-dependent ecosystems, which have been damaged by anthropogenic activities. Hence, all activities aimed at increasing the potential retention capacity of a river catch-

ment including SWRR, to some extent, are the most important regulating ecosystem services that may increase or reduce the negative effects of water-related disasters (see table 1). This finding is in line with the literature (Boyd, Banzhaf, 2007; Chee, 2004; Fisher et al., 2009) showing that in particular regulating ecosystem services ensuring protection against flood can generate benefits in terms of flood-damage mitigation, moderation of weather events, regulation of the hydrological cycle and, finally, the protection of human properties.

Conclusions

What follows from this study is an evidence confirming the prominent role of ES in the field of water retention measures planning aimed on the one hand at preventing and mitigating floods, and on the other at hand conserving water in natural hydro-technical systems to alleviate the effect of droughts. The findings obtained based on the Skórzynka river catchment area highlight the importance of ES and their varied impact on the environment and socio-economic well-being depending on the particular water retention measures considered. To be more precise, the largest number of ES can be provided by SWRR. Moreover, this solution ranks also first among the three investigated alternatives in terms of a simultaneous provision of the highest number of ES and ensuring the highest level of protection against flood and droughts. By referring to these results it is possible to argue that in the research area of the paper SWRR is the best option to be used in counteracting a drought and flooding. But this conclusion is contrary to another study which indicates that the best solution leading to the improvement of the water retention capacity of the Skórzynka river catchment is agrotechnical measures, which should be seen as a priority in programs for adapting to climate changes (Mrozik, Idczak, 2016). It should be noted, nevertheless, that the referenced study focused on the decision-making under certain conditions including, amongst other matters, different criteria. This does not change the fact, however, that, when comparing both studies, it is vital to make an in-depth and complex analysis that allows to assess all the potential costs and benefits resulting from the use of different measures. There is also a need for further research to address the potential trade-offs of planned solutions (i.e. benefits from increased natural water retention versus losses in other services).

Discussing the results further, it is noteworthy that the restoration of the natural water capacity of an each river catchment should be regarded prior to human activity. This is even more crucial as the Skórzynka river catchment

covers an area that is highly influenced by urbanization. It is highly unlikely that under such conditions the natural capacities of the catchment can be restored or maintained without substantial additional investments into infrastructures (Arnbjerg-Nielsen, Fleischer, 2009). With all this, in mind the approach presented in the paper focuses on the ecosystem service concept's implementation into the decision making. This holistic approach addresses the cost-benefit-efficient multifunctional water retention measures.

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The contribution of the authors

Karol Mrozik – 50%
Piotr Idczak – 50%

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STUDIES AND MATERIALS

STUDIA I MATERIAŁY

Natalia ŚWIDYŃSKA

SUSTAINABLE DEVELOPMENT OF INVESTMENT-ATTRACTIVE OF WARMINSKO-MAZURSKIE PROVINCE

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ABSTRCT: The objective of this paper is to demonstrate the relationships between the level of potential investment attractiveness of municipalities and their development proceeding in a sustainable manner. The study involved municipalities located in Warmińsko-Mazurskie province. In order to determine the level of their potential investment attractiveness, Z. Hellwig's method of development pattern was employed, while in order to develop a synthetic index of development based on the index of sustainable development, the absolute measure of development was applied. The obtained results enabled a conclusion to be drawn that the most investment-attractive municipalities are those developing in a sustainable manner.

KEY WORDS: potential investment attractiveness, sustainable development, Warmińsko-Mazurskie province

Introduction

Each region is characterised by a certain level of territorial attractiveness understood as the region's ability to attract new entities i.e. investors, tourists, and inhabitants. The level of this attractiveness is determined by how well a particular region is endowed with economic, social, and environmental values. One of the elements of territorial attractiveness is investment attractiveness understood as the ability to persuade investors to locate investments within a particular area. As regards investment attractiveness, both real and potential investment attractiveness is distinguished. Real investment attractiveness is "a region's ability to satisfy an investor, and to induce absorption of financial and physical capital in the form of investments. It may be measured by assessing the effectiveness of incurred financial, physical, human, and natural capital expenditures" (Godlewska-Majkowska). Potential investment attractiveness is "a set of regional location advantages that contribute to the achievement of an investor's objectives" (Godlewska-Majkowska). According to the methodology of the Institute of Enterprise at the Warsaw School of Economics, an index of potential investment attractiveness for municipalities (PAI1) is calculated based on five so-called microclimates: labour resources, social infrastructure, technical infrastructure, market, and administration (Godlewska-Majkowska). This study investigates the level of potential investment attractiveness, which may be considered equivalent to the potential present in a region.

As already mentioned, investment attractiveness is one of the elements of territorial attractiveness of a particular area. The elements, which determine the level of investment attractiveness, are a combination of a variety of values. These values may be equated with particular orders distinguished within the framework of sustainable development: economic values – economic order; social values – social order; and environmental values – environmental order.

The objective of this paper is to demonstrate the relationships between the level of potential investment attractiveness of municipalities and their development proceeding in a sustainable manner.

Subject of the study

The study involved municipalities of Warmińsko-Mazurskie province, which account for 14% of all *gminas* (both urban and rural) of the province. The municipality with the highest population density is the municipality of Ełk, while the one with the lowest population density is the municipality of

Lubawa. The municipality with the largest area and population is the municipality of Olsztyn, while the municipality with the smallest area and population is the municipality of Górowo Iławeckie (table 1).

Table 1. Characteristics of the municipalities under study

Municipality	area	population	population density
	[ha]	[people]	[people per km^2]
Braniewo	1 241	17 161	1430
Działdowo	1 147	21 402	1946
Iława	2 188	33 174	1508
Lubawa	1 684	10 083	593
Nowe Miasto Lubawskie	1 137	11 101	1009
Ostróda	1 415	33 517	2394
Elbląg	7 982	121 642	1521
Ełk	2 105	60 462	2879
Giżycko	1 372	29 726	2123
Bartoszyce	1 179	24 196	2200
Górowo Iławeckie	332	4 140	1380
Kętrzyn	1 035	27 732	2773
Lidzbark Warmiński	1 435	16 200	1157
Mrągowo	1 481	22 005	1467
Szczytno	1 062	23 992	2181
Olsztyn	8 833	173 444	1971

Source: author's own work based on (Bank of Local Data, 2015).

The average area of the municipalities under study is 2227 ha, the population is 39374 people, and the population density is 1783 people per km^2. The areas of only two municipalities (Olsztyn and Elbląg) exceed the average area. The smallest municipality (Górowo Iławeckie) occupies an area accounting for only 15% of the largest municipality's area.

Materials and research methods

In order to determine the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province, indices were distinguished for particular microclimates determining its level, and then divided into

stimulants and depressants. The indices whose higher values indicate a higher level of development should be considered as stimulants, while the indices whose lower value indicates a higher level of development should be considered as depressants (Sławińska, 2014, p. 117). For the five microclimates, namely labour resources, technical infrastructure, social infrastructure, market, and administration, a total of 39 indices were distinguished, of which 32 are stimulants, and 7 are depressants (table 2).

Table 2. Indices of potential investment attractiveness of municipalities

Microclimate	Index	S/D
Labour resources microclimate	number of persons employed per 1000 people	S
	percentage of persons employed in the working age population	S
	nett migration rate per 1000 people	S
	nett international migration rate per 1000 people	S
	expenditures from the municipality budget on schooling and education per person	S
	expenditures from the municipality budget on culture and national heritage protection per person	S
	percentage of the working age population in the total population	S
	percentage of the registered unemployed in the working age population	D
	non-working age population per 100 people of working age	D
	retirement age population per 100 people of pre-working age	D
	retirement age population per 100 people of working age	D
Technical infrastructure microclimate	surface area of roads' proportion in the municipality area	S
	surface area of railways' proportion in the municipality area	S
	percentage of people using water supply network in the total population	S
	percentage of people using the sewerage network	S
	percentage of people using the gas supply network in the total population	S
	water supply distribution network per 100 km^2	S
	sewerage distribution network per 100 km^2	S
	gas supply distribution network per 100 km^2	S
	expenditures from the municipality budget for transport and communication per person	S

Microclimate	Index	S/D
Social infrastructure microclimate	average floor space of 1 flat	S
	average floor space of a flat per person	S
	number of flats per 1000 inhabitants	S
	expenditures from the municipality budget on schooling and education per person	S
	expenditures from the municipality budget on culture and national heritage protection per person	S
	expenditures from the municipality budget on health care per person	S
	percentage of primary schools equipped with computers with Internet access for schoolchildren	S
	libraries' book collection per 1000 people	S
	children aged 3-5 years old per one place in an institution of pre-school education	D
	population per 1 library	D
Market microclimate	population density	S
	own income – share in taxes constituting the income of the State budget, personal income tax	S
	own income – share in taxes constituting the income of the State budget, corporate income tax per one employed person	S
	percentage of the area of special economic zones in the municipality area	S
	percentage of the area of legally protected areas in the municipality area	D
Administration microclimate	share of own income in the total income of the municipality budget	S
	percentage of the area included in the area development plan in the municipality area	S
	European Union funds for financing EU programmes and projects per person	S
	funds for co-financing own tasks, acquired from other sources, per inhabitant	S

Source: author's own work based on (Nowicki, 2014; Godlewska-Majkowska, 2009; Godlewska-Majkowska, 2010).

In order to develop a synthetic index of the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province, Z. Hellwig's method of development pattern was employed. The first step to developing a synthetic index of the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province was to generate an observation matrix. The next steps were as follows (Stec, 2011, p. 232-251):

1. standardisation of the characteristics' values x_j, according to the following formula:

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{S_j},$$

where:
z_{ij} – standardised values
x_{ij} – output value of the characteristic
$\bar{x}_j$ – arithmetic mean of the characteristic
S_j – standard deviation of the characteristic

2. determination of maximum values (for stimulants) and minimum values (for depressants) of the analysed characteristics:
z_{oj} = max i z_{ij}, for the variables, which are stimulants
z_{oj} = min i z_{ij},, for the variables, which are depressants

3. calculation of Euclidean distances D_{io}:

$$D_{io} = \sqrt{\sum_{j=1}^{m} (z_{ij} - z_{oj})^2}$$

4. calculation of the arithmetic mean ($\bar{D}_o$) and standard deviation (S_o) for the sequence of values D_{io}
5. calculation of the value $\bar{D}_o = \bar{D}_o + 2S_o$
6. determination of the value of the measure of development

$$d_i = 1 - \frac{D_{io}}{D_0}$$

The values obtained by Z. Hellwig's method fall within the range of [0–1], with the values closer to 1 indicating a higher level of development, and the values closer to 0 indicating a lower level of development (Pomianek, Chrzanowska, Bórawski, 2013, p. 442-456).

Table 3. Indices of sustainable development of municipalities

Order	Index
Environmental order	forest ratio
	percentage of naturally restocked and afforested areas in the total area of forests
	total water consumption in households per 1 inhabitant
	percentage of people using water supply network in the municipality population
	percentage of people using the sewerage network in the municipality population
	percentage of people using sewage treatment plants in the municipality population
Economic order	water supply network per 100 km2
	sewerage network per 100 km2
	gas supply network per 100 km2
	economic operators per 1000 inhabitants of working age
	own income of the municipality budget per 1 inhabitant
	expenditures from the municipality budget per 1 inhabitant
	proportion of investment expenditures in total expenditures of the municipality budget
	proportion of agricultural land in the municipality area
	proportion of arable land in the area of agricultural land
Social order	non-working age population per 100 people of working age
	natural population growth
	average floor space of a flat per person
	average number of people per 1 habitable room
	number of persons employed per 1000 inhabitants
	percentage of the registered unemployed in the working age population
	percentage of persons employed in the total population
	expenditures from the municipality budget on schooling and education per 1 inhabitant

Source: author's own work based on (Borys, 2005; Adamowicz, Smarzewska, 2009).

The next step of the study was to distinguish indices of sustainable development for environmental, economic, and social orders. A total of 23 indices were distinguished (table 3).

In order to determine the level of development of municipalities of Warmińsko-Mazurskie province based on indices of sustainable development, M. Cieślak's absolute measure of development (m_{it}) was applied, which is calculated as follows (Krakowiak-Bal, 2005, p. 7-82):

$$m_{it} = \sum_{j=1}^{m} y_{ij}^{\prime t} ,$$

(i= 1,2,…,k; t=1,2,…,T),

where $y_{ij}^{\prime t}$ is a normalised value of the characteristic

$$y_{ij}' = \frac{y_{ij}}{S_j},$$

where:
y_{ij} – value of the characteristic
S_j – standard deviation of the characteristic

This method lacks a pattern of any kind, and the place of the studied municipality is determined by the value of characteristics and their standard deviation indicating the average variation of the characteristics' values (Krakowiak-Bal, 2005, p. 7-82).

Results of the research

The data accepted for the study originated from the Central Statistical Office Bank of Local Data, and relate to the year 2015.

Prior to the study, the variables were subjected to statistical verification due to the obtained value of the coefficient of variation. Only those variables for which the value of the coefficient of variation was higher than 10% were accepted for analysis. Consequently, three indices were excluded from the study of the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province, namely: the percentage of the working age population in the total population, non-working age population per 100 people of working age, and retired age population per 100 people of pre-working age. In turn, in the study into the level of development of municipalities based on the indices of sustainable development, 6 indices were omitted, namely: the percentage of people using water supply network in the municipality population, the percentage of people using the sewerage network in the municipality population, the percentage of people using sewage treatment plants in the municipality population, average floor space of a flat per person, average number of people per one habitable room, and non-working age population per 100 people of working age.

Table 4. A synthetic index of the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province

municipality	d_i	municipality	d_i	municipality	d_i	municipality	d_i
Bartoszyce	0.14	Ełk	0.16	Kętrzyn	0.21	Nowe Miasto Lubawskie	0.00
Braniewo	0.07	Giżycko	0.15	Lidzbark Warmiński	0.15	Olsztyn	0.36
Działdowo	0.24	Górowo Iławeckie	0.05	Lubawa	0.18	Ostróda	0.20
Elbląg	0.17	Iława	0.17	Mrągowo	0.20	Szczytno	0.18

Source: own work based on the (Bank of Local Data, 2015).

The application of Z. Hellwig's method of development pattern enabled the development of a synthetic index of the level of potential investment attractiveness for each municipality of the Warmińsko-Mazurskie province (table 4). The most potentially investment-attractive municipality among those involved in the study is the municipality of Olsztyn, and the least potentially investment-attractive one is the municipality of Nowe Miasto Lubawskie.

The application of the absolute measure of development enabled the development of a synthetic measure of development for each municipality of Warmińsko-Mazurskie province (table 5). Based on the indices of sustainable development accepted for analysis, the most developed municipality of Warmińsko-Mazurskie province is the municipality of Olsztyn, and the lease developed one is the municipality of Braniewo.

Table 5. Synthetic measure of development of municipalities of Warmińsko-Mazurskie province

municipality	m_{it}	municipality	m_{it}	municipality	m_{it}	municipality	m_{it}
Bartoszyce	54.68	Ełk	52.80	Kętrzyn	58.98	Nowe Miasto Lubawskie	53.89
Braniewo	49.40	Giżycko	51.08	Lidzbark Warmiński	57.30	Olsztyn	76.23
Działdowo	60.97	Górowo Iławeckie	54.03	Lubawa	59.81	Ostróda	53.37
Elbląg	58.39	Iława	53.32	Mrągowo	59.48	Szczytno	56.87

Source: own work based on the (Bank of Local Data, 2015).

The Pearson product-moment coefficient of correlation between the index of potential investment attractiveness and the index of development of municipalities of Warmińsko-Mazurskie province indicates a strong positive correlation (r=0.79) – municipalities at a high level of development are, at the same time, potentially investment-attractive municipalities, and municipalities at a low level of development are municipalities of little potential investment attractiveness.

The calculated indices enabled the municipalities of Warmińsko-Mazurskie province to be ranked in terms of their potential investment attractiveness and the level of development (table 6). Figure 1 presents the places taken by particular municipalities.

Table 6. Rankings of municipalities of Warmińsko-Mazurskie province in terms of the level of potential investment attractiveness and the level of development

Municipality	d_i ranks	m_{it} ranks	Municipality	d_i ranks	m_{it} ranks
Bartoszyce	13	9	Kętrzyn	3	5
Braniewo	14	16	Lidzbark Warmiński	11	7
Działdowo	2	2	Lubawa	6	3
Elbląg	9	6	Mrągowo	5	4
Ełk	10	14	Nowe Miasto Lubawskie	16	11
Giżycko	12	15	Olsztyn	1	1
Górowo Iławeckie	15	10	Ostróda	4	12
Iława	8	13	Szczytno	7	8

Source: author's own work.

Based on the obtained ranks, the strength and direction of the interdependence between the potential investment attractiveness of municipalities of Warmińsko-Mazurskie province and the level of their development were determined. To this end, Spearman's rank correlation coefficient was applied, the result of which r_s=0.67 indicates the occurrence of a strong positive correlation.

Summary

There is an apparent strong relationship between the level of potential investment attractiveness of municipalities of Warmińsko-Mazurskie province and the level of their development, determined on the basis of indices of sustainable development. The two most developed municipalities, namely Olsztyn and Działdowo, are also municipalities with the highest level of

potential investment attractiveness. The greatest difference between the ranks of the two presented indices amounts to 8 and relates to the municipality of Ostródawhich only takes the 12th place in terms of the level of development, and the 4th place in terms of the level of potential investment attractiveness.

Based on the obtained results, a conclusion may be drawn that the investment-attractive municipalities are those characterised by a high level of socio-economic development.

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Ewa **OŁDAKOWSKA**

RESEARCH OF ECONOMICAL EFFICIENCY OF ROAD PROJECTS

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ABSTRACT: The guidelines and recommendations for the assessment of economic efficiency of road and bridge projects are specified in two documents: "Blue Book" in range of road infrastructure projects, and in "Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads". The result of works connected with analysis of road investments should be the documents referring to all possible issues discussed in mentioned books. The article is aimed for presenting the successive steps and assessment of economic efficiency of road projects.

KEY WORDS: cost-benefit analysis, assessment of the economic effectiveness of road and bridge projects

Standards of economic assessment of efficiency of road investments

The article is aimed for presenting the successive steps and assessment of economic efficiency of road projects. In Poland two standards are used in case of assessment of economic efficiency of road and bridge projects. They are included in two separate documents: "Blue Book" in range of road infrastructure projects, and in "Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads".

The "Blue Book" is recommended by the Ministry of Infrastructure and Development in order to unify the methods of analysis of costs and advantages of the transport sector projects, realized in range of "Infrastructure and Environment Programme", which total value of qualified costs exceeds 75 millions of EUR. The guidelines included in the "Instructions for economic efficiency assessment" make the accuracy of realized economic analyses dependent on the road type, dividing it into the regional, district, and local roads.

The "Guide for analysis of costs and advantages of investment projects", being a tool of the economic analysis of cohesion policy for years 2014-2020, presents the analytical range of standard analyses of "large projects", including roads, which should include seven stages (Guide for analysis of costs and advantages of investment projects, 2014):

1 – context description,
2 – definition of goals,
3 – identification project,
4 – technical feasibility and environmental sustainability,
5 – financial analysis,
6 – economic analysis,
7 – risk assessment.

(1) *Description of the social, economic, political, and institutional context in which the project will be realized.* The investments which offer services for citizens may realize their goals through including new or modernized objects to the existing infrastructure. It is therefore necessary to cooperate with various stakeholders operating in the system range. Appropriate economic policy, suitable institutions, and strong political engagement may help in realization of some projects and managing them in order to achieve higher advantages.

Construction of roads in Poland reinforces the integrity of our country with other countries of the European Union, supports the international transport, creates better conditions for the efficient and safe traffic flow in

the European transport corridors, facilitates the mobility of goods and services by increasing the traffic safety, and activates the economic expansion of a region and country through better transport services.

(2) *Definition of goals.* The basic premise for realization of transport projects is the necessity of solving the existing or foreseen transport problems or fulfilling the existing or foreseen transport needs, as well as forming the demand for transport towards the sustainability. While defining the goals of a single project it is required to present their cohesion with the goals included in the transport strategy, and having such strategy (on the national and/or regional level, appropriate for a given project) is one of ex-ante conditions for applying for financing the project from the EU funds for 2014-2020 (Blue Book, 2015). The medium for achieving the goals of the road project is usually the improvement of condition of existing road, removing and limiting overcrowding, bypassing the built-up area, reducing the number of accidents, etc.

(3) *Project identification.* The project is defined as a "series of works, activities, or services aimed for realization of the indivisible task of specified economic or technical character, having clearly defined goals". Each goal connected with development of the road infrastructure may be achieved in numerous ways, which means multiple possible realization variants, from which the most promising one is selected. All investment variants are compared with the input variant of costs and advantages analysis, i.e. with the non-investment variant (Blue Book, 2015). The non-investment variant is a variant describing the level of foreseen costs and efficiency of infrastructure when no investment variant is realized, which means that the costs of periodical and partial repairs, as well as costs of current maintenance must be anticipated, allowing for assuring the minimum standard of maintenance and operation of the road infrastructure. The investment variants, beside the costs of maintaining the new or renovated section, are also characterized by the investment outlays to be incurred during the first year and possibly in the next years. The investment outlays are divided into: preparation works, dewatering of the road embankment, realization of substructure layers, works connected with realization of upper layers of the pavement structure, finishing works, realization of traffic safety devices, elements of streets, road greens, engineering objects, realization of street lamps, removal of collisions (rebuilding of gas, sewage, water, power, and telecommunication networks, etc.), and others. Selected variants should be described with use of key parameters, like length, designed speed, roadway width, cross section, etc.

(4) *Technical feasibility and environmental sustainability*. The feasibility analysis is aimed for identifying the alternative investment solutions which may be considered feasible mainly in the technical, economic, environmental,

and institutional range. In particular it is required to prove in what range the project (Guide for analysis of costs and advantages of investment projects, 2014):

- contributes in achievement of goals in range of efficient resources management and climate changes for 2020;
- conforms to the directive regarding prevention and rectification of the natural environment damages;
- follows the rule "the polluting party pays", the prevention rule, and the repair rule mainly at the source;
- conforms to protection of areas Nature 2000 and protection of species covered by the habitats directive and the birds directive;
- is realized as a result of plan or programmed covered by the strategic assessment of environmental influence;
- conforms to the directive on the assessment of the effects on the environment, as well as other regulations including the requirement of such assessment.

The roads location areas should be selected in a way minimizing the potential ecological conflicts and avoiding the direct collisions with areas covered with environmental protection. In the situations of excessive interference with environment, resulting from the character of road investments, it is required to use the environmental compensation reducing the negative influence on environment and compensating the environmental losses (Act from 27.04.2001, Environment Protection Law). In case of particularly heavy influences use the technical measures reducing those influences. In order to limit e.g. negative influence of rain and snow melt sewage on the natural environment it is required to design the solutions limiting the possibility of their penetration to the underground and surface waters. In order to improve the acoustic climate use the road tunnels, anti-noise covers, or acoustic screens.

