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Czasopismo Polskiego Stowarzyszenia
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THEORETICAL AND METHODOLOGICAL PROBLEMS

ENVIRONMENTAL POLICY AND MANAGEMENT

STUDIES AND MATERIALS

GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

THEORETICAL AND METHODOLOGICAL PROBLEMS

PROBLEMY TEORETYCZNE I METODYCZNE

Agnieszka CIECHELSKA

MUNICIPAL WASTE AS A COMMON GOOD IN NATIONAL MUNICIPAL WASTE MANAGEMENT

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ABSTRACT: Today, waste is a raw material and energy source that can be recovered. The economic value of waste results in forming informal groups of pickers appropriating material waste in developing countries. These types of situations are analysed in the literature. Using Ostrom's social-ecological system analytical framework (SES), the authors show that municipal waste in developing countries can be treated as a common good (CPR). This paper aims to answer whether municipal waste in developed countries can be treated this way, although informal collectors' activities are marginal here. The analysis also uses the analytical scheme of Ostrom's SES. However, due to the different organisations of the waste management system in developed countries, the individual elements of the scheme were defined differently than in the literature. This resulted in a different schema of municipal waste as a common good. This approach allows the schema to be applied locally and broadly to all types of municipal waste, not just material waste.

KEYWORDS: municipal waste, sources, recycling, common good, CPR

Introduction

Environmental pollution is unintentional but still accompanies human activities. It is a negative effect on both production and consumption processes. Municipal waste is a special case of pollution. Their "uniqueness" lies in the fact that although they accompany almost every single consumption, their negative impact becomes significant only when we treat them as a joint emission (pollution). The volume of waste generated annually has been estimated at 7 to 8 billion tonnes, of which 2 billion tonnes is municipal solid waste (MSW) (Wilson & Velis, 2015). The global waste generation will reach 3.5 billion Mg in 2050 (Chen et al., 2020). Half of the world's waste is generated in developed countries that have introduced organised waste collection and treatment systems that respect the waste hierarchy: prevention, preparing for reuse, recycling, another recovery (e.g. energy recovery) and disposal (Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on Waste and Repealing Certain Directives (Text with EEA Relevance), n.d.). However, about 40% (about 36 million tonnes) of this waste is exported (Eurostat, 2021). Furthermore, 46%[1] of words' waste ends up in landfills, mostly in developing countries (Nichols & Smith, 2019). At the same time, around 2 billion people worldwide do not have access to regular waste collection services, and around 3 billion do not have access to controlled municipal solid waste disposal services (Wilson & Velis, 2015).

The European Union has started transforming its economy towards a circular economy (CE) to recover materials and energy from waste. It has been assumed that by 2030 65% of municipal waste will be recycled, and only 10% will be landfilled (*Towards a Circular Economy: A Zero Waste Programme*; Directive 2008/98/EC). The targets indicate that the amount of waste recycled in 2030 should be 0.519 billion tonnes (519 megatonnes). Currently, it is 0.36 billion tonnes (363 megatonnes). To make the economy truly circular, the amount of waste recycled would need to be 0.74 billion tonnes (Chen et al., 2020). Recycling rates as a measure of achieving the goals of CE capture the waste covered by the formal system only. Despite the intensification of activities and increased investment to achieve the goals of CE, it is still insufficient to overcome the growing amount of waste. This is why informal activities are so important, as they are aimed at reducing the amount and negative impact of waste.

The placing of a value on waste by politics, and limited primary resources, has meant that certain fractions of municipal waste (including raw material fractions) have become traded in markets around the world. This has been

[1] Other sources report that as much as 70% of waste goes to landfills (Kaza et al., 2018).

reflected in developing countries. There are no formalised systems of collecting and waste treatment in an environmentally and human safe way in these countries. Sometimes they cooperate in more formal groups, especially if a country is progressing in formalising its municipal waste management systems. As system formalisation occurs, competition for access to raw waste increases and conflicts between different resource users intensifies. This situation is partially recognised in the literature. The authors treat raw waste (metal, glass, paper, plastics) as a valuable resource collectively acquired by the community of pickers from the mixed waste stream. This community is organised in different ways, but waste is always a source of livelihood. The waste is described as a non-excludable good, but its value makes it rivalrous. This framing of the problem indicates that raw municipal waste is treated as a common pool resource (CPR).

The concept of common goods

There is no uniform definition of common goods in the literature. Generally speaking, they have a tangible or intangible value from the perspective of a specific community. There are two possible ways to analyse goods and classify them as common goods. The first one involves distinguishing common goods from private and public goods and identifying other characteristics. This approach can be referred to as subject-led (Prandecki, 2017). The other approach involves the identification of the cultural and social context in which the goods exist. This context and its constituent institutions determine whether a good is a common good. This analysis is based on E. Ostrom's SES framework. This approach can be referred to as process-led (Prandecki, 2017). The origin of research on common goods can be traced back to the division of goods into private and public according to the criterion of excludability and rivalry. Goods that have both these characteristics, i.e. are non-excludable and non-rivalrous, are considered pure public goods. They are the opposite of pure private goods, i.e. those that are excludable and rivalrous. Most goods are partially rivalrous and partially excludable. Rivalry means that every increase in the consumption of a resource adversely affects its utility for all other users, which causes an overload effect. In its turn, excludability is determined by the nature of the goods. For some goods, exclusion is quite simple, while for others it is costly or impossible at all, although technological development significantly increases these possibilities (Balcerowicz, 2015).