(5) *Financial analysis.* Range of the financial analysis includes determination of the project financial efficiency indices values, verification of the project financial durability, and determination of appropriate (maximum) financing from the EU funds. It is usually realized from the infrastructure owner's point of view. In order to determine the financial efficiency indices and calculate the financing gap the financial analysis uses the method of discounted flow of financial means. The analysis of financial durability is aimed for verification if the financial resources are sufficient for covering all financial expenses, year after year, during the whole reference period. The financial durability of an investment is confirmed when the cumulated net cash flow are not negative in any of analysed years.

(6) *Economic analysis* is the assessment of project contribution in the prosperity (Guide for analysis of costs and advantages of investment projects, 2014). It includes the quantitative and financial expression of costs and calculation of the net economic advantages upon the basis of so called the increment method. Such approach requires preparation of the forecast of the economic flows for the non-investment variant, preparation of the forecast of the economic flows for the project realization variant, and then determination of differences in the flows between those scenarios. Generally the economic advantages are the difference between the total economic costs in the non-investment variant and the analogical costs in one of investment variants.

Skilful and precise estimation of the investment outlays is the basis for the ANALYSIS OF COSTS AND ADVANTAGES. For the road projects it is recommended to divide them into the categories including the documentation and technical assistance costs, investor's supervision costs, archaeological costs, project promotion costs, road works costs, "contract-related" costs, and reserves for the non-foreseen works.

(7) *Risk assessment* is an activity aimed for avoiding the uncertainty accompanying the investment projects. The recommended stages of the risk assessment (Blue Book, 2015) include: risk identification, risk qualitative analysis, preventive actions and their allocation, monitoring, and risk quantitative analysis.

The procedure of the economic assessment of the road and bridge projects is a procedure (Instructions for economic efficiency assessment..., 2008) based upon CBA method, taking into consideration the advantages of users of analysed investment and the road costs (construction, repairs, maintenance).

The economic analysis of costs and advantages presented in (Instructions for economic efficiency assessment..., 2008) includes comparison of two incremental economic flows:

- net road and bridge costs – NC,
- net savings of users and environment – NB.

The difference of NB and NC flows gives the net value NV being the basis for calculation of the investment economic efficiency measures.

The calculation of economic efficiency is realized upon the basis of independently prepared input data and the parameters of elements being a part of the economic account including:

- traffic measurement and calculation of the average daily traffic,
- forecast of the average daily traffic,
- travel speed,
- road costs,
- vehicle operational costs,

- time costs in the passenger transport,
- time costs in the cargo transport,
- costs of the road accidents,
- costs of emission of the toxic components of exhaust gases,
- costs of users and environment.

The sensitivity analysis is the supplementary stage in the assessment of road and bridge investments. The research include the investment costs only. The research details level depends directly on the investment location. In case of investments out of the cities administrative limits the investment costs increase by 15% is analysed, and in case of investments in the city areas it is required to analyse the investment costs increase by 25%.

Economic indices of efficiency

Realization of the economic assessment of projects, not only the road ones, is possible after determination of the following economic indices of efficiency (Guidelines in range of problems connected with preparation of investment projects, 2015):

a) economic net present value (ENPV), which should be higher than zero,
b) economic rate of return (ERR), which should exceed the assumed discount rate,
c) relation of discounted advantages to discounted costs (NB/NC), which should be higher than one.

The economic net present value (ENPV) is the difference between the total discounted advantages and costs connected with the investment. It is recognized that the project is economically efficient when the economic net present value index is positive. In case of projects where it is not possible to determine ENPV due to their character there is a possibility of realizing the cost efficiency analysis.

The economic rate of return is equal to the assumed discount rate. In case when ERR is higher than the assumed discount rate, ENPV is negative, i.e. the present value of future economic advantages is lower than the present value of project economic costs. When the economic internal rate of return is lower than used discount rate, the project is not economically efficient.

The NB/NC index (advantages/costs) is determined as a relation of summarized advantages to the summarized discounted costs generated in the reference period. It is recognized that the investment is efficient when NB/NC index is higher than one, i.e. value of advantages exceeds value of investment costs.

In case of road projects not considered "large" it is recommended to realize the economic analysis in the simplified way, upon the basis of estimation of the quantitative and qualitative results of realization of a given project.

Analysis of costs and advantages

Analysis of costs and profits is an assessment of investment projects where costs and profits for the society as a result of investment realization are taken into consideration. The analysis is based upon the assumption that in order to increase the social prosperity it is required to realize not only the economically efficient and financially profitable, but also the economically efficient and financially non-profitable, which financial profitability is achieved with use of public funds (Rudnicki, 2005, p. 332). That method is obligatory in case of applying for financing of large projects from the EU funds.

The analysis of costs and advantages may be realized in a time preceding the decision of accepting or rejecting the project (*ex ante* analysis). The basic problem of such analysis is high risk of errors connected with assessment of many aspects included in the final result, and its advantage – the possibility of abandoning or interrupting the investment which might cause big losses for society. The second type of analysis is *ex post* analysis, which is realized after the project is finished in order to assess it. The third type of analysis is *in media res* analysis, i.e. analysis realized during the project realization (Boardman et al., 2001, p. 3).

The process of CBA analysis is realized according to strictly defined rules including the project financial analysis, as well as social and economic analysis (also called the economic analysis or social and economic analysis). The social and economic analysis may have a form of the investment costs and advantages balance. It is then called the qualitative social and economic analysis. However, the investment effects for society and environment may be also quantified (express with use of enumerable parameters) and monetized (converted into money). The monetized social and economic effects are added to the properly prepared account of flows from the financial analysis. It is then called the quantitative analysis of costs and advantages. The quantitative methodology of CBA allows to determine the values of the investment economic efficiency indices (Archutowska et al., 2016, p. 9).

Assessment of economic efficiency of the investment task consisting in rebuilding the national road to the major road standards

The analysis of costs and advantages is the comparison of the project scenario for the investment variant (WI) with the base scenario for the non-investment variant (W0). In order to determine the indices of the economic assessment for the investment task consisting in rebuilding the national road to the major road standards (the required technical data are presented in table 1) the following assumptions have been made:

Table 1. Technical data of the national road rebuilt to the major road standards

No.	SPECIFICATION	UNIT	W0	WI
1	*2*	*3*	*4*	*5*
1	National	-	ROAD	
2	Segment length	[km]	22.2	
3	Terrain type	-	FLAT	
4	Road type	-	COUNTRY ROAD	
5	Road class	-	S	
6	Number of roadways	[pcs]	1	2
7	Number of roadway lanes	[pcs]	2	2
8	Roadway width	[m]	6.50	7.00 emergency lane 2.50
9	Shoulder width	[m]	1.50	0.75
10	Average allowable speed	[km/h]	90	120
11	Pavement technical condition acc. To sosn		B	A
12	Bus bays		yes	yes
13	Traffic character		ECONOMIC	
14	Investment start year	[year]	-	2009
15	Investment end year	[year]	-	2012
16	Investment net cost	[PLN]	-	884,477,342
17	Traffic category	[KR]	6	6
18	Bridge objects	[CONDITION]	4	5

Source: author's own work.

- reference period – 25 years (for the road projects; since the construction beginning, in this case years 2009-2034),
- year consists of 365 days.

In order to define the values of indices of the economic assessment the recommended forms have been prepared: traffic forecast, road costs, vehicle operational costs, time costs in the passenger transport, time costs in the cargo transport, costs of the road accidents, costs of emission of the toxic components of exhaust gases, cumulative summary of costs of users and environment, economic analysis if outlays and advantages, values, and economic indices (table 2). The forms include costs for both variants: W0 and WI**.** The road net costs and savings for users and environment have been calculated for all years of the analysed period.

Table 2. Values and economic indices for the investment task consisting in rebuilding the national road to the major road standards [thousands of PLN]

DESCRIPTION		VALUE OR INDEX FOR DISCOUNT RATE r			
		0,02	0,04	0,06	0,08
1		*3*	*4*	*5*	*6*
NC	Discounted investment net cost	-1 106 447,36	-1 019 179,79	-952 022,77	-898 805,58
NB	Discounted savings of vehicles operational net costs	337 443,85	246 606,03	183 927,28	139 885,92
	Discounted savings of time net costs in passenger transport	13 357 319,20	9 538 485,37	6 946 666,03	5 157 453,90
	Discounted savings of time net costs in cargo transport	5 424 987,06	3 942 518,75	2 919 701,57	2 201 773,84
	Discounted savings of accidents net costs	636 781,21	475 115,95	361 681,27	280 609,48
	Discounted savings of environment net costs	1 330 965,04	986 547,31	744 943,07	572 434,93
ENPV	Economic net present value [-]	**19 981,05**	**14 170,10**	**10 204,90**	**7 453,40**
NB/NC	Advantages – costs index [-]	**19,06**	**14,90**	**11,72**	**9,29**
EIRR	Economic internal rate of return [%]	**36,3061**			

Source: author's own work.

The realized analysis has revealed, for various values of discount rate, that in each of the analysed cases:

1) the discounted savings exceed the discounted net costs including all investment, repair, and maintenance outlays (*ENPV is positive),* which

means that the project consisting in rebuilding the national road to the major road standards is efficient,

2) the sum of discounted savings divided by the sum of discounted net costs is higher than 1, i.e. the task is economically justified,
3) the interest rate of 36.3061% is the rate for which the economic net present value of advantages expected from a given investment will be equal to the value of outlays.

Summary

The analysis of costs and advantages is the practical and versatile assessment of the investment project and determination if a gives project "deserves" to be realized from the social point of view. To that end the social, environmental, and health advantages/savings are valuated and the economic efficiency indices are determined being the economic basis for the investment decision.

The assessment of economic efficiency of road and bridge projects is realized upon the basis of guidelines and recommendations included in two separate documents: "Blue Book" in range of road infrastructure projects, and in "Instructions for economic efficiency assessment for road and bridge projects for regional, district, and local roads".

The "Blue Book" is recommended by the Ministry of Infrastructure and Development in order to unify the methods of analysis of costs and advantages of the transport sector projects, realized in range of "Infrastructure and Environment Programme", which total value of qualified costs exceeds 75 millions of EUR. Whereas the "Instructions for economic efficiency assessment of road and bridge projects" make the accuracy of realized economic analyses dependent on the road type, dividing it into the regional, district, and local roads.

The costs and social and economic advantages of the road infrastructure projects are estimated dividing them into the categories including vehicle operational costs, time costs of the road infrastructure users, costs of the road accidents and victims, costs connected with emission of pollutants, costs of excessive noise influence.

All savings in the social costs should be treated as the project advantages, while all negative results influencing the rise of social costs should be treated as the project costs.

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THE VALUE OF THE COST-EFFECTIVENESS INDEX IN TERMS OF CHANGING OF THE INCINERATORS CAPACITY

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ABSTRACT: The main subject of this paper is the optimization of a model of disposal and treatment of municipal waste, as well as computer software MRGO + (Model for Regional Waste Management), through which the model was implemented. It has been verified by the author and adapted to the needs of the proposed model to optimize the disposal and treatment of medical waste in the example of the Podlaskie Province.

This paper describes the optimization study aimed to analysis of the impact of reducing the capacity incinerators of medical waste on the value of the cost-effectiveness index (E). The study was conducted on the example of the analysis of medical waste management system in north-eastern Poland, in the Podlaskie Province.

KEY WORDS: medical waste management system, system functioning costs, cost-effectiveness index, capacity of incinerators, spatial structure of the system

JEL: A12, C60, Q50, R40

Introduction

Medical waste generated in healthcare facilities is a significant epidemiological, toxicological and sanitary hazard. Medical waste management system requires a structured logistics system of collection, transportation and disposal of waste due to their potential infectious properties (Bazrafshan et al., 2010; Chaerul et al., 2008). Therefore, it seems necessary to carry out the analysis of medical waste management system as well as the optimization of unit processes and consideration of the mutual relations of all system components, processes and correlation. Many decision problems arising in medical waste management system can be represented by an appropriate decision-making model and consequently, solved through operational research (Chaerul et al., 2008; Eriksson et al., 2011; Gaska, 2007; Kollikkathara et al., 2010). The final decision does not necessarily coincide with the decision resulting from modellingwhich is only to help in the decision making process. According to analysts dealing with this subject the solution of the decision problem using operations research is a procedure consisting of the following steps (Apaydin et al., 2007; Biedugnis et al, 2003; Daellenbach, 2001; Dubrovsky, 2004; Seadon, 2010):

- identification of the decision situation and the resulting decision problem;
- construction of a decision-making model;
- decision-making model solution;
- assessment of the correctness and the feasibility of derived solutions and possible verification of the decision-making model;
- providing solutions to the decision maker and the final preparation of the decision.

The review of literature related to the optimization methods common in designing waste management systems indicates that the study conducted and developed by D. H. Marks and J. C. Liebman was of the fundamental significance. The study related to modelling of the waste management system and was verified on the example of the agglomeration Baltimore, Maryland, based on linear programming methods adopted in whole numbers in system optimization. Issues analysis of regional waste management systems also dealt with N. Morse and E. Roth. The optimization models were characterised by a great number of simplifications that may have a significant effect on the generated results and did not quite reflect the reality in which the systems operated. Subsequent optimization models by E. Berman, H. Jakir, J. Kuhner, and J.J. Harrington were updated with the aforementioned elements and dealt with both municipal solid waste and sewage sludge.

In Poland the works on the issues of modelling and optimization systems and waste exports were led by S. Biedugnis, J. Cholewinski Warsaw University of Technology (Biedugnis et al., 1992). This work gave rise to the establishment of rules and criteria for the application of a mathematical model of municipal solid waste and sludge disposal system.

This paper uses optimization model of the export and disposal of municipal waste as well as a computer program MRGO (Model of Regional Waste Management), which is its implementation. It has been verified by the author and adapted to the needs of the proposed model to optimize the removal and disposal of medical waste.

Medical waste due to the very diverse morphological composition and their potential infectious and toxic properties require a specific action depending on the degree of risk to humans and the environment. Medical waste management system is very different from municipal waste management system in the principles of collection of medical waste at source, storage, means and conditions of transport with regard to the provisions of the European Agreement ADR or processing systems and waste disposal. With this in mind The author has reviewed the structure of the mathematical model MRGO+ with a four-element system, and between themselves correlation to the system three-piece, in which the following system objects: source objects (hospitals), intermediate objects (medical waste incinerators) and final facilities located in the area of medical waste incinerator, i.e. the place for the temporary detention of post-process waste from waste incineration process. Such a solution in functioning of medical waste management enabled the achievement of the overall optimization of the system, relating to the effects and costs of servicing the region, not only in terms of local optimization, e.g. in a single *gmina* (PL administrative district). Therefore, it is extremely important to raise funds for the development of a cost-efficient and modern waste management system, in terms of technical and technological solutions as well as environmental protection requirements. Just one district is not capable of coping with these tasks in terms of financial challenges, especially because disposal of waste is the most serious, most difficult and most capital-intensive element of the system.

The structure of functioning of medical waste management system adopted by the authors, was further verified in terms of the system functional division of transport operational tasks. The infectious medical waste management system does not include waste dumping mode, which normally is capable of a 2-3-fold compaction of waste in lorries of large capacity, minimum several m3. As stated in the Act on Waste Management, infectious waste is not subject to segregation and composting due to its infectious properties, hence the medical waste management system is not composed of two-stage

transportation and redistribution stations (waste processing and distribution to various sites of treatment). For this reason, the authors verified multistage transport to the advantage of a single-stage, direct system and in this perspective the elements of the system (stages of activity) are as follows (Eriksson, 2011; Gaska, 2007):

- source forming regions (collection) of medical waste,
- route export of waste from the source areas of collection to an indirect facility in which there are waste treatment processes, independent or combined into a pre-technological and secondary process line,
- route export of waste from the source areas of collection to an indirect facility in which there are waste treatment processes, independent or combined into a pre-technological and secondary process line,
- routes for post-processing waste disposal from the intermediate object to the end-object, where waste undergoes final treatment processes.

In addition, waste landfill storage – one of the methods of waste disposal commonly used in Poland is not applied in the infectious medical waste management system. Only post-process waste may be disposed of I n landfills, and only marked as hazardous type. Therefore, the authors introduced the concept of a "post-process thermal treatment waste temporary storage", i.e. adequately protected and separated area by the medical incineration plant, where post-treatment waste is temporarily stored for up to 3 years in accordance with Polish laws, and then exported to a hazardous waste landfill . Therefore, the costs of transport and storage of waste will be incurred once every three years, which was included in this stage of implementation of transport activities proposed by the author of the cost optimization model.

The aim of the study was to analyse the impact of the parameter describing the degree of reduction in the amount of medical waste in the combustion process (wwp) and the unit cost of transport of medical waste (K_{ij}) on the value of the cost-effectiveness index (E). Optimization studies were carried out on the example of the analysis of medical waste management system in north-eastern Poland in the Podlaskie Province.

With the assumed technical and economical parameters of the system the operating range of tests, performed as part of the optimization study was divided into two stages. In the first stage, the lowest cost of operation of the system was calculated, while the second stage resulted in describing the impact of input parameters of the system, i.e. the degree of reduction in the amount of medical waste in the incineration of waste and the unit cost of transport of waste on the cost-effectiveness index and spatial structure of the system (set of system facilities and related transportation network).

Methodology of operational research

Eighteen sources of waste generation and accumulation (hospitals) within the studied area of the Podlaskie Province were selected for the analysis after taking into account the above mentioned assumptions and environmental conditions. The study also included: four intermediate objects (medical waste incinerators), respectively: IF1 (Suwalki), IF2 (Lomza), IF3 (Bialystok) and IF4 (Hajnowka), where pyrolytic decomposition process of waste will take place, and four end objects (respectively FF1, FF2, FF3, FF4) – areas for temporary storage of post-process waste from the incineration process located in the area of waste incineration facility. The model did not include restrictions on the capacity of intermediate and end objects.

The scope of operational research carried out in the framework of the optimization study was divided into successive stages in order to present options of the proposed model:

Stage I – includes optimization calculations, assuming fixed technical and economic parameters. Sequence 1, made in this stage, was also a comparative course – a benchmark for other solutions and obtained results to compare.

Stage II – included a number of additional runs aimed at determining the impact of the model input parameters of the system on the indicator of expenses of the cost-effectiveness index (E) and the spatial structure of the system (system location of objects and their associated waste disposal routes).

The following input data were taken into account:

- economic parameters describing the system (waste transport unitary costs, inflation and discount rate),
- economic parameters describing the objects of the system (capital and operating costs),
- the size reduction of medical waste in the system of indirect objects expressed in the form of the output factor of the process – wwp [%],
- the planned time horizon [t], (duration of model process).

The data relating to the costs of transport, investments and operation of the system objects, necessary for optimisation calculations, derived from existing plants, located in the model region. The calculation was performed by the unit cost of the work presented in Biedugnis and Cholewinski (Biedugnis et al., 1992) taking into account the current prices and fees. The cost of medical waste removal from the source unit to the disposal site, with the adopted technical and operational conditions is K_{ij} = PLN 9.57, and when expressed in unit cost of 1 ton of transport per 1 minute (k) = PLN 1.33/t/min.

The economic efficiency calculations of the method were presented in the work by Biedugnis and Cholewinski (Biedugnis et al., 1992) whose dynamic model related to inflation and discounting of the annual capital and operating costs in each model period. Transport costs are also dicounted and adjusted for inflation.

Description and interpretation of the results of optimization studies

Calculations were carried out in the following runs:

Stage I – run 1 – the run like in the solution with the following parameters: duration of model period, respectively t1 = 5 and t2 = 15 years, the unitary cost of transportation of medical waste in the first and second model period, respectively, 1.33 and 0.44 PLN/t/min, the level of reduction of medical waste in the intermediate facilities expressed as a coefficient of the process output, wwp=10%.

Stage II – run 2 – the assumed duration of model the period I and II respectively t1 = 5 years and t2 = 15 years, the influence of bandwidth limitations of four incineration facilities to obtain the optimal solution, that means, to obtain the lowest cost-effectiveness index. Capacity constraints were introduced in Bialystok at level of 190 t/year in Lomza – 182 t/year, in Suwalki – 250 t/year and Hajnowka of 330 t/year.

As a result of optimization calculations for the course 1 (Stage 1) of the pre-established model system of the 26 facilities (18 – the source of the medical waste, 4 – incineration, 4 – storage of hazardous waste, 55 – possible routes for waste transport), the was a number of facilities selected in model periods I and II: 3/3 incinerators, 3/3 of the landfills and 21/21 waste transport routes, in consequence minimizing the cost of the system.

Process levels in intermediate and final facilities in each model period for Stage 1 are presented in table 1.

For the stage 2 (table 2) – the introduction of this type of incineration capacity constraints resulted in a significant changes in the spatial structure of the system along with the change of the amount of waste transported in model periods I and II in relation to the first run. Also the change in the quantity of waste transported along specified routes, what further resulted in a modification in the processing activity levels of individual intermediate and final objects during model periods I and II. As a result of calculations optimization solution was obtained, which was proposed incineration facility of medical waste in Hajnowka, the throughput computing in the first and second periods model was defined at the level of 293.100/330.000 t/year, with an overall bandwidth of 88.80/ 100%.

Table 1. The level of processing activities of intermediate and final objects for the 1st run [ton/year]

System facilities	Process	Processing activity level [t/year]	Duration of model studies I=5 years, II=15 years
IF1	incineration	140.400	I
IF1	incineration	148.800	II
IF2	incineration	210.400	I
IF2	incineration	222.400	II
IF3	incineration	434.400	I
IF3	incineration	450.900	II
FF1	storage	14.040	I
FF1	storage	14.880	II
FF2	storage	21.040	I
FF2	storage	22.240	II
FF3	storage	43.440	I
FF3	storage	45.090	II

Source: author's own work.

Table 2. The level of processing activities of intermediate and final objects for the 2nd run [ton/year] within the model area

System facilities	Process	Processing activity level [t/year]	Duration of model studies I=5 years, II=15 years
IF1	incineration	120,099	I
IF1	incineration	120,099	II
IF2	incineration	182,000	I
IF2	incineration	182,000	II
IF3	incineration	190,000	I
IF3	incineration	190,000	II
IF4	incineration	293,100	I
IF4	incineration	330,000	II
FF1	storage	12,010	I
FF1	storage	12,010	II
FF2	storage	18,200	I

System facilities	Process	Processing activity level [t/year]	Duration of model studies I=5 years, II=15 years
FF2	storage	18,200	II
FF3	storage	19,000	I
FF3	storage	19,000	II
FF4	storage	29,310	I
FF4	storage	33,000	II

Source: author's own work.

The introduction of these capacity limitations intermediate objects resulted in a significant increase in the cost of the system, and thus a significant increase in the cost-effectiveness index E of approx. 17% (from 1597.60 PLN/t to 1,864.90 PLN/t).

Conclusions

The medical waste management system is a dynamic system, characterized by its parameters changing with time. Taking into account the time factor in the suggested model allows analyzing the system as an investment enterprise, i.e. assuming its realization from the very beginning, a modernization enterprise or a retrofit enterprise including both retrofitting of existing facilities as well as realization of new system solutions thus providing a solution of the lowest total cost of the entire system.

The structure of the medical waste management system is determined mainly by the process output index – wwp. The increase of this index is correlated with the increase of the amount of post-process waste directed to a storage landfield. A further consequence is the increase in the system functioning cost, expressed by the cost-effectiveness index E. At assumed terrain limitations for final facilities, there is the need to achieve a lowest process output index, by way of selection of a proper technology of the thermal neutralization of medical waste, whilst taking into account technical and organizational aspects, and whilst maintaining environment protection standards.

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Maria Walery – 60%
Izabela A. Tałałaj – 35%
Yaroslava B. Mosiichuk – 5%

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Piotr **BOŁTRYK**

THE PROCEDURE OF OBTAINING A DECISION ON THE ENVIRONMENTAL CONDITIONS OF CONSENT FOR THE IMPLEMENTATION OF AN UNDERTAKING ON THE EXAMPLE OF AN INVESTING CONSISTING IN THE CONSTRUCTION OF A BROILER HOUSE IN A MULCHING SYSTEM TOGETHER WITH ACCOMPANYING INFRASTRUCTURE (part 1 – initial assessment of the investment)

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ABSTRACT: The purpose of this paper is to give the reader the understanding of the procedure for obtaining a decision on the environmental conditions of consent for the accomplishment of the undertaking in Poland. The method of case study was used in the research. The subject of the study was the implementation of the investment in the municipality of Kuźnica involving the construction of a broiler house in the mulching system for 30,000 broiler chickens with accompanying infrastructure. The tips contained in the paper can provide invaluable assistance to investors wishing to undertake projects requiring environmental conduct.

KEY WORDS: decision, environment, procedure, evaluation

JEL: K23, K32, K40

Introduction

The assessment whether an investment will affect the environment must be the subject of analysis by any investor wishing to complete an investment in the territory of the Republic of Poland to confirm or eliminate the need for an environmental impact assessment (herein after: EIA) for the project being implemented.

The purpose of environmental impact assessment is to anticipate potential environmental hazards during the investment planning stage and the scale of these threats, and to counteract or reduce these threats and to minimize the negative impact of the planned investment.

Environmental impact assessment, in accordance with the Polish law, may be carried out, inter alia in individual proceedings on the issue of decisions concerning environmental conditions of theconsent to the completion of undertaking (further also: environmental decision, decision on environmental conditions of the implementation of an investment project).

The procedure associated with issuing of environmental decisions constitutes one of the stages of the broadly understood investment proceedings:

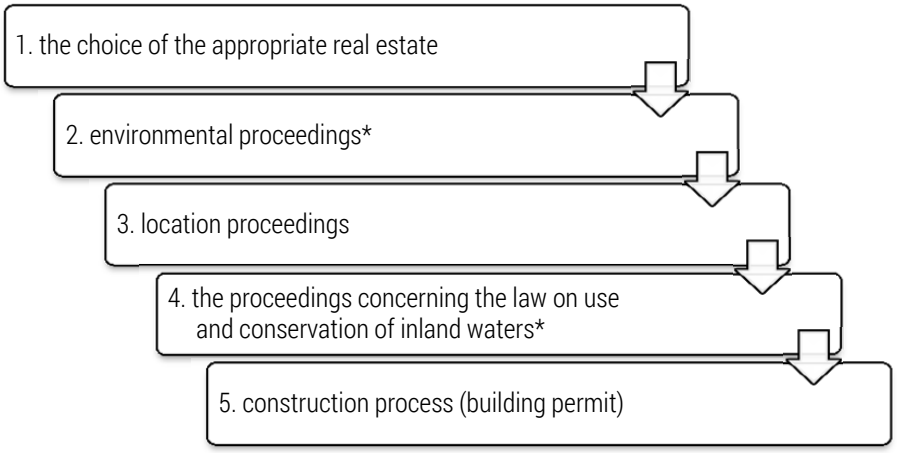

Figure 1. The stages of the investment process

Source: author's own elaboration.

The proceedings on the issue of a decision are conducted on the basis of the act of October 23, 2008 on the provision of information on the environment and its protection, public participation in the protection of the environment and environmental impact assessment (D. U. No. 199, pos. 1227 as

amended, hereinafter referred to as "the act"), the act of 14 June 1960 called the Code of Administrative Procedure (D. U. No. 30, pos. 168 as amended, hereinafter c.a.p), as well as the government order of 9 November 2010 on projects that may have significant effects on the environment (D. U. No. 213, pos. 1397, issued based on the delegated legislation from article 60 from the act – hereinafter referred to as "the order"), which is of key importance for the very existence of an environmental impact assessment in the investment process.

The discussed order deals with separation and classification of projects that can always have significant (§ 2 of the order) or potentially significant (§ 3 of the order) effects on the environment. The environmental impact assessment is since the initial stage, leading to the issue of a decision on the environmental conditions of consent to the completion of a project (WSA judgment in Wroclaw dated 22.05.2014, file no. : II SA/Wr 206/14).

Only the investments belonging to any of the above groups may be subject to proceedings in Poland on the issue of a decision concerning environmental conditions of the implementation of an investment project (at the same time taking into account the investments carried out in Natura 2000 areas – article 59 paragraph 2 of the act). This means that investors wishing to pursue projects not expressly stated in the abovementioned order are legally exempt from the obligation to obtain an environmental decision before applying for a building permit.

Table 1. Exemplary projects that can always have significant or potentially significant impact on the environment

§ 2 of the order: Some of the projects that can always have a significant impact on the environment	§ 3 of the order: Some of the projects that can have a potentially significant impact on the environment
Livestock breeding or animal husbandry in the quantity of over 210 LSU;	Livestock breeding or animal husbandry in the quantity of 60-210 LSU;

Source: author's own elaboration based on § 2 and § 3 of the order.

The investment discussed in this article consists in the construction of a chicken coop in the mulching system of 30,000 broiler chickens together with the accompanying infrastructure. The choice of the above-mentioned undertaking was not accidental. This is an investment that was the subject of issuing a decision on the environmental conditions of investment implementation in the community Kuźnica, Sokólka county, Podlasie province in years of 2014-2017.

The author of the article participated in the proceedings as a plenipotentiary, and the number of legal problems encountered during the proceedings prompted him to discuss them as part of this study.

In the first place, it should be given attention to the question of the classification of the investment in question to a specific category of undertakings resulting from the abovementioned order (30,000 broiler chickens). Unfortunately, it does not use the amount of livestock expressed in heads. In turn, it introduces a term known as Livestock Units (hereinafter referred to as LSU, see table 2). Real heads conversion into Livestock Units is based on the conversion factor constituting an attachment to the order.

Table 2. Head converter into Livestock Units

No.	The type of animals	A conversion coefficient of real heads into Livestock Units (LSU);
(...)**30**.(...)	Hens and ducks	0.004

Source: author's own elaboration based on an attachment to the order.

Considering the above data, a calculation can be made to classify this investment into one of the two groups listed in the order.

30,000 (heads of chickens) x 0,004 (conversion factor resulting from the order) = 120 LSU.

Thus, it is already known that this investment is eligible for projects that can potentially have a significant environmental impact and it is required to issue a decision on environmental conditions of the investment implementation.

Investor's request

To be able to obtain such a decision, the investor is required to apply for a decision on the environmental conditions of the investment. This is a proceeding that only can be initiated by a party with a legal interest in this matter (article 61 §1 c.a.p. in conjunction with article 28 c.a.p.). The investor who plans to build a chicken house for 30,000 broiler chickens certainly has such a legal interest.

However, it cannot be forgotten that the applicant does not have to have a right to land at the time of applying for an environmental decision. The obligation to legitimize the right to a real estate for construction properties arises only when applying for a building permit. *"The issue of a decision in his*

favor (that is inventor's – author's note), even if it is final, does not give him rise to the rights to the site for future investment, nor does it affect the ownership or rights of third parties, previous owners or persons with limited rights to property or contractual obligations" (the judgment of NSA in Warsaw dated April 14, 2015, ref. file: II OSK 2145/13).

An investor wishing to obtain an environmental decision for a building project of a broiler house for 300.000 broiler chickens (120 LSU) with accompanying infrastructure should submit to the authority that has the right to make the decision (according to the law it is the local commune head or mayor) the following documentation:

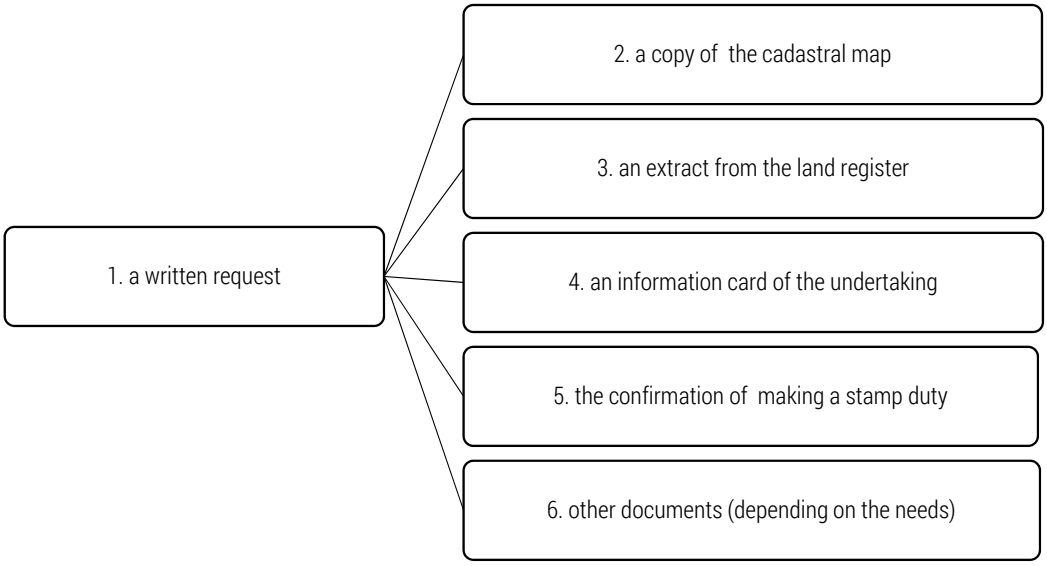

Figure 2. Required elements of the application for an environmental decision for the construction of a poultry house

Source: author's own elaboration based on article 74 pos. 1 of the act.

It should be noted that a copy of the cadastral map should include the projected area on which the project will be implemented and the area to be affected by the project, which together with the extract from the land register will allow the authority to determine the other parties to the proceedings. The fee for issuing the decision is currently PLN 205. Other required documents that need to be attached depending on the needs include the power of attorney together with its fee (PLN 17) when the investor acts by a properly authorized representative.

It should be stressed that in accordance with article 64 §2 c. a. p., if the application is incomplete, or it does not meet other legal requirements, the authority within a period not shorter than 7 days will call the party to supplement it and in the event of the lack of the required documents the application will be left without recognition. Thus, the commented regulation gives the possibility to supplement the missing documents within the time limit set by a commune head or mayor. Only after the expiry of the prescribed time limit the case is not substantively recognized, and the application initiating the proceedings is considered ineffective (Dawidowicz, 1989, p. 89).

As it was already mentioned, the attached cadastral map is used to establish the parties to the proceedings. This is a very important activity that must be undertaken by the authority immediately after the time when the complete application has been received, or supplemented by a request.

In the case of construction of such an investment as poultry breeding,first it should be emphasized that a party in the proceedings concerning the issue an environmental decision to the investor is any entity whose property is within the reach of the planned undertaking. Apart from the applicant, the parties to the proceedings are therefore the owners of the real estate located in the area where the planed undertaking canaffect the environment. It is unaffected by the fact that the impact resulting from the planned operation of the installation will cause any nuisance to the owner of such property. It is also irrelevant whether the implementation of this project will result in a breach of environmental standards. The concept of "impact" cannot be narrowed to merely to the effects of excessive influence, exceeding emissionor environmental quality standards.

Furthermore, when determining the impact of the project, it should be considered such impacts to which no administrative emission standards have been established. An example is odor emission, which is not currently covered by any of the standards in force to quantify its nuisance (NSA judgment in Warsaw of 15.05.2013, file number: II OSK 108/12).

Failure to notify the initiation of an administrative proceeding and the conduct of the proceeding without the participation of even one of the parties constitutes a qualified procedural flaw, which results in the renewal of the proceedings at the request of the omitted party pursuant to article 145 §1 c. a. p. (NSA judgment in Warsaw dated 06.10.2000, file number: V SA 316/00). In addition, the failure of the authority to notify the party about proceeding initiating cannot be justified by the fact that the party has otherwise learned of the proceedings (WSA judgment in Warsaw of 01.09.2006, file number: I SA/Wa 768/06).

The qualification of an entity as a party to the proceedings results in making it equal in its rights with the applicant, about to the probationary initia-

tive, the possibility of contesting the decision, and the obligation to deliver all letters with a return delivery note. However, it should not be forgotten about the content of article 74 pos. 3 of the law, according to which if the number of parties of the proceedings exceed 20, the mode of delivery by an official announcement is applied. *"The announcement which is stipulated in article 49 of CPA (in relation with article 74 pos. 3 – author's note) has the effect that any interested party, who is the party to proceedings, may know about the proceedings and their course, thus enabling its potential participation in them"* (WSA judgment in Poznan dated 18.06.2013, file number: II SA/PO 395/130).

Initial assessment of the investment

It is equally important that the division of undertakings into two categories resulting from the order is not accidental and it is of major importance in the context of environmental decision-making. For projects that potentially have a significant impact on the environment, an environmental impact assessment is optional, depending on the will of the authority conducting the proceedings. However, the decision in this respect cannot be arbitrary.

When determining whether an investment (from a potentially significant environmental impact group) requires EIA, the investigating authority will consider all the following aspects:

- the type and nature of the project, including:
  - its range,
  - its connection with other implemented and planned projects in the area,
  - emissions and the occurrence of other nuisances,
- the location of the project, including:
  - possible threat to the environment, especially in existing land use,
  - natural and landscape values,
  - conditions of local spatial development plans,
- the type and scale of possible impact resulting from, inter alia:
  - the scope and nature of the impact of the project on natural elements,
  - considering probability, duration, frequency and reversibility of the impact (article 63 pos. 1 of the act).

Despite the wording that the conditions should be "taken together", their assessment can only be limited only to those that occur in the case. It is obvious that for the issuing of a decision imposing the obligation to carry out an environmental impact assessment, it is sufficient to state the possibility of a significant environmental impact of the proposed project on the environment in any of the aspects mentioned in this regulation and not in all taken together (WSA judgment in Poznan on 13,12.2012, file number: IV SA /Po 1056/12).

It cannot also to be forgotten that the decision to determine whether an investment requires to carry out the assessment of its environmental impact is preceded by an application for an opinion to the competent authorities. In the case of the discussed investment, they are the local Regional Director for Environmental protection and State County Sanitary Inspector. (Opaliński, 2016, p. 160).

Considering the above, it should be noted that the discussed investment 9a chicken house for 30.000 broiler chickens, 120 LSU) requires both a building permit (Okolski, 2014, p. 56, a contrario in article 29 §§ 1-4 of the act of 7 July 1994 concerning the building law D. U. 1994, no. 89, pos. 414, as later amended) as well as the decision on land development conditions (article 59 §1 in conjunction with article 50 §2 point 2 of the act dated 27 March 2003 concerning planning an spatial development – D. U. 2003, no. 80, pos. 717 as late amended), therefore obtaining an opinion, in this case of the State County Sanitary Inspector (article 78 §1 point 2 of the act) is an obligation of the authority conducting the proceedings.

In article 64 § 2 of the act it is clarified which documents and applications should be submitted to the evaluating authorities.

- an application for a decision on environmental conditions,
- a project information card,
- excerpts and extracts from the local spatial development plan or the information on its absence.

After the reception of the above-mentioned documentation, the evaluating authorities conduct two-step analysis of the investment. In the first place, they determine whether there is a need for an environmental impact assessment, and then (if the answer is yes) they give an opinion on the scope of the environmental impact report.

The produced opinions should be issued within 14 days from the date of receiving the application for their issuance (article 64 § 4 of the act), they should take the form of a decision, but which is not a complaint. As it was stated by WSA in Gorzów Wielkopolski: "The opinion concerning the decision on the need to carry out an environmental impact assessment will be expressed in the form of a decision issued based on article 123 § 1 CAP, which is not a subject to complaint. An entity challenging its correctness, however, will be able to do so in a form of a complaint against the decision on the obligation to carry out an environmental impact assessment filed under article 65 § 2 of the act of 3 October 2008 on the provision of information on the environment and its protection, public participation in environmental protection environmental impact assessments" (WSA judgment in Gorzów Wielkopolski on 02.06.2010, file number: II SA /Go 232/10).

On the other hand, if two reviewing authorities, that is the Regional Director of Environmental Protection and the sanitary inspection body, have issued in the same case two opposing views, then the applicant authority may favor one of the submitted stands according to its own assessment according to its own decision (WSA judgment in Gdansk dated 12.11.2011, file number: II SA /GD 698/10).

However, the body conducting the proceedings is not bound by the position of the authorities involved in the case, but it is subject to a final assessment, based on the opinions sought and the selection criteria referred to in article 63 § 1 of the act, whether the assessment of its environmental impact is appropriate for a given project or whether there is no basis for carrying out such an evaluation (WSA judgment in Lublin on 11 May 2011, file number: II SA /Lu 866/10).

In the discussed case, both the State County Sanitary Inspector in Sokółka and the Regional Director for Environmental Protection in Białystok voiced the need for a full environmental impact assessment of the project, about potential social conflicts.

The commune head of the community of Kuźnica issued a decision on the need for an environmental impact assessment and set the scope of the report. According the article 65 § 2 of the act this decision is contestable, which means that at such an early stage of the proceedings the parties other than the investor can verify the validity, as well as the scope of the future environmental impact report.

It is equally important that the decision is also issued when the authority conducting the investigation does not find the need to carry out an environmental impact assessment. In this case, however, it is unappealable. According to the NSA verdict in Warsaw, the possibility of filing a complaint was limited to by the legislator only to the decisions that state the obligation to carry out an environment impact assessment for a proposed project likely to have a significant environmental impact. A complaint that does not require the conduct of an environmental impact assessment of a project is not entitled (NSA judgment in Warsaw on 19.01.2012, file number: II OSK 2084/10). The path to question is not closed, however, as it may be challenged in an appeal against the decision of the first instance authority. Because of the recognition of the appeal as justified, in addition to repealing the decision of the first instance authority, it may also be possible to revoke the decision issued pursuant to article 63 § 1 of the act (WSA judgment in Bialystok on 29.09.2009, file number: II SA/Bk 372/09).

It is also worth adding that the environmental impact assessment can also be carried out in the event of a doubt as to the information contained in the project information sheet, which as it is known, a mandatory annex to the

application for a decision on the environmental conditions of the investment. Where there is a doubt as to the evaluation of information contained in the project information sheet, the authority would be obliged, in accordance with the general principle of material truth, according to the instruction of article 7 of the c. a. p. to summon the applicant to remove such doubts. If these doubts were not removed, then, according to the precautionary principle, it would be necessary to declare the need for an environmental impact assessment. Evaluating whether this kind of supplementation of evidence is necessary or not cannot be detached from the order of the individualization of the case and from the realities of the actual case. It cannot also be assumed that for each project it is possible in advance to determine precisely the amount of substances emitted into the environment or to determine precisely the emission of the factors affecting the environment about the implementation of the project. Evaluations or this kind of supplementation of evidence is necessary, however, it cannot be separated from the order of the individualization of the case, and from the actual case (judgment of NSA in Warsaw on 01.02.2013, file number: II OSK 1837/11).

In article 65 § 1 of the act, the legislator indicated a 30-day deadline for issuing a decision on issues that concern the obligation to conduct an environmental impact assessment or the lack of such an obligation. The deadline starts with the date of submission of the complete application, that is the application for a decision on the environmental conditions. It should be noted that the 30-day deadline also considers the 14-day deadline for issuing opinions (Opaliński, 2016, p. 1650.

This means that the first stage of proceedings for undertakings of potentially significant environmental impact should end within 30 days. Until then, the applicant should be informed whether his or her investment will require an environmental impact assessment.

This stage closes first, crucial part of the procedure. By now, the investor should be informed if his/her undertaking should be encompassed with the environment impact assessment or not. In second part of the article, the focus is on further steps that investor has to take into consideration, such as an environmental impact reports, the environment impact assessment (EIA) and the environmental decision itself.

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THE ASSESSMENT OF THE PUBLIC ACCEPTANCE OF THE IMPLEMENTATION OF INDIVIDUAL SEWAGE TREATMENT PLANTS IN ŚNIADOWO MUNICIPALITY

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ABSTRACT: The aim of the article is to present the public perception of the implementation of an individual wastewater management system, i. e. the so-called household sewage treatment plants in Śniadowo municipality. The contingent valuation method (CVM), part of which is a willingness to pay survey (WTP), was used to get to know the opinions of the inhabitants on the implementation of individual wastewater treatment systems. The contingent valuation method was implemented based on surveys conducted in the selected municipality.

KEY WORDS: contingent valuation method, the social acceptability of the investment, WTP questions, household sewage treatment plants.

Introduction

Wastewater management is one of significant elements of the state's environmental protection activities. Wastewater management addresses three important aspects: social, economic and environmental. It is a major area of interest for many specialists. There are many solutions and methods that can be used to carry out an efficient wastewater treatment process. In urbanized areas, collective sewage systems are used. On the other hand, in rural areas, where the investment costs of such a system are much higher, household sewage treatment plants or drainage-free systems are the most frequently used. Each of these methods has its advantages and disadvantages, but all of them allow the protection of water resources against excessive pollution.

The aim of the article is to present the public reception of the implementation of individual sewage treatment plants in **Śniadowo** municipality, the contingent valuation method (CVM), part of which is a willingness to pay survey (WTP), was used to get to know the opinions of the inhabitants on the implementation of individual wastewater treatment systems. Public opinion polling of the local community was carried out based on surveys.

Wastewater management solutions in rural areas

Wastewater management is currently one of the most important aspects concerning living standards in one's own home or one-family house. Recent years have seen an increase in the volume of wastewater discharged. To a considerable extent, it is true of cities, but it is even more visible in rural areas. This is a result of the intensive development of these areas, and the constant increase in living standards and thus the provision of sanitary facilities.

Wastewater treatment is one of the basic activities related to improving water quality and environmental protection. This is not an easy task, because of the different nature of pollution and therefore the need to apply technical solutions with different degrees of complexity (Kaczor, Bugajski, 2006). However, the main task of wastewater treatment systems is to improve sanitary and hygienic conditions in the countryside and to increase the standard of living of the inhabitants. Nowadays, it has become a standard to equip every newly constructed building, both domestic and household, with sanitary installations (Hartmann, 1996).