Over time, criteria have been developed to characterise goods that cannot be classified as either private or public goods (Jakubowski, 2012; Randall, 1983; Romstad, 2002). Among these criteria, one can distinguish:

- whether the goods are natural or man-made,
- whether they exist for profit or consumption,
- whether they are renewable or not,
- whether they are local or global (Oakerson & Parks, 2011).

Many researchers investigating the issue of common goods think that the differentiation criteria do not fully capture the specific nature of common goods. To see the big picture, they should be analysed in the context of social relations, traditions and culture (Ostrom, 1990). For example, it is commonly believed that the long-term use of a resource entitles the user to receive property rights, equivalent to introducing private or state oversight. However, E. Ostrom demonstrated that such oversight is not always effective. Sometimes, the community uses a resource who sets the rules of use, introduces social oversight, and excludes outsiders. Together with a system of social and cultural relationships, these possibilities have become key elements in defining common goods (Ostrom, 1990, 2009).

The problem of common goods is believed to be first analysed in the discussion triggered by Harding's paper illustrating the social dilemma known as the "tragedy of the commons"(Gordon, 1954; Hardin, 1968). The dilemma is caused by the difference between private and common interests whenever multiple users use the same renewable resource. Private interest is maximised by intensifying the use of the resource. As a result, its replacement capacity becomes insufficient, and the resource becomes degraded, causing social losses. Traditionally, this approach has described shared renewable natural resources such as forests, pastures, or fisheries. Such goods are referred to as open access resources.

In reality, communities sharing a resource for their livelihoods act collectively and adapt the rules and principles of operation to changing circumstances, seeking to preserve the resource in the long term. This feature distinguishes open access resources from common-pool resources (CPR). As far as natural resources are concerned, the use is individual, but the benefits or costs of individual use are shared by all users (Ostrom, 2002). Whether degradation of the resource occurs depends mainly on the stability and functioning of the community's institutions (Ostrom, 2002). Traditionally, CPR includes agriculture, near-shore fisheries, grazing, forests, groundwater reservoirs, irrigation systems, natural resources, municipal material waste (Arvanitidis & Papagiannitsis, 2020; Cavé, n.d.-a, 2014; Cox et al., 2010; Hess, 2011; Husain & Bhattacharya, 2004; Pires Negrão, 2014).

More recently, Ostrom's approach has been applied to the analysis of goods reaching far beyond the local dimension, as well as to technology-based and man-made goods. These are referred to as new commons. Specific issues and characteristics of new commons are similar to those typical for CPR. However, some new issues are related to ecological economics, adaptive systems, intellectual property, or sustainability (Hess, 2011). For example, the following goods have been mentioned as new commons in the literature: knowledge, climate change, inventions and intellectual property rights, internet, urban infrastructure, global plastic pollutions or biodiversity (Egerer & Fairbairn, 2018; Hess, 2011; Holman & McGregor, 2005; Lambert et al., 2021; Sarker et al., 2008).

Therefore, it can be considered that common goods can be partially rivalrous, and the high cost of exclusion makes exclusion either impossible or at least significantly reduced. Shared use is a key differentiator of common goods. It may occur at the stage of production, distribution and/or consumption. Interestingly, the same good may be classified in different categories, at different times or for different users (Euler, 2018).

Research method

Analysis of the common good system using the SES analytical framework proposed by Ostrom can be applied to different types of resources: renewable and non-renewable, as well as natural and anthropogenic. Ostrom defines a CPR resource as a certain 'stock' from which appropriators (individuals or companies, or teams/groups of users) withdraw units of the resource. Resources may be of natural origin (e.g. forests) or man-made (e.g. a bridge or waste). The more units of a resource are appropriated, the worse the condition of the resource as a whole. In extreme situations, the resource may become destroyed entirely. Ostrom describes a renewable resource by referring to the concept of a stream, i.e. the positive difference between the increment of the resource (its replacement rate) and the sum of the appropriated units of the resource. If the stream runs dry or is too small to renew, then a "tragedy" occurs.

The common good concept can be applied to both natural and man-made resources. Oakerson distinguishes between "resources" and "objects", depending on whether the CPR is natural or man-made (Oakerson, 1986). In the case of man-made, technology-based common goods, the community benefits from a system of objects (a function, good or service provided by the system) that are large enough to make it costly (but not impossible) to exclude potential users and beneficiaries. A system of objects produces object

units (e.g. the number of bridge crossings per bridge per year). For an object to exist in the long term and remain productive, its normal rate of wear and tear cannot exceed expenditures on maintenance, repairs and improvements. The replacement rate is equivalent to conservation and repair expenditures, which serve to keep the resource in good condition for long-term use. The effects of improvement and maintenance are available to all, whether or not they have participated in these works. The exclusion of non-participants is usually very expensive and sometimes impracticable, leading to overuse.