The solutions that are used in waste water collection and treatment depend mainly on the type of buildings that are in the area. In the case of compact buildings, it seems more economical to use a communal sewer with a sewage treatment plant. On the other hand, if there are dispersed constructions, where the distance between buildings is greater than 120 meters, then it seems justified to use individual systems that would remove and clean up pollution. An example of such systems is outflow tanks (septic tanks) and household treatment plants (Błażejewski, 2003).

The sewage holding tanks system consists in collecting generated wastewater in leak free tanks and then removing it with the use of gully emptier to a sink station located in the closest wastewater treatment plant, which is prepared to receive and effectively treat this wastewater. Holding tanks are used in the absence of a sewage network on plots smaller than 800 – 1000m^2 and when high ground water level does not allow for the use of sewage treatment plants (Nowak, 2005).

According to the Regulation of the Minister of Infrastructure on the conditions to be met by buildings and their location, holding tanks should be placed not less than 5 meters away from windows and doors of a residential building, 2 meters away from an adjacent plot, and 15 meters away from water intake. Good access is also required to enable the tanks to be emptied. In addition, these tanks should have impermeable bottom and walls, tightly covered with a closed opening for the removal of collected sewage and sediments, as well as venting, at least 0.5 m above the surface of the terrain (the Regulation of the Minister of Infrastructure of 12 April 2002).

The sewage holding tanks system should be used in unimproved land as a target or transitional solution until the households are connected to collective sewage systems or household sewage treatment plants.

Sewage from the kitchen, bathroom, toilet and other living quarters should be fed into the household sewage treatment plant. It should not be filled with rainwater, surface water (from roofs, yards, etc.), water from swimming pools and other tanks of more than 1m^{3,} as well as chemical substances. The plot should comply with regulatory requirements. In the first case, it is important where the primary settling tank will be located. It shall not be closer than 2 meters from the boundary or road. The minimum distance from gas and water pipes is 1.5 meters (the Regulation of the Minister of Infrastructure of 12 April 2002).

The facilities of individual wastewater treatment plants are miniatures of those used for the wastewater disposal in large, collective wastewater treatment plants. Although the amount of wastewater produced by a single house is smaller than that of large settlement units, so that it does not pose a threat to the environment.

Household sewage treatment plants in their operation are based on mechanical and biological treatment processes. However, the choice of the method of disposal of pollutants depends on many aspects, such as the amount of sewage, the surface of the terrain, ground and water conditions or economic conditions (Heidrich, et al., 2008).

The most popular household sewage treatment plants include: ATLANTIS 2000, BIOCLERE, PROX AT 6 and soil-water treatment plant IBMER.

When analyzing the sewer system in economic terms, it turns out that household sewage treatment plants are profitable when the average length of a sewage collector exceeds 20 meters in relation to one household. However, using pressure sewage system, this distance may be several times longer (Błażejewski, 2003). Notwithstanding, the use of septic tanks is more cost-effective when they are used for a brief period (up to 3 years) [Household water treatment plants – a guidebook for villagers].

Depending on the selected type of a household sewage treatment plant, significant differences in investment outlays, annual operating and expected costs may occur (Kundziewicz, Miłaszewski, 2011). An overview of investment outlays, annual operating costs and expected household sewage treatment plant costs is given in table 1.

Table 1. An overview of investment outlays, annual operating costs and expected household sewage treatment plant costs

Type of cleaning equipment	Investment outlays [PLN]	Annual operating costs [PLN]	Expected total cost		
			Annual y [PLN/a year]	Monthly [PLN/a month]	Per unit [PLN/m^3/a year]
Wastewater plant ALTANTIS 2000	3000	150	345	28,8	1,3
Wastewater plant BIOCLERE	8000	170	690	57,5	2,5
Wastewater plant PROX AT 6	7500	334	821	68,5	3
Wastewater plant IBMER	5000	100	425	35,4	1,5

Source: (Kundziewicz, Miłaszewski, 2011).

Considering the above listed costs, they can be compared with the costs of septic tanks, which range from 3 000 to 6 000 PLN. On the other hand, only wastewater disposal costs 15-20 PLN per m^3. In statistical terms, 10m^3 tank is filled by a family of 4 people within about 14-18 days. This means that it must be emptied twice a month for 300 PLN on average. Therefore, it is understandable that the installation of a household sewage treatment plant, despite the costs of its installation, is very quickly profitable and more efficient, and its construction can also be financed with EU funds. On the other

hand, the cost of connection to the communal sewage system varies greatly and depending on a city or municipality, it ranges from 800 PLN (Wodzisław Śląski) to 5000 PLN (Katowice), (KZGW internet site).

Therefore, when choosing an appropriate solution for wastewater treatment, the opinion of the local community, economic conditions, technical solutions considering the specific characteristics of a given municipality as well as the ecological aspect should be considered.

Environmental valuation using the CVM contingent valuation method

The contingent valuation method is used to determine preferences of a given person or group of people, and public or private-public goods. This is done by expressing the opinion of the respondents and then translating the survey results into monetary values. This method has several important advantages. First of all, the method of contingent valuation is the only method by which the valuation of "non-usable" goods, i. e. the natural environment, so-called "wild nature" – is carried out. It should then be stressed that the results obtained using the above method (provided that the tests have been carried out properly) are of high objectivity. This method has been constantly improved, and particularly intensive development of its use has been visible since the 1990s (Wróblewska, 2014). The contingent valuation method (CVM) is a survey method conducted on a group of respondents who have a good or service or are interested in possessing it. The method distinguishes two categories of questions: WTP – Willingness to Pay, and WTA – Willingness to Accept. In the first category of questions, there are indications concerning the willingness to pay for a specific item, activity or service. The second category of questions refers to the issue of tolerance of adverse changes and conditions related to the examined good or service (Graczyk, 2005). The contingent valuation method was first used in the 1960s and has undergone many modifications over the last 50 years. For the first time, it was used on a larger scale in the 1980s. During this period, the method of contingent valuation was a research method, the results of which may be described in scientific publications. The pioneer of the presented method, in relation to environmental goods, was an American researcher R. Davis (Graczyk, 2005). It is worth noting that the contingent valuation method is widely used in economic valuation, especially in respect to parameters and non-useable features, which are difficult to measure in the case of the natural environment (Śleszyński, 2000).

Polish sociologist J. Sztumski, said that anything that is part of any reality can be subjected to social research. Depending on the subject matter of research, reality may include social, financial, economic, political, pedagogical, religious and many other issues (Sztumski, 2005).

The research method chosen for conducting studies is very important. Not every research analysis can be carried out using any technique. The choice of a method relates not only to the issue of preparing and conducting studies, but also to describing and analyzing results and drawing conclusions 9Nowak, 2007). The method of contingent valuation allows to determine the economic value and not only the value in use of a given good. It is based on the opinion of respondents making a choice between hypothetical situations. This allows considerable flexibility in the selection of goods that do not have separate markets and it is difficult to value them. It is extremely useful and more and more commonly used (Marks-Bielska, Zielińska, 2014). The contingent valuation method based on a WTP question, is carried out based on a questionnaire of surveys, which contains questions referring to price preferences for specific services and goods. This method is largely concerned with environmental issues, water resources, waste management or wastewater management. The questions are focused on financial and economic issues, namely the losses resulting from human impact on the environment and the price amounts that the inhabitants of a given area would be willing to pay for the protection of the environment and natural values. This method is used in ecology and spatial management, but it can also be used in medicine, pharmacy, power engineering, industry, fishery and agriculture. People who use this method emphasize its clear and uncomplicated way of preparation and implementation. This is mainly due to the fact that, in addition to questions, specific price amounts or percentages are usually attributed to questions that can be addressed by respondents. In this method, questions are usually closed or closed-ended. The second type of questions is more difficult and requires more experience on the part of a researcher in their preparation (Żylicz, 2004). This method is commonly used, especially for elements related to flora and fauna or environmental protection. An example of this method is the valuation of endangered animal or plant species. In France, it is widely used to test the readiness to increase water usage fees, in return for improving its quality. These studies have shown that a large part of the population demands an increase in charges, but by those subjects which pollute water most, that is agriculture and industry. The contingent valuation method was also used in Greek coastal regions. During the survey residents' opinions were analyzed on increasing payments made by tourists for the use of some marine facilities, in exchange for transferring income obtained for the protection of saltwater and marine fish. This method was also used by Bangkok

park management to determine the possibility of raising the price of using its facilities in exchange for a more favorable environmental impact. In turn, in Colombia and Mexico inhabitants were asked about increasing charges for potable water and wastewater, to raise drinking water standards and to build wastewater treatment plants. The contingent valuation method has also been widely used in Poland. The most famous studies were on the aquatic environment and referred to the willingness of the population to pay payments for the protection of the Baltic Sea against its progressive eutrophication. In another case, the inhabitants of Ełk were asked about the possibility of increasing the protection and reclamation of Ełk lake. In many Polish municipalities and cities research is carried out using the contingent valuation method concerning environmental values and the protection of the environment (Rauba, 2016).

Literature studies carried out on the contingent valuation method show that a few studies related to water resources have been carried out based on this method both in Poland and worldwide. However, there are few studies concerning the social reception of individual wastewater management systems implementation, determined by the readiness to pay for their implementation.

Wastewater management in Śniadowo municipality

Śniadowo municipality is located in north-eastern Poland, in the western part of Podlaskie voivodeship, in Łomża county and covers an area of 162.59 km^2. The population of Śniadowo municipality is 5450 people. There are 43 villages in the municipality (www.sniadowo.pl).

Śniadowo municipality with a high degree of water supply (98%) still faces the problem of unresolved wastewater management in rural areas. The part of the municipality that covers the locality of Śniadowo together with the neighboring village of Ratoon Stare is equipped with a system of communal sanitary sewage system, discharging sewage to the wastewater treatment plant located on the outskirts of Śniadowo. The residents of other localities have no possibility to connect their buildings to the sewer network and discharge wastewater into empty tanks (septic tanks) with a capacity of up to $10m^{3,}$ which after many years of use do not guarantee full tightness. It is in turn leads to soil and groundwater contamination. The location of tanks on plots is in accordance with legal regulations governing these matters, i. e. the distance from the windows and doors of external buildings is at least 5 meters, and the distance from the border of a neighboring plot, street or pavement is at least 2 meters. The maintenance and operation of such a res-

ervoir is to a substantial extent a burden on the inhabitants' budget, as the cost of extraction and removal of sewage from the reservoir to the nearest wastewater treatment plant in Śniadowo amounts to several hundred PLN per month. It should be also mentioned here that legal provisions clearly indicate that this is a transitional solution. The best solution to this problem would be to install a sewer system in the entire area of the municipality, however, due to dispersed development, the construction of sewage connections seems unreasonable, as it would entail huge costs. It is therefore necessary to find a unique way of collecting and treating waste water. Such a solution, which is a supplement to the communal sewage system, is the use of individual sewage system, i. e. the so-called household sewage treatment plants. In Śniadowo municipality it is only allowed to build mechanical and biological household sewage treatment plants whose capacity cannot exceed 5 m^3 per day. It is mainly conditioned by the municipality's land conditions and the lack of space, as well as the presence of permeable and poorly permeable land. In accordance with the regulation on technical conditions to be met by buildings and their location, the underground bottom settling tanks of household sewage treatment tanks are located at least 2 meters from the border of a neighboring plot, road or pavement and at least 15 meters from water reservoirs (Wastewater management program for Śniadowo municipality for the years 2012-2020).

The assessment of public acceptance of the implementation of individual sewage treatment plants in Śniadowo municipality

In the evaluation of social acceptance of individual sewage treatment plants in Śniadowo municipality the contingent valuation method based on WTP question was used. The research tool was a questionnaire survey consisting of three parts. The first part of it contains questions concerning sewage management in Śniadowo municipality, especially relating to the removal of sewage. It also contains questions on the development of wastewater management. The second part of the survey comprised questions about the preferred amounts for using an individual wastewater management system. The third part of the questionnaire concerned personal data and the general socio-economic characteristics of the respondents, which included questions concerning age, gender, education, income and the place of residence of the respondents.

The survey was conducted on a group of 70 respondents, including 49 women and 21 men. Most of the respondents (55%) were aged 18-30 years

and lived in single-family houses. They had in their majority secondary (36%) or higher education (41%) and their monthly remuneration amounted to about 2000 PLN. The analysis of the obtained information indicates that people aged 24-25 years (about 64%), who most often have secondary or tertiary education, show a greater interest in wastewater management and the implementation of individual wastewater treatment plants.

Referring to the question of sewage management system satisfaction in §niadowo municipality, more than half of the respondents (61%) answered that they were quite satisfied. 20% found that their level of satisfaction was high. 11% stated that the sewage management system in Śniadowo municipality was rather not satisfactory for them. In turn, 3% of respondents believed this system was unsatisfactory for them. The remaining 55 of respondents did not have an opinion on this issue.

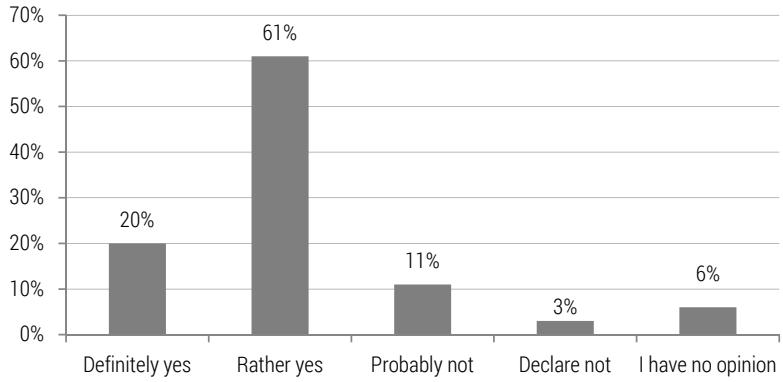

Figure 1. The answer to the question: "Are you satisfied with the sewage management system in the municipality of Śniadowo?"

Source: author's own study.

In response to the question of meeting the expectations of the sewage management system in Śniadowo municipality, the most respondents (56%) responded rather positively. 24% indicated that this system did not meet the expectations of the inhabitants. 8% of the respondents stated that the system meets their expectations at a very high level. The remaining 10% of respondents did not have an opinion on this issue.

69% of the respondents stated that they were not preoccupied with sewage management in Śniadowo municipality. 20% of respondents were definitely affected by any problems. 5% of the respondents that it happened sporadically that some problematic issues occur, while 2% of the respondents stated that they had serious problems with sewage in Śniadowo municipality. 4% said that these problems were related to unpleasant smell.

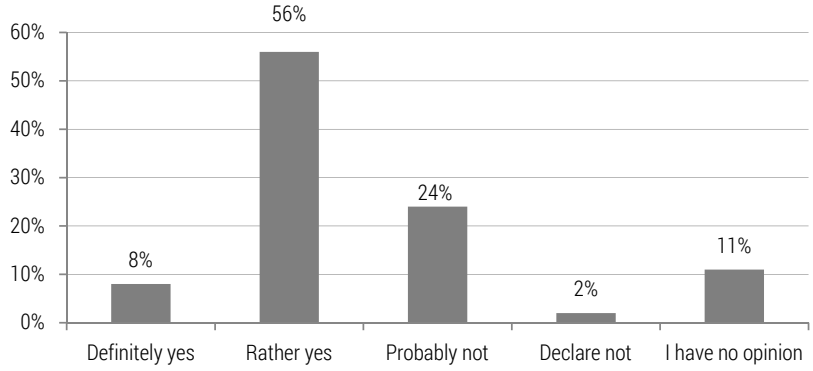

Figure 2. The answer to the question: "Do you think that the sewage management system in the municipality of Śniadowo meets the expectations of all inhabitants of the municipality?"

Source: author's own study.

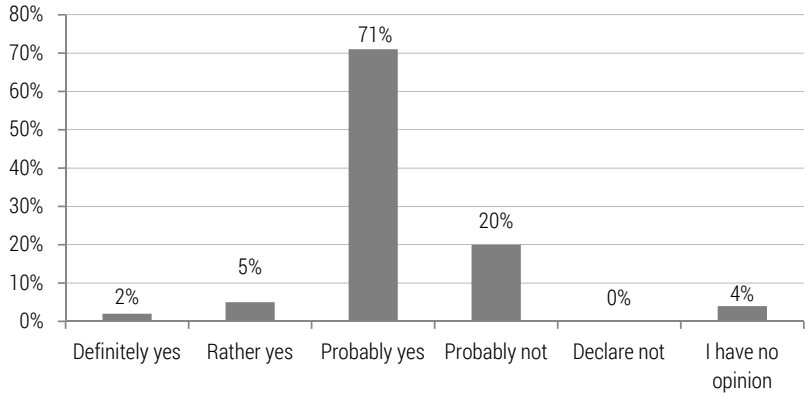

Figure 3. The answer to the question: "Have you ever experienced wastewater problems in the municipality of Śniadowo?"

Source: author's own study.

The largest part of respondents (43%) used a drainage system. 30% of the respondents indicated that they had a household sewage treatment plant. The remaining 27% of the surveyed inhabitants of Śniadowo municipality are connected to a common sewage system.

Referring to the most favorable sewage management system for their own households, most of the respondents (45%) indicated a household sewage treatment plant. The remaining respondents (45%) pointed to the collective sewage system.

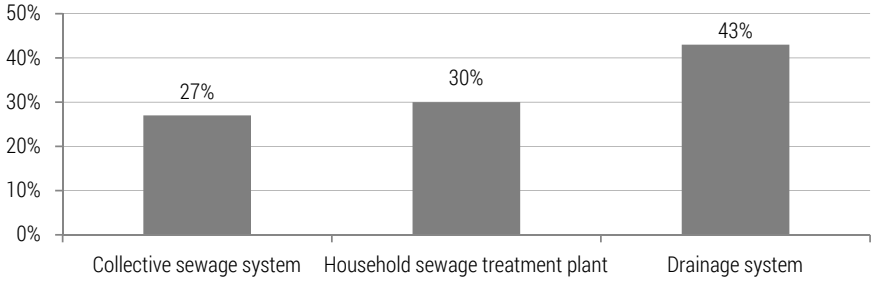

Figure 4. The answer to the question: "Which wastewater management system do you use?"

Source: author's own study.

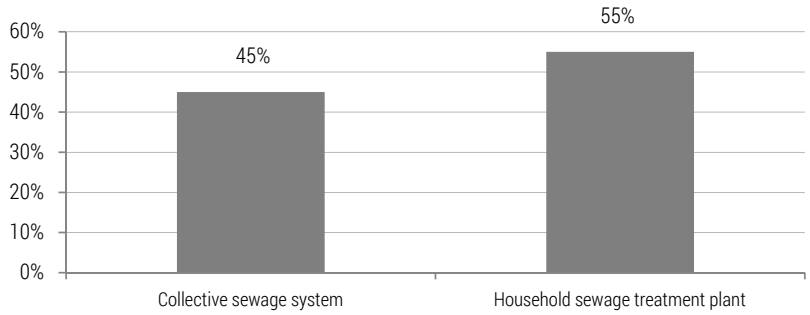

Figure 5. The answer to the question: "Which of the wastewater management systems do you consider to be a better solution for your own household?"

Source: author's own study.

In response to a question concerning the costs that residents would be willing to incur for installing a household sewage treatment plant, the largest number of respondents (32%) indicated 200-500 PLN. 21% marked the price range of 500-1000 PLN. 11% of the respondents considered that they would be willing to bear the cost of 100-200 PLN. 8% of the respondents indicated an amount below 100 PLN, while 6% of respondents chose an amount of above 1000 PLN. The remaining 22% of the respondents replied that they already had a household sewage treatment plant.

When asked about the level of satisfaction of municipality residents with co-financing of the installation of a household sewage treatment plant, 35% of the respondents said they were quite satisfied, while 23% of the surveyed people stated that they were satisfied with this funding. 12% of the respondents were not satisfied and were unsatisfied with the level of the subsidy. The remaining 24% had no opinion on this issue.

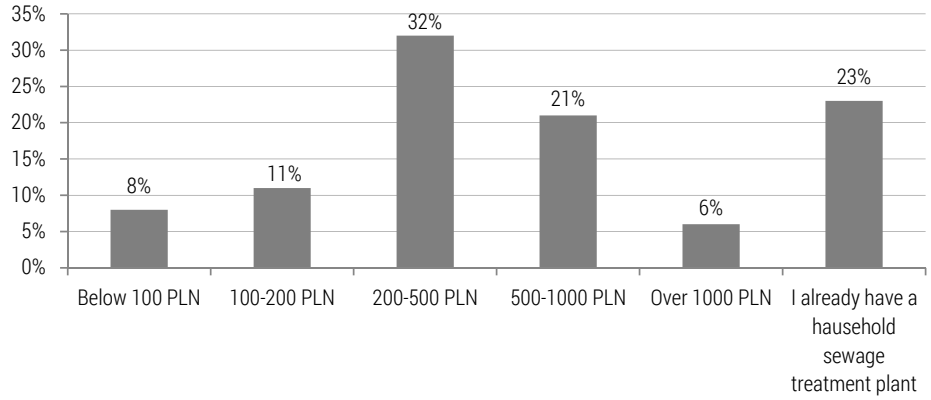

Figure 6. The answer to the question: "What cost would you be willing to bear to install a household sewage treatment plant?"

Source: author's own study.

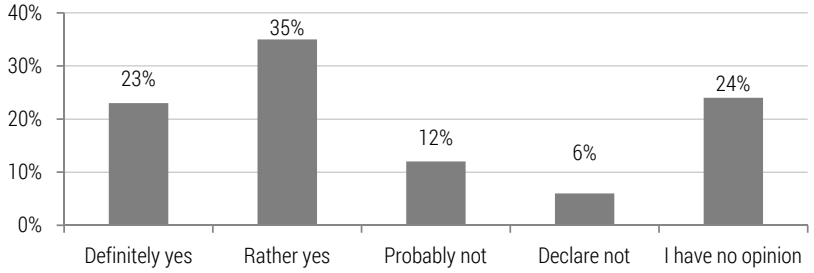

Figure 7. The answer to the question: "Will you be satisfied with the percentage of co-financing to install a household sewage treatment plant?"

Source: author's own study.

Indicating the price that the residents of Śniadowo municipality would be willing to pay for 1m^3 of wastewater treated in a household sewage treatment plant, 35% marked the amount of 1-2 PLN. Slightly fewer respondents (32%) indicated 3-5 PLN. 26% stated that they would be willing to pay less than 1 PLN, and in the case of 5% of people, this amount could amount to 6-8 PLN. 2% of the respondents indicated a price range of 9-10 PLN.

Regarding the annual costs that the inhabitants of the municipality would be willing to bear for the operation of a household sewage treatment plant, almost 30% of the respondents replied that they could amount to 50-100 PLN. The same number of respondents indicated the range of 100-200 PLN, and 20% marked the amount of 200-400 PLN. Slightly fewer residents (17%) showed the costs of 400-600 PLN. 6% of respondents indicated the amount

of 600-800 PLN, while 3% of the respondents stated that they could pay 800-1000 PLN annually.

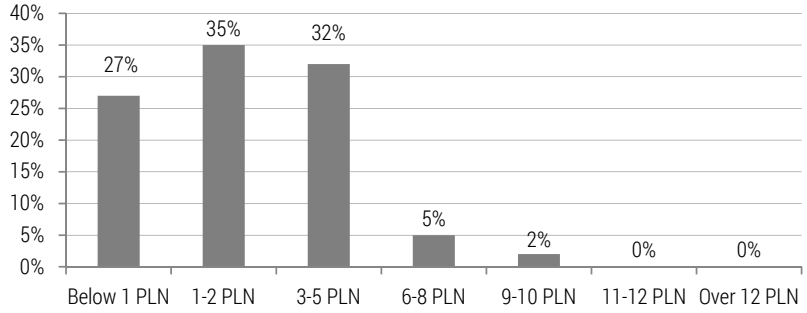

Figure 8. The answer to the question; "What amount would you be willing to pay for 1 m^3 of wastewater treated in a household sewage treatment plant?"

Source: author's own study.

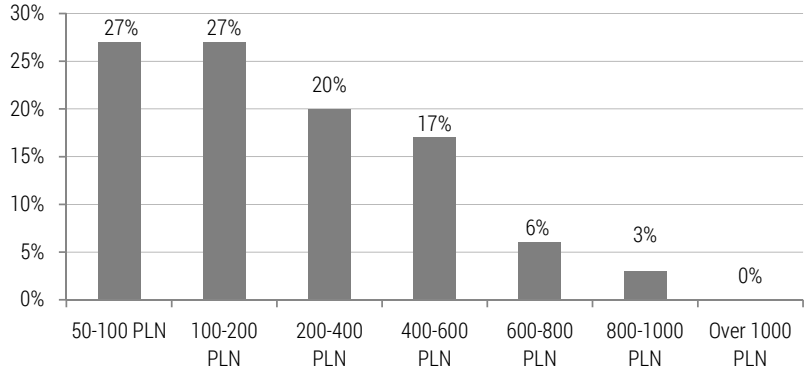

Figure 9. The answer to the question: "What annual costs would you be willing to pay for the operation of household sewage treatment plant (e. g. repair and maintenance)?"

Source: author's own study.

The carried-out research showed that the social reception of the implementation of the individual wastewater management system in Śniadowo municipality is very high.

Most of the residents of Śniadowo municipality show great interest in environmental protection issues, including sewage management. Therefore, it can be concluded that they are aware of their responsibility for the state of the natural environment and the risks associated with the lack of adequate waste water treatment. And in the case of the price that residents of Śniadowo

municipality would be willing to pay for 1m^3 of wastewater treated in a household sewage treatment plant, respondents indicated that the increase in charges could be up to 10-20%. In addition, most respondents (55%) indicated a household sewage treatment plant as the most beneficial wastewater management system for their own households and would be willing to incur higher costs to install an individual wastewater treatment system to reduce the negative impact of wastewater on their lives and the condition of the natural environment.

Conclusion

Environmental protection measures in water and wastewater management include the treatment of wastewater to such an extent that it can be discharged into soil or water. This is done in many ways, making it possible to distinguish many methods. In the municipality of Śniadowo the most common activities wastewater collection and treatment are household sewage treatment plants and connection to the collective sewage system, which includes only the inhabitants of two localities. Financial considerations are a significant problem in meeting the needs of the inhabitants of Śniadowo municipality in sewage management. The local government does not have sufficient funds to ensure the connection of each household to the collective sewage system or to finance a sewage treatment plant at every household property.

The conducted research has shown that residents of Śniadowo municipality are interested in the problem of wastewater management and are willing to pay additional fees for improving the quality of treated wastewater. The respondents indicated that fee increases in this area could be up to 10-20%. At the same time, they could spend up to 1,000 PLN for the establishment of a household sewage treatment plant or pay a fixed fee of about 200 PLN per year for the operation of a household sewage treatment plant. The results of the research also indicate that the inhabitants of Śniadowo municipality are aware of the necessity of taking care of the natural environment and that they are aware that they should bear certain costs to live in areas that will be free from pollution as much as it is possible.

The local authorities encourage the owners of households to invest in household sewage treatment plants with co-financing from public funds, because the cost of constructing a collective sewer system in the whole municipality would be very high. In addition, it should be noted that Śniadowo municipality, as part of "Wastewater Management Program 2012-2020", prepared a simulation of the expenses to be incurred relating to the expansion

of the sewer system. The first variant assumes the construction a household sewage treatment plant in each household, which is not connected to the communal sewage system. It is envisaging that the cost of a one-time investment, together with the preparation of documentation, will amount to 13,150 PLN. For the whole municipality, these costs will amount to 16,187,650 PLN. In turn, the construction of a collective sewer system, which would cover all households in the municipality would cost 26,425,000 PLN. Both amounts are very high and exceed the financial capacity of the municipality. Therefore, it was decided to encourage household owners to invest in household sewage treatment plants with co-financing on the part of the local government. Every year several dozen households use this type of solution (Wastewater management program for Śniadowo municipality for the years 2012-2020).

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The contribution of the authors

Krystyna Rauba, literature review: 60%, acquisition of data:20%, analysis and interpretation of data: 60%

Aneta Brulińska: literature review: 40%, acquisition of data: 80%, analysis and interpretation of data: 40%

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Edyta **PAWLUCZUK**

ECOLOGICAL ASPECT OF WASTE CONCRETE FINES APPLICATION AS CEMENT REPLACEMENT IN FINE-GRAINED COMPOSITES

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ABSTRACT: Cement production is a very energy-intensive process which is responsible for around 5-8% of global carbon dioxide emission caused by human activity. Thus, replacing it with other materials is very beneficial for the environment. The paper presents the research on the use of a waste concrete fines which partially replaced cement in concretes. The fines was obtained in the thermal and mechanical treatment of concrete rubble. Then the research experiment considered the impact of two factors on selected physical and mechanical properties of the fine-grained concretes. These factors included: contents of the recycled fines (10, 20, 30% of cement's mass) and its grinding time (0, 30, 60min). The results confirmed that the right technology enables the recycled fines to substitute 20% of the cement's weight. Such activity allows energy saving compared to clinker and will also cover part of the ever-increasing cement demand – while protecting raw material.

KEY WORDS: waste concrete fines, recycling, ecological aspect, carbon dioxide emission

Introduction

Contemporary society is increasingly paying close attention to the ecological aspects of life related to sustainable development, health, eating or the environment protection. Increasing environmental consciousness manifests, among others, in such selection of used materials and technologies to minimize the negative impact on the environment. Appropriate industrial solutions based on limitation of waste production and returning it to life cycle will protect non-renewable resources for the next generations according to sustainable development idea. Construction and demolition waste (C&DW) is one of the heaviest and most voluminous waste streams generated in the EU. It accounts for approximately 33% (821 million tons) of total waste generated (EC, 2015). In the EU, more than 200 million tons of this waste is produced every year, which gives around 500 kg per capita (Bio Intelligence Service, 2011). Figure 1 presents the amount of C&D waste generated in Poland in 2004–2013 and forecasts to 2022 (from 2014 year because so far there are no data).

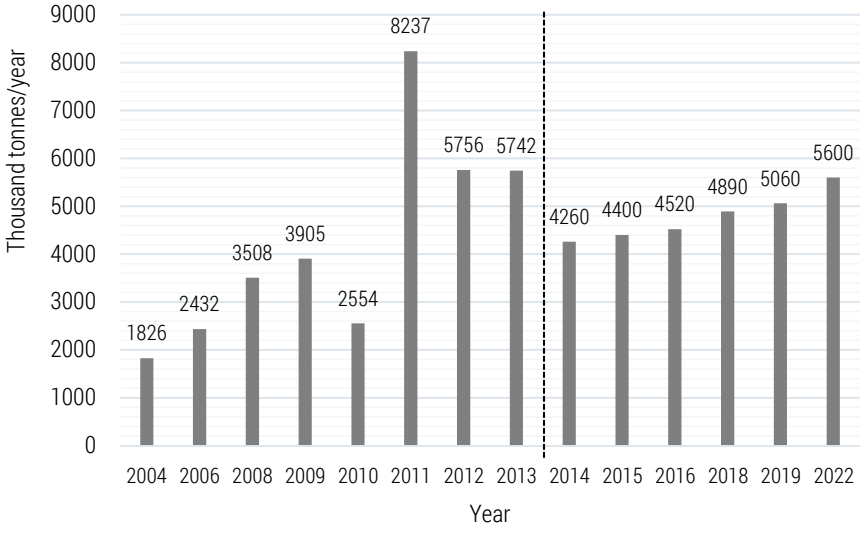


Figure 1. Amount of C&D waste generated in Poland and forecasts for generation to 2022
Source: (C&DW, 2015)

It is therefore necessary to change the material production technologies used in construction in a way reducing energy consumption and use of non-renewable raw materials. The revised Waste Framework Directive (EC, 2008) is an important step towards better material management and increas-

ing resource efficiency in the EU. It proposed a hierarchy of waste management based primarily on waste preventing and reusing. The Directive has called on the member states to take necessary measures to reach a minimum target for reusing, recycling or recovering 70% of waste by 2020 (EC, 2008). Concrete is the most consumed material with 25 billion tons worldwide and 2.5 billion tonnes in the EU. After demolition generally is used for road bases, hole fillings or as coarse recycled aggregate for new concrete. However, when crushing concrete rubble or "cleaning" recycled aggregate from an old cement mortar to improve its properties, up to 30% of the fine fraction (sometimes even up to 65%) is produced. Because of many impurities and weak properties such fine fraction is not recommended to use as concrete component and usually ended up at landfills.

The results of this study indicated the possibility of using this concrete fines as partially cement replacement in concrete, what could manage, in the environmentally friendly way, many millions of tons of such waste produced annually in EU.

An overview of literature

Recycling of concrete rubble is one of the main ways of construction waste recovering. The last standard PN-EN 206, (2014) introduced the possibility of partial replacement of coarse natural aggregate by recycled concrete aggregate. However, during the rubble crushing process about 30% of the fine fraction (<4 mm) consists of cement mortar and pollution is produced additionally. Moreover, to improve the quality of recycled aggregates, various methods of separating the cement mortar from the aggregate grains are proposed (Ismail, 2013; Dosho, 2007). As a result 35% of high-quality coarse aggregate and 21% of fine aggregate is produced but 44% of fines contains a large amount of original mortar generally regarded as a waste material is also obtained (Dosho, 2007). However the ways of reusing that waste fines must be found immediately. For a last few years the researchers have been working on this issue. Gastaldi et al. (2015) and Schoon et al. (2015) have used different amount of the recycled fines (< 63μm) mainly for the production of a clinker and achieved promising long-term results. Shui et al. (2008) studied the possibility of re-hydration of the recycled mortar subjected to 800°C. Ahmari et al. (2012) proposed the possibility of producing a new geopolymer binder based on powder from the recycled concrete.

In present article fine waste material obtained from the production of high quality recycled aggregates was used as a partial replacement for Portland cement. For this purpose special thermal-mechanical treatment method of concrete rubble, based on patent application (P.417362) was tested.

The world demand for cement is about 4160.0 million tonnes and is constantly growing. Portland clinker is produced through a combustion process: first calcium carbonate from the quarry is calcined to lime; then this lime is combined with clay to produce clinker. This process requires thermal energy, e.g. 2.9 GJ/t clinker with the best available technology. The CO_2 emission related to both calcination and combustion is ~ 830 kg CO_2/t clinker produced. Cement production is a very energy-intensive process which is responsible for around 5-8% of global CO_2 emission caused by human activity with a growing tendency (Błaszczyński and Król, 2014; WRI, 2005). Taking into account the fact that the world produces billions of tons of cement annually, it is easy to imagine damages caused in the environment. Thus, the introduction of alternative binders from waste and their use as a cement additive or replacement will contribute to minimizing negative impacts on the natural environment by reducing pollutant emissions and the efficient use of waste.

The aim of this study is to determine the possibility of using the recycled concrete fines after thermal-mechanical treatment as partially cement replacement in the fine-grained concretes and analysis the beneficial impact of such activity on the environment. The fine-grained concrete recipe is based on the reactive powder concrete (RPC) composition, which contains 700-1200 kg/m^3 of cement.

Research methods

To conduct the research were used: Portland cement CEM I 42.5R, standard sand fraction 0/1 mm, CHRYSO Fluid Optima 350 additive and silica fume. The recycled fines was obtained by processing cement mortar separated from concrete rubble. In the first stage concrete rubble was subjected to pre-grinding in a jaw crusher in order to obtain coarse aggregate and then special thermal-mechanical treatment, based on patent application (P.417362, 2016) for mortar separating was used. Roasting temperature in the experiment was set at 650^{o}C according to patent guidelines. The recycled material was roasted for one hour in a pre-heated furnace in order to weaken the adhesion of the cement mortar to the aggregate grains and recover binding properties of the dehydrated paste phases.

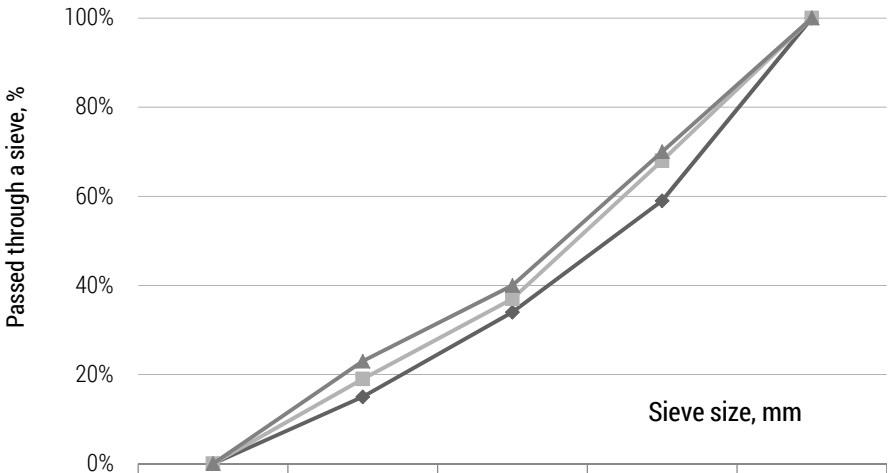
Then material was placed in the Los Angeles drum for separation the old cement mortar from the aggregate's surface. After 1000 revolutions the drum's content was sieved (sieve size – 4mm) to separate the coarse aggregate. The remaining mortar was re-sieved (sieve size – 0.5 mm) to separate the concrete fines used for further examination. Next after grounding in a

mill for: 0 min, 30 min and 60 min specific surface area and skeletal density were examined (table 1) and the sieve analysis was performed (figure 2).

Table 1. The properties of the recycled concrete fines and cement

Properties	Recycled concrete fines in depend on grinding time, min			Cement CEM I 42.5R
	0	30	60	
Skeletal density acc. EN 1097–7 [cm^3/g]	2.76			3.05
Specific surface area acc. EN 196-6 [cm^2/g]	2 086	2 674	3 162	3 400

Source: author's own work.



	0	0,063	0,125	0,25	0,5
0 min	0%	15%	34%	59%	100%
30 min	0%	19%	37%	68%	100%
60 min	0%	23%	40%	70%	100%

Figure 2. Grain size curves of the obtained recycled powders

Source: author's own work.

Prolonged grinding of the concrete fines increases mainly dust faction <0.063 mm. Next cylindrical samples (3 cm – diameter and 3.5 cm – height) were prepared and after 28 days of curing chosen physical-mechanical properties like compressive strength, water absorption, density and water capillarity of composites were conducted.

Research experiment and results

In order to determine the influence of the recycled fines on selected properties of fine-grained composites I planned a research experiment consisting of 9 basic and one control series without recycled fines (No 10). The experiment included two factors (X_1, X_2):

X_1 – the content of the recycled fines: 10; 20; 30% of the cement mass,

X_2 – grinding time of the recycled fines: 0 min; 30 min; 60 min.

Final recipe of the concrete mix with a starting cement content of 900 kg/m^3, which corresponds to reactive powder concretes is presented in table 2. Next, the moulded samples were pressed for 10min with a force of 250 kN.

Table 2. Recipes of concrete mixes per 1 m^3

Composition	Control	X_1=10%	X_1=20%	X_1=30%
Cement CEM I 42.5 R [kg/m^3]	900	810	720	630
Recycled fines [kg/m^3]	-	90	180	270
Silica fume [kg/m^3]	225	225	225	225
w/c	0.30	0.33	0.38	0.43
w/s	0.24	0.24	0.24	0.24
Water [dm^3/m^3]	270	270	270	270
Superplasticiser [dm^3/m^3]	22.5	22.5	22.5	22.5
Standard sand 0/1mm [kg/m^3]	834.5	834.5	834.5	834.5

Source: author's own work.

Table 3 shows the average results of the compressive strength tests after 28 days of curing ($f_{cm,28}$), water absorption (WA), density (D) and the water capillarity (Cap).

Figures 3a-d show a graphical interpretation of the obtained results.

Table 3. The average test results of composite properties

Series nº	Variable values		Composite properties			
	X_1	X_2	$f_{cm,28}$	WA	D	Cap
	[%]	[min]	[MPa]	[%]	[kg/m³]	[%]
1	10	0	75.21	2.86	2389.37	0.83
2	20	0	68.67	3.29	2361.93	0.95
3	30	0	63.77	3.36	2334.49	1.07
4	10	30	79.11	2.16	2407.15	0.80
5	20	30	81.87	2.46	2379.71	0.95
6	30	30	66.65	2.49	2352.27	1.00
7	10	60	89.55	1.55	2424.93	0.75
8	20	60	88.53	1.93	2397.49	0.85
9	30	60	69.53	1.95	2370.05	0.94
10	0	0	71.90	1.68	2430.63	0.66

Source: author's own work.

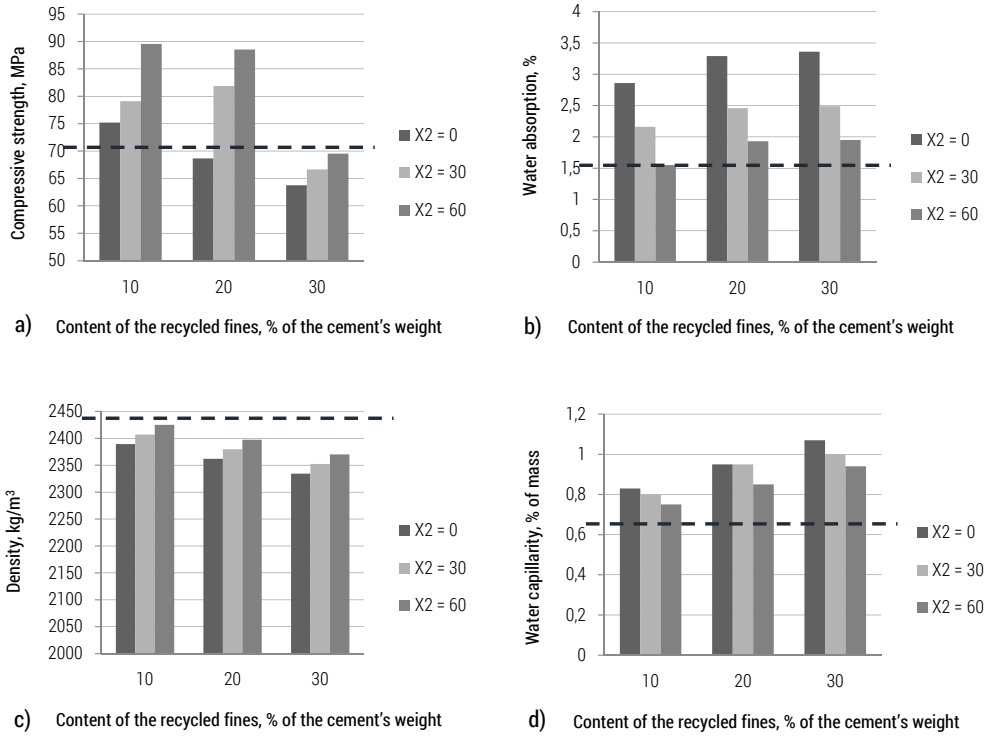


Figure 3. Graphs of changes in composite properties depending on X_1 and X_2 variables (a – compressive strength, b – water absorption, c – density, d – water capillarity)

Source: author's own work.

The above analyses show that two variables considered in the experiment had a significant influence on the tested concrete properties. An increase of the recycled fines from 10% to 30% in concrete caused a 15-22% loss of compressive strength (depending on the grinding time). Grinding the fines for 60min resulted in the fragmentation and an increase of grain content to 0.063mm (Figure 2), which probably improved packing of designed aggregate granulation. It led to the strength growth by about 23% when 20% of concrete fines were used in compare to control concrete. At a temperature of 650°C portlandite dehydroxylation was occurred, resulting in calcium oxide was formed, which in contact with water hydrated again. Such a significant improvement in compressive strength when concrete fines was used is partly puzzling and may be due to the small size of the test specimens. But the general trend is visible and indicates the possibility of using recycled fines as a substitute for cement after proper treatment. Fines grinding time has a beneficial effect on composite water absorption, similar to the control, and on water capillarity due to the increase of the smallest fraction improving the tightness of the concrete structure. An increase in the recycled fines content from 10% to 30% caused a rise in water absorption by 17% and 26% at a grinding time of 0 min and 60 min respectively. This is probably due to a higher porosity of the recycled material and different grain size from the cement. A similar relationship was observed when the water capillarity was tested. Figure 4c concludes that both the content of the recycled powder and the grinding time do not significantly affect the concrete density. As the content of fines increased, the density of the composite decreased slightly (about 2%) because the material has a lower density compared to cement (table 1). The conclusion is that the longer grinding od fines positively affects the material's structure. It improves particle packing in the sample what developed concrete properties. To reduce the adverse effect of the presence of recycled fines in concrete is proposed to apply it in an amount of 20% of cement mass.

Ecological aspect of cement replacement by waste concrete fines

Above test results of physical and mechanical properties of cementitious composites indicate that it is possible to replace Portland cement by waste fines of up to 20% of its weight. However, this requires the use of a suitable thermal-mechanical treatment, in particular a high temperature in which the hydrated cement in waste partially recover its binding capacity. In table 4 stages of the production processes of Portland cement and recycled concrete fines were presented.

Table 4. Production processes of Portland cement and recycled concrete fines

Kind of binder	
Portland cement	Recycled concrete fines
Stage of the production process	
Extraction of raw materials	Selective demolition of the building – concrete rubble
Crushing / Grinding	Preliminary crushing
Correction of composition	Essential crushing
Homogenization	Roasting in temp. 650°C
Roasting in temp. up to 1450°C	Mechanical treatment – separation cement mortar <4 mm
Grinding in a ball mill	Grinding in a ball mill
Storage and packaging	Storage and packaging

Source: author's own work.

As can be seen in table 4, the production processes of Portland cement and recycled concrete fines consist of similar steps, in spite of their different origin. However, determining the amount of energy that consumes production of 1t of recycled fines is quite difficult, because so far, this process is carried out on a laboratory scale and not industrial. On the other hand, it may be provided that the amount of energy should be reduced as compared with the cement production. It is due to much lower roasting temperature needed for recycling fines treatment. In addition, greenhouse gases, mainly carbon dioxide, are emitted during the production process of clinker binder. When clinker is roasted, decarbonisation of calcium carbonate ($CaCO_3$) into calcium oxide occurs. Carbon dioxide in the amount of 510 kg to 610 kg per 1 ton of cement is by-product (Błaszczyński, Król, 2014). In the concrete fines production process, when the roasting temperature of 650°C is used, dehydroxylation of calcium hydroxide $Ca(OH)_2$ takes place which results in calcium oxide and water vapor (1):

$$Ca(OH)_2 \xrightarrow{650^oC} CaO + \uparrow H_2O$$

The decomposition of calcium carbonate with CO_2 emission takes place at about 800°C (Krzywobłocka-Laurów, 1998). Thus, it can be assumed that the production process of concrete fines consumes less than a half of energy needed to clinker production and does not contribute to by-products formation such as carbon dioxide. The development of effective management methods at each stage of waste production allows to return such secondary materials into circulation. This results in ecological and economic benefits

and improves the raw material-product balance. Recycling of concrete waste fines will allow energy saving compared to clinker and will also cover part of the ever-increasing cement demand – while protecting raw material.

Conclusions

Cement production is a very energy-intensive process, so replacing it with other materials is very beneficial for the environment. The waste fines used instead of cement was obtained in the thermo-mechanical processing of concrete rubble. Because of roasting at 650°C, the cement paste in concrete became partially dehydrated, which activated the cement's binding capacity. The influence of two factors like the content of the recycled fines and its grinding time on selected physical and mechanical properties of concretes were analysed. I found out that in most cases the grinding time of the recycled fines and its content significantly affected the obtained results. The best results especially for compressive strength were observed, when recycled fines in an amount up to 20% of cement mass was applied. Particularly advantageous effect was obtained when grinding powder for 60min was used because it had a specific surface area similar to that of cement (3400 cm^2/g). Therefore I can concluded that the results presented in paper are promising and this way should be developed. Proposed solution on one hand allows to manage part of fines waste, on the other hand supports the sustainable development idea by saving the natural resources and reducing the CO_2 emission and energy needed for cement production process.

The author is also conducting research into the possibility of using this material as a pozzolanic additive for cement composites.

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GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

PROBLEMATYKA OGÓLNOEKOLOGICZNA I SPOŁECZNA

Joanna PIETRZAK-ZAWADKA • Jan ZAWADKA

NATURE MUSEUMS AND THEIR ACTIVITIES FOR ENVIRONMENTAL AND FOREST EDUCATION

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ABSTRACT: The aim of the article is to show the specificity of nature museums and their functions in the field of natural and forest education. The paper presents the idea of nature museums in Poland and their functions (eg. educational, informative, fun). Discusses the activities of museums with collections of natural and isolated from this collection of museums typically forest museums. The analysis and the results show the diversity of these institutions on many levels: location, content of collections (the specifics of collection), the presentation of collections, educational activity.

KEY WORDS: nature and forest education, nature museum, functions of nature museums, forms of education

Introduction

Education is a universal value and a basic human right. Within the framework of it should be taken actions to support the full development that will prepare him to the unremitting efforts, increase its capacity for autonomy and personal responsibility. The main task of education is a multilateral development of the personality of the young generation, active in three areas: knowing the world and changing it, and live the values (Paśko 2009). According to UNESCO, a man twenty-first century should use all possible opportunities to update, deepen and enrich their knowledge and adapt to the changing world (Delors 1998).

Education can be realized in the process of formal and informal. Formal education (schools, universities, etc.) has a specific curriculum, the associated plan of activity and defined content. Students have the chance to meet the need for competence only partially, rarely able to demonstrate in action. For the young audience a sense of purpose and meaning of science can thus be disturbed, the presentation of the topics can not be linked either to the interests of the student, or the surrounding reality (Okoń 1998).

In many cases, the formal education system for various reasons do not meet all the educational needs of young people. The opposite of this type of education is informal education, in which the individual uses the educational impact of the environment in which he resides, collecting observations and experience. Basically learns from family, friends, neighbors, colleagues etc., casually absorbing the things heard, seen repeated, what is important to her, new, interesting. Non-formal education has no purpose, structure or plan (Okoń 1998, Anderson et al. 2002). Often this category are included classes on wheels interests or in museums, science centers, art galleries, theaters, botanical gardens and zoos. Such activities already at school level can give the opportunity to develop an integrated, attractive to recipients and effective environmental education. The place of this type of activities can be nature museums, where the activities for environmental and forest education is an issue taken up in the present work. Although the literature on museums is quite extensive, there are no studies on the polish museums that collect natural history. The knowledge about the specifics of these museums and their activities is small compared with other countries, eg. Denmark and the United Kingdom (Kordowska 2015). Problematic is also an indication of the number of museums of natural history and a clear distinction of this type. According to the GUS (2015) in 2015 in Poland functioned 843 museums, 30 of them defined as natural. The Base Museum National Institute of Museology and Protection of Collections of National distinguishes 13 nature museums, and the portal of all the existing museums in Poland (www.museo.pl),

identified 37 such facilities. These differences may be caused by discrepancies in the definition of museums of this type by various institutions and organizations.

Research methods

For the purpose of the work we analyzed a variety of information on the nature museums. They were Central Statistical Office of Poland (GUS) statistics and data of the available publications and other numerical combinations. For the purpose of the work the authors have tried to define the nature museums. For them, the nature museum is an institution whose main activity is focused on the acquisition, preservation, collection and sharing collections of a live or dead specimens of nature. Its non-core functions can be educational activities in this field, as well as research activities and publishing.

Nature museums and their role in education

The authors identified in Poland 56 nature museums. They are distributed throughout the country, but the largest number of them is in the Malopolska province – 10 units (figure 1). In the area of the province also it operates the largest number of museums in total – 119 objects (www.stat.gov.pl). Regions with a significant number of institutions of this type were, moreover Mazowieckie and Podlaskie.

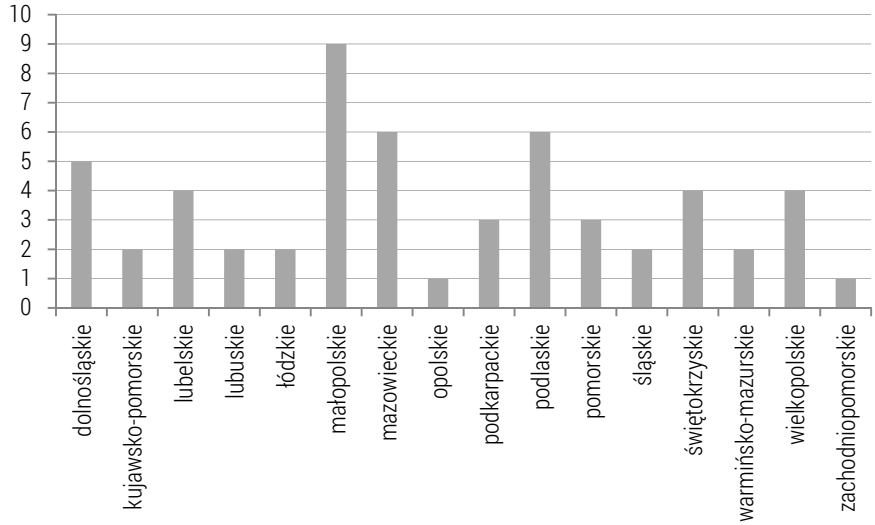

Figure 1. Nature museums by provinces in Poland

Source: author's own study.

The smallest number of museums of natural history recorded in the Opole province, Podkarpackie and Śląsk – 1.

From the point of view of maximizing the number of visitors it is advisable location of the museum in interesting regions in terms of nature. It is then the possibility of extending the educational offer of workshops directly in the natural environment. This element is valuable because of the variety the most cameral museum lessons. Important functions perform museums located in areas or near national parks or scenic – the hour drive (Kordowska 2015). In the area of valuable natural area operated 26.7% analyzed institutions (figure 2).

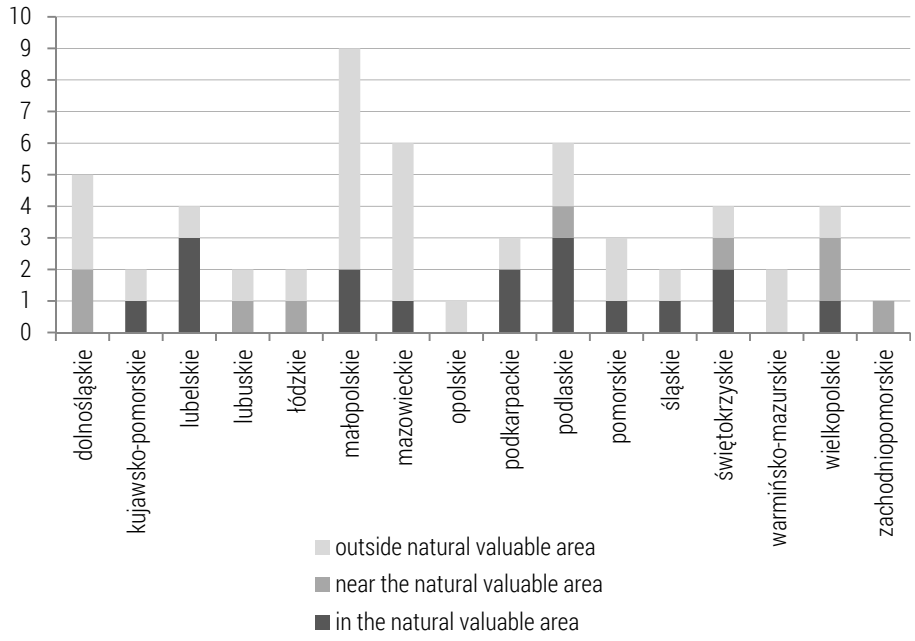

Figure 2. Location nature museums of terms of nature valuable areas

Source: author's own study.

Nature museums besides valuable natural areas, eg. In urban areas, have a more difficult task. In order to make offer more attractive in these facilities you can build interesting nature trails at the museum building or acquire attractive dioramas (Stasiak 2000). Besides valuable natural areas it recorded 55.3% of this type of museums.

Presentation of collections in nature museums

The nature museums are presented a variety of natural history collections. In about 70% of the analyzed objects dominated zoological collections (dermoplastic or dissected preparations of mammals, birds, fish and reptiles, horns and antlers, entomological collections). There were less numerous museums, which presented mostly botanical collections (herbaria and driers, sections of trees, exhibitions of vegetation). In addition, for a more attractive offer education in nature museums can meet collections paleontological, geological, and entomopaleontological.

Against the background of nature museums in Poland stand out facility with the living "exhibits" for example Museum of White Stork in Kłopot (Lubuskie), where there are currently more than 30 stork nests. In the museum you can see an exhibition dedicated to the stork and embark on a tour of the area educational path. Another distinctive building is the Meadow Museum in Owczary possessing exhibition devoted to Polish and grassy ecosystems of the world.

The Museum Missionary-Ornithological in Kodeń you can see the ornithological exhibition, containing the collections gathered by Kazimierz Kozicki – a collection of birds' eggs of Polish species.

Most often in museums collections presented in the traditional way. Specimens can be seen, not touched, they are arranged at a distance from the visitor (table 1). In turn, the interactive form of sharing collections of exhibits is a presentation using modern multimedia techniques, eg.: multimedia presentations, film science, visualization, as well as replicas or models that can be touched.

Table 1. Examples of presenting collections of nature museums

Presentation of the collection	Examples of exposure	Museum facility
Traditional	Designed exhibitions and exhibits	Museum of Natural History, Ethnography and Art in Srokowo
Interactive	Kiosks with touch screen	Ojcow National Park Museum, Poleski National Park Museum, Nature and Forest Museum, Bialowieza National Park
Virtual	Presentation of the exhibition is available in the form of on-line or other digital media; virtual tour of the museum	Museum of Natural History, University of Wroclaw

Source: author's own study based on the data contained on the websites of selected nature museums.

Computer technology now allow to explore the museum in a virtual way – exhibits are made available via the Internet. These resources can occur in two forms: as a museum entirely virtual or supplement the traditional museum.

The importance of nature museums in environmental education

The most extensive museums function seems to be the educational function. This activity mainly includes educational activities and exhibition, accepting the form of museum lessons, leadership, cooperation with schools and publishing (Kordowska 2015, Munley 2012, Folga-Januszewska 2010, Nyhart 2001, Suarez, Tsutsui 2004, Ponder et al. 2001). The most common form of activity are permanent and temporary exhibitions, museum lessons, educational workshops, screenings of nature films, seminars, conferences, lectures. Often these are integrated into classes (eg. a combination of a multimedia presentation with practical exercises) to make their form the most attractive (table 2).

In addition to the permanent exhibitions important function in the education act temporary exhibitions. Sometimes in museums take place several temporary exhibitions a year, so tourists can visit the same facility several times. Temporary exhibitions concern, among others the presentation of the art of painting (The opening of "Culture Lomza painted with brush" at the Museum of Nature in Drozdowo, exhibition of photographs (eg. photographic exhibition "Palace of the tsar in Bialowieza" at the Museum of Bialowieza National Park, a photographic exhibition by Andrzej Waszczuk "One hundred views of Warmia" the Museum of Nature in Olsztyn, "tropical forest", "exotic pets" at the Natural History Museum in Krakow), presentations of interesting exhibits of flora and fauna, or travel reports ("South America through the eyes of naturalists" – Natural History Museum in Krakow). Sometimes during the presentation temporary exhibition in the museum presents live specimens of plants and animals.

The nature museums are also made available library collections. The vast majority of the volume at the broad nature. Within the department of natural stands library collections devoted to: botany, zoology and nature of the region.

Table 2. Types of educational activities at the Natural History Museum in Wroclaw

Type of classes	Form of classes	Examples of topics	Recipients
Museum lesson	Power Point presentation	Threatened and endangered species in Poland and in the world (CITES)	Junior high school, high school
Museum lesson	Exercise: Exhibit Museum (2 x 1 hr. for the group)	Threatened and endangered species in Poland and in the world (CITES)	Junior high school, high school
Museum lesson	Presentation (PowerPoint) 1 hr., exercise – based on the work card, visit exhibitions Museum – 2 hours.	Earth – Water Planet Water – environment fish life	Primary school, middle school
Workshops	Workshop – 2 hours. (Among others about how they look, what they eat, how they hunt owl, barn owl, tawny owl)	The mysteries of the life of owls	Primary school, middle school
Classes integrated	Presentation (PowerPoint) 1 hr. + Classes at the large exhibition hall 1 hour. (For 2 groups of 15 people);Exercise: exercises room 1 hour + Classes at the large exhibition hall 1 hour. (For 2 groups of 15 people)	Morphological characteristics of molluscs (snails, bivalves, cephalopods, chiton) and examples of the most unusual.	Primary school, middle school
Practical work in the field	Fieldwork (one trip)	Insects around us	Junior high school, high school
Guided tour	Story	Nature around us	Kindergarten groups, students in grades 1-3 elementary school

Source: author's own study based on www.muzeum-przyrodnicze.uni.wroc.pl.

Museums of forest

Among the museums of nature can be divided into those whose collections relate to issues of forestry and the forest environment. In Poland, it was awarded 9 of its kind museum (table 3).

An interesting example is the Museum of Forest and Wood in Rogów where educational needs prepared mock exposing three forms of land use: forest reserve, an area of relative biological balance and the area of ecological threats. In this museum are available the following exhibitions: "Meeting the forest", two dioramas forest, the exposure of forest species from the "Polish

Red Book". An interesting exhibit is a collection of 18 historical "books of wood" made of wood various species of trees and shrubs from the beginning of the nineteenth century . the spine of each book is made from the bark of different species of trees, and cover with a cross-section of the tangential wood.

Table 3. Types of educational activities in selected museums of forest

	Name of museum	Subject	Educational activities
1	Museum of Forest and Wood in Rogów	Collections represent different disciplines forest, zoological, entomological and ornithological	Conduct museum lessons and chamber music field
2	Forest Museum in Forest District Spychowo	Ornithological collection, historic hall	Educational activities with a forester
3	Forestry Museum – Cultural Centre Forest in Gołuchów	Exhibitions "Culture-the role of the forest" and "History of forestry in Poland", "Forest machinery", "Forest protection".	Educational activities with a forester, a virtual walk
4	Spruce Istebna Museum in Jaworzynka	History Beskid spruce stands, and research into, and the cycle of growth spruce Istebna, aviary grouse.	–
5	Private Museum of Nature and Hunting "Łuczakówka" in Krynica-Zdroj	Zoological exhibition, a collection of complementary exhibits African fauna.	–
6	Museum of Hunting and Horsemanship in Warsaw	Polish hunting room at the turn of the century; dioramas zoological Powozownia namely Zbigniew Prus-Niewiadomski.	Museum lessons, conducted by teachers of content in an attractive setting museum exhibitions, virtual walk
7	Nature and Hunting Museum "Knieja" in Nowosiolki	Exciting and interesting hunting trophies, "Kabarga" – hunted in Siberia "reindeer" (antlers) from Lapland "brown bear" coming from the Siberian taiga with a deep, beautiful wildlife. Very popular is the Carpathian deer, which has become a symbol of the Carpathian Landscape Parks. For the purpose of teaching are presented forms of development antlers and roe deer.	Guide
8	Natural History Museum of Hunting in Uzarzewo	Exposure to natural collection of birds' eggs with nearly 200 species.	Activities and museum lessons, educational events
9	Nature and Forest Museum, Białowieża National Park	Exposure to natural, dioramas.	Activities and museum lessons, educational events

Source: author's own study.

Another interesting example is the Museum of Forestry in Forest Culture Center in Gołuchów, which has two permanent exhibitions: "Culture-the role of the forest" and "History of forestry in Poland".

Another example is the Museum of Nature and Forest Białowieża National Park in Białowieża, where are presented exhibitions botanical, zoological and cultural heritage. At the exhibition you can admire the pieces of the ecosystem Białowieża Forest and scenes from the life of animals, for example prey of wolves. In the museum you can see the phase of wood decay and other ecological processes. The creators of exhibitions took care of setting the full sound and light exposure, so visiting the various exhibitions we are accompanied by the sounds of animals, singing birds and other sounds of the forest.

As part of the cultural exhibition shown how the historical use of the forest over the centuries (haymaking, bee-keeping, processing of wood turpentine and charcoal). All issues of nature are presented in program blocks through realistic dioramas depicting animals, fungi, plants in their natural environments.

Conclusions

The museum as an institution established to collect, study and care for objects having artistic or historical protective functions, educational and aesthetic. Their popularity is determined not only the value of collections, but the effective promotion and creating a positive image. We recommended to continue research in this area.

It is worth noting that the natural history museum in the modern world meets the many needs of young people, such as the need for aesthetic experiences, satisfying curiosity, deepening knowledge, forming worldview, search patterns and ideals of life, the need for a pleasant and valuable leisure time.

To museum objects changed their image from inaccessible exhibitions on objects attractive for modern-day tourists, it is an innovative approach to ways of presenting their exhibits and exposure. An important issue seem in this aspect may be activation of visitors during a visit to the museum building and creating the opportunity to hold a variety of workshops, courses and field exercises. Very important it is also the use of technological innovations, eg. multimedia and interactive exhibitions. Analyzing the offer of museums in the field of environmental education can distinguish several attractive, interesting and innovative educational solutions. These are: – interestingly organized classes and workshops museum using multimedia and interactive computer technology (eg. Natural History Museum in Krakow); sharing collections online through the organization of the so-called. e-museums (eg. Natu-

ral History Museum in Wroclaw); – offering children and young people activities through participation in the creative process and cognitive (eg. Museum of Nature and Technology, Ecomuseum John Pazdur in Starachowice, Museum of Nature in Olsztyn); – offer for disabled children and youth (eg. Natural-Forest Museum of the BNP, the Museum of Natural History – ISEZ-PAN, the Museum of Natural Wolin National Park). In the modern world the museum is one of the most important institutions operating in the sphere of culture, because it is difficult to imagine a school trip without visiting museums.

However, as follows from the analysis, museums are not only treasuries luxuries, but actively participating in the development of science and culture, have become tourist attractions, and are an important factor in the development of tourism. One of the most important segments of the tourism market is young people and children, so the above analysis can be useful for many establishments museum in the preparation of appropriate educational offer for young travelers.

The analysis offers nature museums in Poland proved that, despite the common opinion about museums as individuals inflexible, proposing stiff and not very attractive program of sightseeing in discussed in the pages of this paper museums observe a significant change in the way of executing cognitive-educational. This is particularly noticeable in relation to the parts of the young visitors.

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The contribution of the authors

Conception: Jan Zawadka (50%) Joanna Pietrzak-Zawadka (50%).

Literature review: Jan Zawadka (50%) Joanna Pietrzak-Zawadka (50%).

Acquisition of data: Jan Zawadka (50%) Joanna Pietrzak-Zawadka (50%).

Analysis and interpretation of data: Jan Zawadka (50%) Joanna Pietrzak-Zawadka (50%).

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STRATEGIC MANAGEMENT OF THE USE OF NATURAL VALUES FOR TOURISM DEVELOPMENT ON THE EXAMPLE OF PODLASKIE REGION

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ABSTRACT: The first part of the study presents the results of research in the natural values of Podlaskie region. It shows the characteristics of tourism and recreation forms, which are preferred on environmentally valuable areas. In the second part of the article the author proposes a strategy model for the development of nature tourism, ecotourism, green therapy and recreation. The model describes the strategy steps, stating proposals for specific provisions that take into account the specificity of these forms of tourism and recreation. The final part indicates major benefits that come from the creation and implementation of strategies aimed at exploiting the potential of the natural region.

KEY WORDS: the natural values, strategic management, region

Introduction

The tourist potential of Podlaskie region is very high and indisputable by many tourism researchers in recent decades (Business Mobility International, 2009, Borkowska-Niszczota, 2014, Panfiluk, 2015). The problem discussed among others at the individual meetings and scientific conferences is the following question: how to use this potential in the economic development of the region for tourists and for the development of the region and improve the quality of life in Podlaskie region?

The aim of the study is to present a synthetic diagnosis concerning the most important natural values of Podlaskie region on the basis of performed research. The author presented the concept of strategic approach to the development of nature tourism, health tourism and green therapy and recreation in the region based on the experience gained in the work of regional self-government (including the construction of several development strategies), his own research in the field of tourism in the years 2002-2015 and analysis of tourism development in Polish regions.

The natural values of Podlaskie region

In today's world, more and more people are concerned about improving the quality of their lives (Trzebiatowski, 2011). The author's research has shown, that an important indicator affecting the quality of life is clean natural environment. This environment is characterized by a certain natural values that determine the tourist attractiveness of the region. Natural values should be understood as goods given to us by the Creator, goods that arose independently of human activity. These are: climate, terrain and rich biodiversity. They represent one of the most important factors for tourist trips. Clean uncontaminated fauna and flora with a lovely landscape attract tourists, who are willing to overcome hundreds and even thousands of kilometres to rest, heal and experience unusual contact with nature, especially the kind that is unique in the world.

The most valued natural assets are located on environmentally valuable areas such as national parks, landscape parks, nature reserves, areas of protected landscape, monuments of nature, which are usually subject to different forms of protection (Iddle, Bines, 2004, p. 34). Among the natural areas there are also valuable natural sites that are not under protection, eg. unique forest areas rich in flora and fauna, geological outcrops, park complexes, etc.

The greatest natural values of Podlaskie region are large forest complexes of Białowieża Forest, Knyszyn Forest and Augustow Forest, Narew valley

with a highly developed system of riverbeds, picturesque valley of River Bug with high landscape values, Biebrza Marshes which are the most natural in Central Europe, the glacial landscape of North Suwałki region with many lakes. These are areas of rich biodiversity in terms of flora and fauna (Matwiejuk, 2004, p. 83-84). Natural and environmental assets of Podlaskie region present a number of opportunities for the development of tourism, because many areas of the region were preserved in almost natural (primary) state due to the lack of human interference.

In order to recognize the most important natural values in Podlaskie region a research was carried out in 2008-2010 (Szczepanowski, 2011, p. 73-78), and was still continued in 2011-2013. The study was conducted among residents of Podlaskie region, Suwałki, Łomza and Northern Kurpie, who have the greatest knowledge and experience in the development of tourism in Podlaskie province. Therefore, questionnaires were sent to the owners of the largest hotels, motels, inns, chairmen of PTTK branches, travel agencies, Podlaskie Regional Tourist Organization and local tourism organizations in Podlaskie region. In this group, the questions in a questionnaire were answered by 34 entities, which accounted for 75% of all major companies and organizations of tourist region studied. The second group were owners of farms engaged in tourism activities in rural areas (including tourist farms). Survey responses were obtained from 84 farms located in all municipalities of Podlaskie region (surveys return was at the level of 64%).

The multitude of pre-determined factors that make up the tourist attractions forced the author to make a choice by the method of diagnostic survey. As a result of in-depth interviews and consultations with experts in the field of tourism, with universities of Białystok, and the most experienced practitioners of the tourism industry, 6 factors were selected for further study that characterize the most important tourist natural values of Podlaskie region. Diagnostic surveys and expert interviews allowed for the preparation of the questionnaire and conducting surveys. In the questionnaire the indicator concept was used. The respondents were asked the extent to which selected natural values are important to them and affect or may affect the development of tourism in Podlaskie. The scale of 0-5 was adopted, where 0 indicates that the value does not affect the development of tourism, 5 means that the value affects it in the highest degree. The comparison of the level of importance of natural assets in the opinion of representatives of tourism organizations, hotels and owners of tourist farms is shown in figure 1.

The highest average rating in entire comparison of 118 subjects who participated in the research, was received by clean natural environment value with an average of 4.83. As many as 98 respondents rated it at the highest value – 5.

The next positions were taken by the following values:

- large number of forest areas – average 4.34;
- good landscape values – average 4.25;
- high biodiversity – average 4.12;
- national and landscape parks – average 4.11;
- presence of rivers (Narew, Biebrza, Czarna Hańcza, Rospuda and others) and the Augustow Lake District – average 3.99.

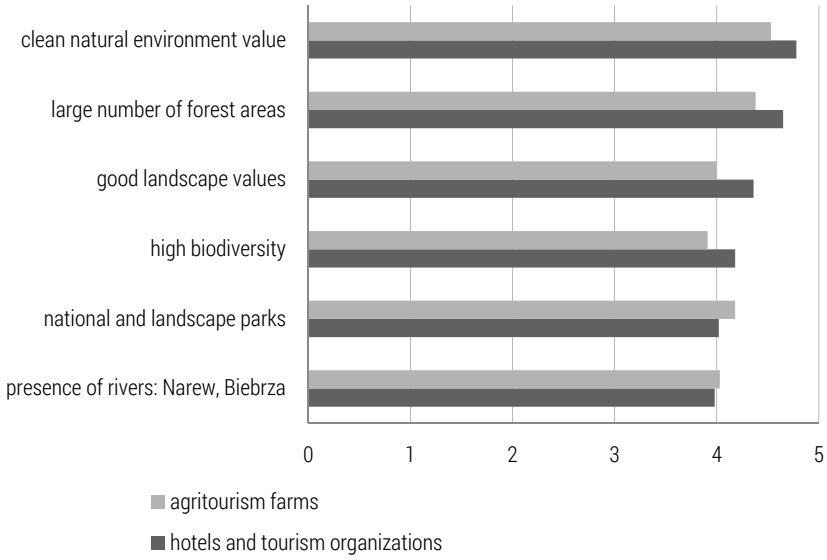

Figure 1. Natural values of the Podlaskie region in the opinion of representatives of tourism organizations, hotels and owners of tourist farms

Source: author's own research.

The most valuable natural values of the region of Podlaskie were also evaluated by both owners of agritourism farms, as well as representatives of tourism organizations, owners of hotels, motels, and inns. Clean natural environment value has been assessed by the owners of agritourism farms with an average of 4.78, and by the tourism organizers at the level of 4.53. In contrast, presence of a large number of forest areas value was evaluated at respectively 4.65 and 4.38. The representatives of tourist organizations and hoteliers assessed these values slightly higher than other respondents. This is probably due to the fact that the owners of agritourism farms, who experience clean environment, are more used to it and are less exposed to the pollution, which increasingly occur in cities. Representatives of tourism organizations and tourism organizers offering accommodation on a higher level,

put the good landscape values on position 3, and the high biodiversity on position 4. The owners of agritourism farms put national parks, landscape and nature reserves as third most important environmental value, while at fourth they put presence of rivers, such as Narew, Biebrza, Czarna Hańcza and others. At the same time it should be mentioned that the differences in individual values assessment are very low and are within tenths of a percentage point. A surprise in the comparison of 118 entities is merely the fifth position of national parks and landscapes, which in the circulation reviews were rated the highest, also by many experts in the field of tourism in Podlaskie.

Nature tourism, ecotourism, green therapy and recreation in the development of the region

High, above-average natural values of the region of Podlaskie province constitute an excellent opportunity to practice nature tourism and ecotourism. The definitions of these terms in the subject bibliography are varied. However, they are always related to learning and direct experience of a natural, pure, untransformed or slightly transformed natural environment. Nature tourism and ecotourism initially were not commercial in nature and were referred to as alternative tourism, the aim of which was to be in the natural environment, usually combined with learning about it. This kind of tourism was generally practiced by educated people, characterized by a high level of environmental awareness. Over time, nature tourism began to take the form of commercial and even mass tourism (Page, Dowling, 2002, p. 48). Ecotourism in the 80's of the twentieth century was enriched by the social and cultural content (Cabellos-Lascurian, 2002, p. 48).

Nowadays the term nature tourism defines all journeys aimed at studying, observing and enjoying the nature (Mika, 2007, p. 207). In defining the nature tourism, the aspect of non-infringement of biodiversity of visited natural systems is noted in addition to cognitive elements (Krzymowska-Kostrowicka, 1995, 5.2).

Ecotourism covers only traveling individually or in small groups, which in addition to the natural environment can be focused on direct contact with the culture. It is assumed that eco-tourism should not only harm but help protect wildlife and indigenous culture, but also bring economic benefits to local communities. It can take commercial forms, provided that the income goes to the people and constitutes a factor in the economic recovery of the area (Cabellos-Lascurian, 1996, p. 301).

Analysis of global trends in tourism clearly shows an increase in the number of arrivals to areas of high natural values and the rise in popularity of

forms of tourism related to the learning about the environment. In the 90's, the average growth rate of tourist arrivals in the world was estimated at 7%, and ecotourism at 20-34%. In 2004 in the field of ecotourism and nature tourism, its growth was three times higher than the total growth in the world tourism market (TIES, 2005). This trend is beneficial, especially from an economic point of view, because tourism is a chance for economic recovery of poorly developed areas with high, extraordinary natural values. Thanks to the development of tourism, including natural and eco-tourism, municipalities' and region's tax revenues increase. Local governments have larger budgets to realize the necessary investments, which lead to a reduction of unemployment, creation of new jobs, which allows suppression of the processes of migration from rural areas and small towns to large urban centres.

Civilization changes of XX and XXI century, related to among others the competitiveness, staying on the market, increasing the pace of life cause stress and all kinds of mental and physical problems in many people. Therefore, resting and recreation becomes increasingly important for the discharge of nervous tension. Measure that prevents civilization diseases in the modern dawn is recreation, which also contributes to the development of interests and personality and increase physical activity of the society. It seems that a very effective and friendly way to combat stress is green therapy and recreation.

The green therapy concept was introduced by B. Poskrobko. It is understood as a treatment for light mental and emotional disorders without the use of drugs through direct contact with nature, experiencing natural landscapes, colors, smells and sound of nature through its impact on the psyche. It is supposed mainly to treat disorders caused by overwork, or too long, constant working using the computer. Green recreation means activities performed in order to strengthen physical, mental and creative forces of the man. It is assumed, that it should take place mainly in the open air in different ecosystems – forests, fields, meadow or water, as well as in parks, groves, gardens, herb gardens or flower gardens. Places of recreation should arouse the interest of the participants; therefore, they should be enriched with different information and educational devices, for example technical and cultural in order to strengthen the physical and mental relaxation (Poskrobko, 2013, p. 5-6).

Green and leisure treatment may be carried out in different organization forms. For example, by multilateral organizations operating in large forest areas, swamp-meadows and the field. Polish forests, characterized by, inter alia, very clean air, high biodiversity, sparsely populated and poorly developed economy are predestined in this respect.

The development of nature tourism, eco-tourism and green therapy and recreation is also supported by the profile of practicing tourists which is dominated by people in middle-age groups, higher education and high and medium income (Zaręba, 2006, p. 84). Participants of nature tourism, for example birdwatchers, usually spend more money per day of travel than an average tourist (Wight, 1996, p. 24). A chance in the development of nature tourism is rich wallets of tourists from Belarus and Ukraine, who among foreign visitors in Poland spend the most on tourist destinations. Those tourists after deducing declared spending on shopping dedicated $ 94 for one day of their stay in 2012, and tourists from Ukraine $ 84, with an average of $ 78 USD from overseas and European Union in 2012 (Polish Tourist Organisation, 2013, p. 10.

The specific character of nature tourism, ecotourism (Page, Dowling, 2002, p. 51) and green therapy and recreation makes its development more difficult than other forms of tourism. It requires long-term planned activities, extensive cooperation of regional authorities, management of protected areas, local tourist organizations, owners of travel agencies, tourist facilities, and inhabitants of the region.

Author's research regarding natural values of Podlaskie region proved high potential for nature tourism and ecotourism development. Unfortunately, over the last 15 years, the number of tourists visiting Podlaskie region does not increase, including provided accommodation. Similar situation is observed in regions with equally high natural potential, such as: Warmia-Masuria, Lublin, Rzeszów, Lubin (Szczepanowski 2009 and further research according to GUS). However, world market (*Fact Sheet: Global Ecotourism, The International Ecotourism Society*, Washington, 2005; UNWTO World Tourism Barometer 2017) presents constant growth of number of tourists interested in nature tourism. Thus, potential itself is not sufficient. In order to accelerate the development of tourism, especially nature tourism, it is necessary to efficiently manage touristic potential.

Strategic management in tourism development in the region

Perspective and a more durable direction of development of tourism is provided by strategic management which is defined as an approach to economic and social opportunities and challenges in a comprehensive management process, focused on the formulation and implementation of effective strategies (Gryffin, 2005, p. 224). In tourism, management process based on the formulation and implementation of a strategy that promotes, among others, higher degree of compliance of organizations and institutions of different

stakeholders in tourism with their surroundings and the achievement of strategic objectives (Michałowski, 2008, p. 168). The objectives of the development of tourism, which are the objectives of tourism policy, usually come down to:

- rational use of production factors involved in the tourism economy,
- the adaptation of tourist and travel services for possessed tourist attractions,
- coordinating the development of tourism and its relationship with other spheres of life,
- the search for the optimum response to the tourist needs,
- the application of the measures necessary to achieve these objectives.

To achieve these goals, tourism development strategies should be prepared based on knowledge and knowledge of the factors of its development and possibilities in given socio-economic circumstances, taking into account the expectations of all stakeholders.

In Poland, there have been attempts for strategic approach to the development of nature tourism, mainly in the development strategies of the provinces. Research by (Rochmińska and Stasiak, 2004) suggest that strategies for regional tourism are very often ones of the strategic areas. As many as 11 Polish provinces considered it to be one of the main elements of its socio-economic development. The analysis of the development strategies of all Polish provinces conducted by B. Zawilińska indicates, that issues concerning environmental protection, in particular the conservation of biodiversity, as well as the empowerment of protected areas in parts of the strategy were not taken into account at all. As part of the strategy, in which tourism is important, trends and preferred forms are discussed in detail. Unfortunately, nature tourism, even in the provinces, which strongly accentuate the natural wealth of the land, does not appear, or is merely mentioned. Records of nature tourism or ecotourism can be found only in the development strategies of Podkarpackie (where tourism development is seen as one of the directions of actions to ensure the income of the population living in environmentally valuable areas), Podlaskie (where support for the development of tourism, including eco-tourism, is to serve the development of the economic base) and the Warmia-Mazury (where attention is paid to the development of the concept and promoting tourism products, among others, in the field of eco-tourism) (Zawilińska, p. 129).

Unfortunately, from the perspective of almost 15 years from the date of approval of the development strategy of provinces, as well as tourism development programs (including the region of Podlaskie) it is clear that little or even almost nothing of the assumptions were realized. Only the educational paths in forests, national and landscape parks were extended, which is mainly

thanks to the management and employees of the State Forests and some national parks and landscapes. Thus, it can be said that many benefits that could have been provided by the preparation and implementation of strategies (plans) of development, and thus a systemic approach covering all areas related to the tourist economy have been lost. This condition may be due to the lack of choice of strategic areas (called engines of development of the region) (Polski, 2004, p. 35).

Preparation of tourism development strategy should be accompanied by measures in the form of creating the instruments of its implementation by public organizations and businesses, and then the implementation of specific tourist projects. All these activities make up the tourism management, which in turn has a direct impact on the management of tourism, implemented by the various operators involved in tourism (Wiatrak, 2010, vol. 8, No. 3 (29). It should be emphasized that the management of tourism is not only the organization of tourism in the area, but also its collision-free operation of the system, the economy and society.

The attempts of forming the methodology of tourism strategy may be found in literature. The stages of strategy construction are presented, among others, by A. Rochmicka. (Rochmińska, Stasiak 2004), however, without such aspects as monitoring and location of strategic products. Rather complete procedure of tourism development strategy construction is presented by D. Milewski (Meyer, Milewski, 2009). However, in author's opinion, it lacks the indication to the mission of the strategy. Interesting methodology of regional strategies construction is prepared for many regions by Polish Tourism Development Agency. In those materials, for instance, for Świętokrzyskie region (Polish Tourism Development Agency 2005), authors take notice on the creation of region identity and creation of region brand. Analyzed strategies are often incomplete and do not refer to regions naturally valuable.

In regions with large amounts of valuable natural areas it is necessary to take sectoral strategies for tourism development (figure 2) which takes into account the development of nature tourism, eco-tourism, green therapy and recreation.

The basis (foundation) is constituted by prospective diagnosis, endearing future, anticipated, internal and external conditions for the development of tourism in the region. The purpose of this diagnosis is to present balance of favorable and unfavorable features of the terrain and space and to identify the competitive advantages and barriers to growth on this background. Elements of benefit resulting from the prospective diagnosis for the development strategy of nature tourism, eco-tourism and green therapy include: "unique natural, scenic medicines which are an opportunity for the develop-

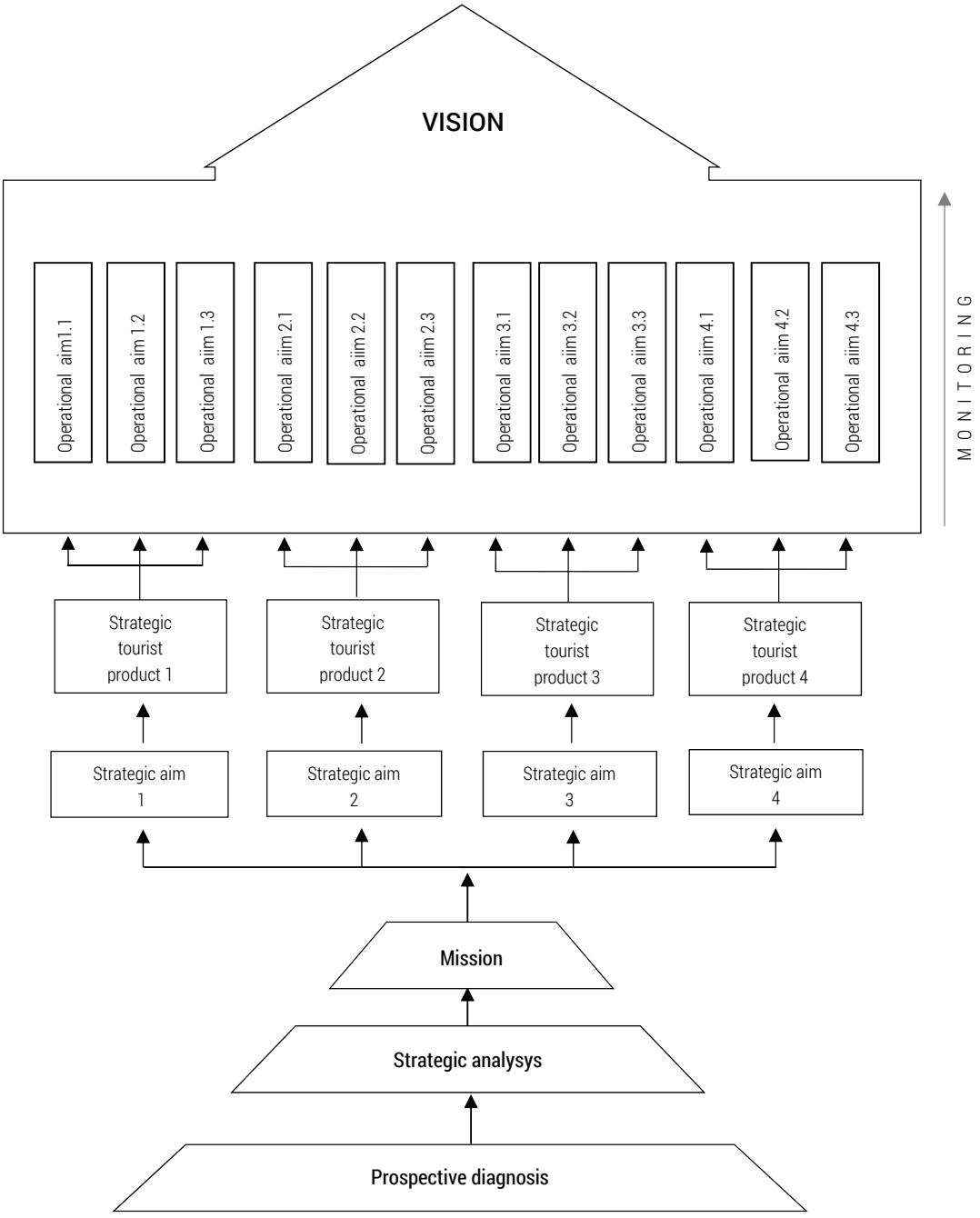

Figure 2. Sectoral model of strategy for tourism development

Source: author's own research.

ment of regions due to global trends aimed at a healthy lifestyle. Barriers include: poor accessibility, lack of accommodation infrastructure".

The next step in creating a tourism development strategy should be strategic analysis. A common form of analysis in development strategies is a SWOT analysis. It analyses the strengths and weaknesses in forces in the region in the field of nature tourism, ecotourism, green therapy and recreation and environment analysis of the region in terms of the potential opportunities and threats to the processes of tourism development.

Tourism development strategy should outline a long-term vision of development (10-20 years). A **vision** is desired, an ideal target state of tourism in the region. It allows to assess the level of tourism development e.g. every 5 years, checking whether the mission, strategic objectives are being carried out, operational and strategic products are being created. Therefore a concise and clear-cut vision, which constitutes the desired end state of tourism development in the region all over the stage of implementation of the development strategy, should be founded. Sample content of the determined vision is: "Podlaskie region in 20 years will be ecologically pure and welcoming to all tourists and inhabitants of the region".

Mission is an overarching goal, which is stated in a high level of generality (Kot, 2003, p. 23). It is the leading goal, to which (like vision) all activities related to the strategy should apply. For the described strategy it may sound as follows: *Podlaskie is a region using biodiversity with its richness of culture and respect to make the quality of life for residents and tourists better, opened especially for investors with environmentally friendly solutions.*

Strategic objectives for the development of tourism in the region require a hierarchical order and to identify the measures needed to achieve these objectives, taking advantage of the region's strengths. Examples of strategic objectives are: "development of health tourism based on forest areas and peat deposits, expansion of environmentally conscious development of hiking trails in national parks and landscape of the region, creation of nature tourism centres and green recreation and therapy".

The strategic goals should point to the creation of specific strategic tourism products which are to become leading products in the area. Focusing on the development of a number of selected products is much better than the dissipation of forces and resources over multiple products. An example of a product can be The European Centre for Green Therapy and Recreation. The concept of the Centre presents the objectives of the research and implementation project, located on the Polish-Lithuanian-Belarusian borderland. It is a specific corner of Europe characterized by the highest biodiversity, sparsely populated and with poorly developed economy. In this area such specialties as therapy and recreation in ecosystems, and flower and herbal

therapy in special gardens, smell therapy, music therapy, or hippotherapy in tourist facilities can be developed in parallel. The basis of the concept are the new expectations of the growing number of tourists who wish to find mental relaxation, rest their eyes tired with working using the computer while looking for new attractions and experiences (Poskrobko, 2014, p.131-148).

A desirable activity, therefore, is to create tourism products which enable achieving market success and a significantly increase in competitiveness of the area. This creates the possibility of building a high-quality products that in the future will become branded products, which means being recognizable, having its own name and logo as well as ensuring high satisfaction for tourists.

The final part of the strategy is to develop concrete operational objectives describing practical actions that will be taken by the competent institutions and organizations involved in tourism in the region. Examples of operational objectives for implementation of European Centre for Green Therapy and Recreation are: developing of the concept of tourism development and recreational centers, appointing of green therapy and recreation, public consultation in relation to the design and location of facilities, development programs, tours, sightseeing and recreation.

A well-prepared strategy also gives an answer to the question: how to achieve the desired state of development of nature tourism, ecotourism, green therapy and recreation? It is important to remember to appoint a special team that will monitor implementation of the strategy that will be implemented in life, not only adorn the shelves of local government office or regional government office.

Author's research conducted in 2016-2017 in all marshal offices in Poland prove that there is a lack of current tourism development strategy in regions of high natural values (such as Podlasie). Whereas, in regions with current strategy there is lack of monitoring. It is, thus, recommended to create the team responsible for monitoring and efficient control of the process of particular parts of the strategy implementation; those regarding mission, vision, strategic goals and, of course, operative goals for realization of natural potential of the region exploration.

Conclusions

Podlaskie region has special, outstanding and often unique natural values, which were examined, systematized and partially described in this report, and constitute an excellent development potential of the region. These values are mainly clean environment, biodiversity and a large number

of forest areas. They allow a good rest, the regeneration of physical and mental forces, and also help in the treatment of various diseases. Natural values of the Podlaskie region thus constitute an essential factor in the development of a higher quality of life for local residents as well as visitors (tourists) visiting this area. At the same time they are the basis for the development of nature tourism, ecotourism, green therapy and recreation. Taking into account the natural conditions of Podlaskie region, a holistic, long-term approach is needed which will be based on the construction of the development strategy for the successive stages proposed in this paper. The benefits that will be streamed from well-prepared and implemented development strategies, especially in regions with extensive amounts of valuable natural areas are among others:

- increased interest of local communities in acquiring closer knowledge of the natural values of the area,
- regional society participation in the in the construction of strategy through consultations,
- the creation of new jobs and sources of income for the local community,
- enabling the pursuit of a stable business in the field of tourism (including farming and forestry)
- the possibility of greater respect for the protection of nature sites,
- increasing opportunities for the conservation of biodiversity,
- construction and modernization of transport, catering and accommodation infrastructure.

Harmonious cooperation between tourism entrepreneurs, regional authorities, municipalities, local and regional tourism organizations, travel offices and other entities associated with the tourist industry is needed in order to obtain these benefits, or at least a part of them.

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DISCUSSION AND REVIEWS

RECENZJE OMÓWIENIA, PRZEGLĄDY

Stanisław **ŁUNIEWSKI**

THE REMOVAL OF ASBESTOS AND ASBESTOS-CONTAINING PRODUCTS AS THE COMPONENT OF WASTE MANAGEMENT

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Introduction

Asbestos is a set of naturally occurring minerals. They belong to the amphibole class and to the serpentine class. Chemically, they are hydrated iron-magnesium aluminosilicates that are frequently composed of $Ni^{2}+$, $Ca^{2}+$, Na+, $Mn^{4}+$. In nature their number is approx. 150 (Pyssa, 2014). For years asbestos has been used for construction purposes due to its insulation and fireproofing properties. Owing to its carcinogenic effect on the living organisms, asbestos was considered as the harmful raw material, the usage of which in housing began to be banned and the removal of asbestos from both man's existence and from the natural environment began to be necessary. These issues are regulated by legislative regulations on waste management on both the EU level and the national level.

Asbestos and asbestos-containing products

The occurrence

Asbestos is a mineral that can be found in the entire world. However, its greatest deposits being important for industrial purposes were located in two countries: Canada and the USSR – with 2/3 of the global production of this mineral at the turn of the 20th century. Among highly developed countries in the 20th century, for example, Italy and the United States of America produced approx. 2% of the global production of asbestos respectively, whereas Greece and Australia approx. 1% of the global production of asbestos. In Africa its main producers were the Republic of South Africa and Zimbabwe (10% of the global production of asbestos in the 20th century). The producers with an average level of production were China and Brasil (7% of the global production of asbestos in the 20th century). The data regarding the volume of production as regards the most important producers of asbestos in the years 1940-2013 is included in table 1.

In the first decade of this century asbestos is no longer excavated in both highly developed countries and in African countries. A similar level or even slightly more significant production of this mineral is recorded in Russia, China and Brasil which are presently the key producers of asbestos that is, on the other hand, banned in countries known as economic superpowers.

Table 1. Global potentates in the production of asbestos (1940-2013)

Producer	Production volume				
	1940	1960	1970	2000	2013
The Soviet Union (2013-Kazakhstan)	102 000	598 743	1 065 943	983 000	1 000 000
Canada	313 514	1 014 647	1 507 420	320 000	-
RSA	24 850	159 540	287 416	18 782	-
Zimbabwe	50 809	121 529	79 832	145 000	-
China	20 015	81 647	172 385	350 000	400 000
Brasil	500	3 538	16 329	170 000	300 000
USA	18 198	41 026	113 683	5 260	-
Globally – Total value	573 728	2 213 533	3 493 800	2 070 000	1 940 000

Source: own elaboration on the basis (Pyssa, 2014).

The origins of asbestos date back to the ancient times. At that time asbestos was used, among others, for making tablecloths, shrouds, handkerchiefs and also as oil lamp wicks. Between the 15th century and the 19th century asbestos was used mainly because of its fireproofing properties. It was used as the admixture for non-flammable paper and for the production of candle wicks and fire-resisting fabrics. The golden age of using asbestos in various industry sectors was at the turn of the 19th and 20th century. It was applied for producing gaskets made of asbestos and rubber in order to use them in steam engines, fire-resisting fabrics used by firefighters, building materials (asbestos and cement slabs – eternite – which is a perfect construction material for roofing tiles and cladding as well as panels for decorating walls and ceilings), (Pyssa, 2014).

Properties

The manner of using asbestos for commercial activities is dependent on its type. Table 2 presents both physical and chemical properties of the main types of asbestos minerals.

Table 2. Physical and chemical properties of the most popular asbestos minerals

Mineral / Properties	Chryzotile	Crocodolite (riebeckite)	Grunerite (amosite)	Anthophyllite	Tremolite	Actinolite
Chemical formula	$Mg_3(Si_2O_5)(OH)$	$Na_2FeII_3FeIII_2(Si_8O_{22})(OH)_2$	$(Fe,Mg)_7(Si_8O_{22})(OH)_2$	$(Mg,Fe)_7(Si_8O_{22})(OH)_2$	$Ca_2Mg_5(Si_8O_{22})(OH)_2$	$Ca_2(Mg,Fe)_5(Si_8O_{22})(OH)_2$
Chemical analysis (% of the main components)						
SiO_2	38-42	49-56	49-52	53-60	55-60	51-56
Al_2O_3	0-2	0-1	0-1	0-3	0-3	0-3
Fe_2O_3	0-5	13-18	0-5	0-5	0-5	0-5
FeO	0-3	3-21	35-40	3-20	0-5	5-15
MgO	38-42	0-13	5-7	17-31	20-25	12-20
CaO	0-2	0-2	0-2	0-3	10-15	10-13
Na_20	0.1	4-8	0-1	0-1	0-2	0-2
Na_20+	11,5-13.0	1,7-2.8	1,8-2,4	1.5-3.0	1,5-2,5	1.8-2.3
Colour	From white to pale green	Blue	From light grey to pale brown	From white to grey, pale brown	From white to grey	From pale green to dark green
Decompo-sition temperature (CC)	450-700	400-600	600-800	600-850	950-1040	620-960
Acid resistance	With the ten-dency of fast reaction	Good	With the ten-dency of slow reaction	Very good	Very good	With the tendency of slow reaction
Alkali resistance	Very good	Good	Good	Very good	Good	Good
Fiber construc-tion (texture)	Mostly flexible, silky and hard	From flexible to breakable	Mostly breakable	Mostly breakable	Mostly breakable	
Main producers – countries	Canada, China, USA, Italy, Zimbabwe, South Africa, Russia	South Africa	South Africa	Mozambique, USA	Italy, USA	

Source: (Smolik, Gembalczyk, 2007).

The asbestos volume necessary to be removed in Poland

The problem of asbestos occurs also in Poland. The character as well as the severity of the asbestos problem in Poland is the function of the volume of the material used so far in Poland's economy. It is estimated that in the years 1945-1998 (when, owing to the initiated implementation of the gov-

ernment program of removing asbestos in Poland, its usage is banned) approximately 2 mln tones of this mineral have been used. It was mainly t chryzotile asbestos imported from the USSR. The main material used for the production of asbestos and cement products (a-c) that were mainly used in the construction sector was chrysotile asbestos, whereas till the mid 1980s crocodolite (the most aggressive asbestos) was used for the production of mostly pressure pipes (Szałucha, www.zielonewydarzenia.pl).

The most serious situation as regards the removal of asbestos is in two districts: Mazowieckie and Lubelskie, whereas a slightly less serious situation is observed in the districts located in the Western part of Poland: in Wielkopolskie district and Kujawsko-Pomorskie district. Podlaskie district is among districts with a medium advancement degree of the asbestos problem. In this dimension the problem is of material type and determines the scale of tasks that need to be realized so that the problem can be fully solved. Thus, also the hazards of epidemiological and ecological character will be eliminated.

Epidemiological and ecological hazards posed by asbestos and asbestos-containing products

From the epidemiological perspective the main problem which first of all gives reason to taking actions aiming at complete removal of asbestos and asbestos-containing products from Poland is the fact that this mineral has proven carcinogenic effect on man and is considered as one of the most frequent carcinogenic factors in the environment. It is stated in literature that "pathogenic activity of asbestos is the result of inhaling the fibers suspended in the air. The risk resulting from absorbing the asbestos fibers via the alimentary canal is marginal for health. The aggressive character of asbestos fibers is related to the degree of penetration and to the amount of fibers in the lower tract of the respiratory system. This process is dependent on both the physical and aerodynamic properties of the fibers. Thin fibers with the diameter smaller than 3 μm are more easily both transmitted and deposited in the lower tracts of the respiratory system. Adversely, thick fibers with the diameter larger than 5 μm are stopped in the upper part of the respiratory system. Twisted fibers of chrysotile with a large diameter have the tendency to stop mostly in the upper parts in opposition to needle shaped fibers of amphibole asbestos which easily penetrate the lung areas. For human organisms the greatest threat to a human organism is posed by respirable fibers with the diameter smaller than 3 μm, i.e. the fibers that get into the pulmonary alveolus where they can penetrate the lung tissues" (Smolik, Gembalczyk, 2007). Therefore, the most serious hazard for the respiratory system is

posed by asbestos fibers that penetrate it without pain but cause irreversible damage depending on the depth of the penetration.

There are distinguished three types of the exposure to asbestos dusts, the main factor of epidemiological hazards. These are:

- occupational exposure – related to working in a mine or in plants producing and using asbestos products as well as related to working in car garages and removing asbestos products and materials containing asbestos;
- para-occupational exposure – regards inhabitants of the areas located near mines and plants processing asbestos as well as the families of workers in these plants;
- environmental exposure – related to the presence of asbestos in the atmospheric air, drinkable water and groceries.

Although everyone is exposed to asbestos dusts, the largest hazard is posed to the workers of companies that use asbestos in their technological processes. Asbestos is responsible for a considerable number of occupational diseases. According to the International Labour Organization systematic contact with asbestos dusts exposes people to the risk of suffering from one of the following diseases (*Zapobieganie zagrożeniom*..., 2007):

- asbestosis – slow scarring of the lung tissue which results in respiratory failure;
- lung cancer occurring usually 10-40 years after the first exposure, its development is accelerated by asbestosis and nicotine addiction;
- mesothelioma, cancer typical for asbestos exposure, caused by microscopic respirable asbestos fibers deposited in lungs, it develops 10-40 years after the first exposure.

The data obtained from the Nofer Institute of Occupational Medicine in Łódź implies that the number of occupational diseases caused by asbestos dusts has been increasing recently. In 2005, for example, the number of recorded cases of mesothelioma disease increased almost five times (4,75) when compared with the year 1995. Taking into consideration the statistics of other countries as regards the number of disease cases also in Poland the number of disease cases is likely to increase, especially as regards lung cancer and mesothelioma (*Zapobieganie zagrożeniom*..., 2007). This is a postponed effect of the previous exposure. Therefore, one may expect that despite progress in the program of asbestos removal, the epidemiological problems related to the contact of human populations with asbestos will be more intensive in the future. Hence it will still constitute serious challenge for medical services and state budget which are burdened by the costs of treating people for the diseases caused by asbestos dusts.

The seriousness of the epidemiological problem is intensified by the fact that owing to the common usage of asbestos in economy in the past, the major group of Polish population could have contact with this substance. Therefore, the problem needs to be solved promptly which, owing to its scale, constitutes serious challenge of organizational and economic character.

The solution of the asbestos problem as the priority of the state healthcare policy and ecological policy and one of the basic aspects of waste management

The occurrence of the aforementioned hazards induced contemporary countries to undertake the activities aiming at complete removal of asbestos and asbestos-containing products. In Poland such activities were initiated at the end of the 20th century but they were paid attention to much earlier. On 19 June 1997 Seym passed the resolution on the program of asbestos removal from economy (M. P. from 1997, No. 38 item 373). On the same day there was enacted a bill introducing a ban on using asbestos-containing products (Journal of the Acts of 1997 No. 101, item 628 with further modifications) and the Cabinet approved of the *Program of removal of asbestos and asbestos-containing products from Poland* (Warsaw, May 2002). It is estimated that in Poland there were then approx. 15,5 mln tonnes of asbestos-containing products (85% in the construction sector). This quantity was estimated on the basis of the statistical data regarding production, import and distribution of asbestos products and on the basis of the approved indicators showing the usage of them (Szałucha, www.zielonewydarzenia.pl).

When the production and usage of asbestos products have been discontinued the main sources of hazards are:

- improperly stored asbestos waste, including abandoned rubbish dumps, especially in forests and uncovered excavations;
- usage of asbestos products, which results in air pollution with asbestos dust as the result of: corrosion and mechanical damages of asbestos and cement tiles, abrasion of clutch and brake discs,
- improper removal of asbestos-containing products from roofing and elevation.

Therefore, the exposure to asbestos is the result of abnormalities in the realization of the asbestos removal program, i.e. non-observance of the designed procedures of removing asbestos products from buildings and installations, their transport to the storage spot and storage. However, it needs to be remembered that so far there remain significant amounts of

asbestos in buildings used by people and asbestos dusts still have harmful effect on their health.

In this context it is necessary to mention that asbestos dusts have negative effect also on the natural environment. Asbestos dusts deposited there constitute additional source of epidemiological hazards.

Presently the following anti-asbestos program is in force: *Program of Asbestos Abatement for the years 2009-2032 passed by the Parliament on 14 July 2009, altered by the act of the Cabinet of 15 March 2010* (Warsaw 2010). The main objectives specified in the previous program have been maintained there, these were:

- removal of asbestos-containing products from Poland;
- reduction of negative effects for health that were caused by the presence of asbestos in the country;
- elimination of the harmful effect of asbestos on the environment.

The necessity to approve of a new anti-asbestos program was the result of Poland's accession to the UE, which changed the legislative, economic and social conditions of implementing the program. The *Program's* tasks are distributed on the central level (creation of legislative, political and economic conditions), regional level (implementation of objectives and tasks of the *Program* on the regional level) and local level (municipal, operationalization of objectives and tasks on the directly executive level. Owing to the perspective of perceiving the asbestos problem there ought to be mentioned tasks that are imposed by the Program especially on municipalities:

- collection (by a village mayor or a city mayor) of information regarding the quantity, type and location of asbestos-containing products and passing of this information to the district marshal by the Asbestos Database;
- preparation and updating of the programs related to the removal of asbestos and asbestos-containing products as well as taking them into consideration in the municipal waste management plans;
- organization of local trainings as regards the asbestos-related problems;
- organization of the removal of asbestos and asbestos-containing products from the obtained Polish and EU funds while taking into consideration the principles stipulated in the *Program*;
- inspiration for citizens to adopt proper attitude towards the asbestos problem;
- cooperation with a marshal of the provincial parliament as regards the inventory of asbestos-containing products and programs for their removal as well as with regard to proving appropriate technical and transport background for them;
- cooperation with mass media in order to voice the *Program* objectives and tasks as well as the responsibility of citizens for its realization;

- cooperation with non-governmental organizations supporting the *Program*.

An essential turning point in the Program realization was the day 22 January 2010 when the act on waste and some other acts were passed (Journal of Acts of 2010 No. 28, item 145). The act facilitated the processing of waste containing asbestos in devices and by doing so separate requirements for these types of devices were introduced. The Act on waste passed on 14 December 2012 (Journal of Acts of 2013 r., item. 21) confirmed that asbestos is a hazardous material, which involved all the consequences for the ways and procedures of tackling with it.

From the economic perspective financing of the Program tasks has crucial importance. These are the sources of financing the removal of asbestos:

- own resources of the buildings' owners;
- own resources of private investors;
- own resources of local self-government units;
- resources of the state budget which are at the disposal of the Ministry of Economy;
- resources of environmental protection funds.

The National Fund for Environmental Protection and Water Management over the last two years has initiated two support programs related to the removal of asbestos:

- The Priority Program for the years 2010-2013, within the frameworks of which funds were allocated for particular regional funds for environmental protection and water management. The total sum of planned payments is 38 mln PLN (in 2011 – 6 mln PLN, 2012 – 10 mln PLN and in 2013 – 22 mln PLN).
- The Priority Program SYSTEM – support of activities related to environmental protection and water management realized by WFOŚiGW (Regional funds for environmental protection and water management) for the years 2014-2018. Allocation of funds is anticipated in 2015, whereas spending of funds – till 2017.

The Program for the years 2010-2013 has been evaluated five years after its realization. The evaluation resulted in making the following settlements:

1. The Ministry of Economy realizes the Program activities in the form of five subject-related sets. These include: legislation tasks, educational-informational tasks, tasks related to the removal of asbestos-containing products, monitoring of POKA realization as well as tasks related to health protection.

2. In the years 2009-2014 there were realized 71 educational and informational projects aiming at intensifying the initiative of self-governments. All in all, within the frameworks of the funds earmarked for this purpose there were spent 4,13 mln PLN. Within the frameworks of the activities there were organized numerous local trainings for volunteer fire brigades, municipal office, cooperative societies and housing associations. In sum, in the years 2010-2011 and 2013-2014 there were trained 857 people. What is more, the three-year training session for self-government administration was participated by 2 934 people.
3. Within the frameworks of the realized tasks till the end of 2013 1,57 mln Mg of asbestos waste was neutralized. Successful acceleration of the rate at which harmful products are removed is conditioned, among others, by the elaboration of municipal programs of removing asbestos and the collection of reliable information on the amount and location of these products.
4. In the years 2009-2014 the Ministry of Economy offered financial support for realization of these activities to 967 units of territorial self-government. As the consequence, 84% of municipalities in Poland introduced data from its area in the Asbestos Base.
5. In 2013 there was elaborated up-to-date Electronic System for Spatial Information (ESIP) for monitoring the realization of the Program of Asbestos Abatement from Poland. The so called ESIP integrates the information from the Asbestos Database with the spatial data. The system enables the collection of a set of data on selected levels of accuracy, unbiased and complex verification of the cataloguing of asbestos products, rationalizes the process of making decisions and enhances the effectiveness of management as regards the process of POKA realization.
6. In municipalities with the largest asbestos contamination, i.e. in Szczucin and Ogrodzieniec, the removal of asbestos products from usage was a success. Moreover, all the plants that previously produced asbestos products were cleaned and organized and most of these plants run an entirely different economic activity. There was observed also a moderate level of air pollution with asbestos fibers in Poland.
7. The European Union approved of Poland's activities. The European Parliament resolution from 2013 included the appeal to member states to follow Poland and assess the effect and analyze costs with reference to the plan of acting for safe removal of asbestos till 2028.

Despite the achievements gained until now there is still an urgent need to systematically monitor the asbestos problem and the progress in solving this problem especially in areas that are weaker in both social and economic terms, i.e. in rural areas where the social factor is least efficient and lack of

investment for these areas is a well known fact. From the economic perspective when particularly essential legislative conditionings are analyzed on a large scale, the asbestos problem in rural areas in Podlaskie district is particularly essential.

Supreme Audit Office conducted the evaluation in 2015 (April-September). The audit regarded the years 2009-2015. The results are decidedly negative; it was stated unanimously that the deadline for removing asbestos-containing products will not be met. There was a problem with finding satisfactory financial means for the secure removal of asbestos-containing products. There was also no success as regards the elaboration of legislative bases ensuring effective cooperation between the owners of buildings containing asbestos and self-government authorities. However, what matters most is the fact that the amount of asbestos that needs to be removed is still not known (Realization of the ''Program of Asbestos Abatement..., 2017). The amount of asbestos mentioned in the Asbestos Database is not reliable because 26% of municipalities (data from October 2015) did not introduce data into the regional database on asbestos products and waste containing asbestos. The Electronic System for Spatial Information, the main instrument for monitoring, has not been implemented so far.

The removal of asbestos and asbestos-containing asbestos takes place in accordance with a certain legal order. In Poland in the legislation regarding the solution of this problem the lawmaker proved to be inconsistent. The Program was established via the Act of Government, thus it is not the act of the universally binding law. The obligation to remove asbestos and asbestos-containing products that territorial self-government units have been imposed on results from the regulations of the domestic law, not from the statutory regulation. Adversely, the regulations for the units using asbestos and asbestos products were regulated by the legislative act in the form of a decree. Lack of legislative regulations for municipalities resulted in the inadequate attitude to solution of the asbestos problem which was frequently noticeable when the activities listed in the *Program* were not undertaken.

Until now more than 43% (23 mln PLN) of the funds earmarked for the entire period of the Program realization have been spent. The Minister of Economy is responsible for the distribution of funds. The activities undertaken by the Ministry and by the Program coordinator do not result in the proper realization of the planned undertakings. The amount of the asbestos products, the amount of harmful waste and asbestos-containing products as well as the number of municipalities using WBDA have not been identified so far. It was impossible to calculate what is the number of people working with asbestos as well as the number of workers trained to work with asbestos (Realization of the ''Program of Asbestos Abatement..., 2017).

Following the evaluation activities the Supreme Audit Office determined which activities ought to be taken by the Ministry of Economic Development. These include:

- overview and analysis of the valid regulations related to asbestos in order to elaborate a consistent, compatible and all-embracing proposal of changes;
- financial and logistic support in the removal of asbestos-containing products from public buildings with the first degree of urgency and in the areas with the largest concentration of asbestos in the environment;
- elaboration of financial support instruments for the exchange of roof and elevation coating;
- search for secure methods of neutralizing asbestos ([Realization of the ''Program of Asbestos Abatement…, 2017).

The Supreme Audit Office admitted that the realization of the objectives set up in the *Program* till 2032 is impossible and addressed the Prime Minister to consider the rationalization of the *Program*.

Conclusion

Management of hazardous waste, including asbestos and asbestos-containing products, is of particular importance from both epidemiological and ecological perspective because of the hazards it causes. They have been identified and in 2012 there was introduced a ban of importing, processing and selling asbestos in 53 countries. In Poland, in accordance with the passed long-term Program of removing asbestos and asbestos-containing products used in Poland and transformed into the Program of cleaning the Country for the years 2009-2032, till 2032 at the latest asbestos and asbestos-containing products will have been removed. The evaluation of these Programs prepared by the Supreme Audit Office indicated inadequate realization of the Program. There were shown specific objections and recommendations. Their realization may prompt NIK (Supreme Audit Office) to exclaim that the works on the removal of asbestos and asbestos-containing products will be completed earlier than 200 years ahead from now. The realization of "The Program of Asbestos Abatement in Poland for the years 2009-2032" implies that *In accordance with the estimates of the Supreme Audit Office when the present rate at which asbestos-containing products are removed is maintained, these works may end within approx. 200 years,* [Realization of the ''Program of Asbestos Abatement…, 2017, p. 9).

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