Members of the community (actors) using the common good can have different functions. Among them, we can distinguish between suppliers, producers and appropriators. Suppliers ensure the supply of a common good, while producers actually build or repair the resource system. A supplier and a producer may or may not be the same person. For example, a government that finances and designs road construction is a supplier. However, if it agrees with the future users of the road that they will build and maintain it, then the users are both suppliers and producers (Ostrom, 1990, 2019). The broadest group of actors are appropriators, which are individuals or companies, or teams or groups of users, that use a resource at the same time. They appropriate source; that is, they take resource units out of the system. They may consume the resource units they withdraw, use them as factors of production in their own operations, or transfer ownership of the resource (in various forms) to others, who then become the new users (Ostrom, 2019).

Appropriators may have varying degrees of property rights held. Some may have no legal claim (e.g., wild tenants), and others may have specific legal claims to withdraw units of the resource. Appropriators establish rules for the use of a resource in order to limit access to it and to reinforce its renewability. They establish internal institutions for this purpose, but they may also employ external bodies, such as state courts. In doing so, they create a system of formal and informal institutions. Moreover, the whole system of the common good operates in a legal and institutional environment created by authorities at different levels. In this way, institutions are, as it were, nested at successive administrative and spatial levels. With respect to commercially traded goods, there are three manifestations of property rights: the right to use the resource, the right to sell and take the proceeds of the resource, and the right to change the form and content of the resource. Appropriators may wield considerable market power and influence the price of final goods by, for example, forming a cartel. Then the strategies affect others as well as themselves. If appropriators do not have such power of influence, they can most influence other community members. Analytical framework Ostrom's SES is illustrated in figure 1.

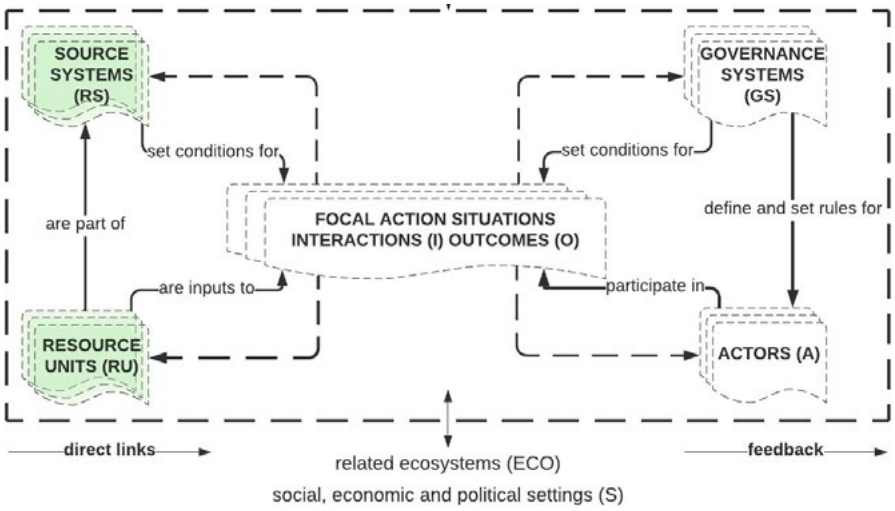

Figure 1. Analytical framework SES

Source: (Ostrom & Cox, 2010).

Municipal waste as a common good in developing countries

There is very little scientific literature analysing municipal waste in the context of common good issues. But only the raw material waste fraction in municipal waste is analysed as CPR. Articles, with this theme, are mostly case studies of developing countries, including Brazil (Pires Negrão, 2014) (Cavé, n.d.-a), India (Chaturvedi, B., & Gidwani, 2011) (Bose & Blore, 1993), China (F. Chen et al., 2018), or Egypt (Fahmi & Sutton, 2010). Municipal waste management doesn't exist in the described cases or is poorly organised. As the transportation and "processing" of waste is done "on the street", no one can be effectively excluded from access to waste. So in developing countries, recycling is carried out by informal picker groups – poor residents who select raw material waste and sell it as a factor of production. This is a way for them to raise funds for their livelihood. However, pickers are only interested in the raw material fraction, leaving worthless and troublesome mixed waste. The necessity to reduce its negative impacts makes the involvement of the municipal sector. And if it provides transport services or waste treatment, it is also interested in economic benefits from the raw material fraction. In this way, the number of appropriators (groups of pickers, a municipal sector) interested in this fraction and competition for access to the best waste increase. This is a reason why raw material waste is rivalrous.

Informal picker groups, over time, establish their own rules of operation and sometimes create formal institutions (e.g. pickers' union, Brazil). The progressive formalisation of waste management processes is accompanied by a growing number of different appropriators competing for the same resource. This is a source of potential conflicts that will intensify in the future (Cavé, n.d.-b, 2014; Pires Negrão, 2014). At the same time, an increasingly complex network of formal and informal institutions is being created. As a common good system, the analysed local municipal waste systems are or can be nested within national and international systems. Thus, the identified institutions may have different territorial scopes: local, regional, international and even global(Pires Negrão, 2014). Municipal waste as CPR in developing countries is illustrated in figure 2.

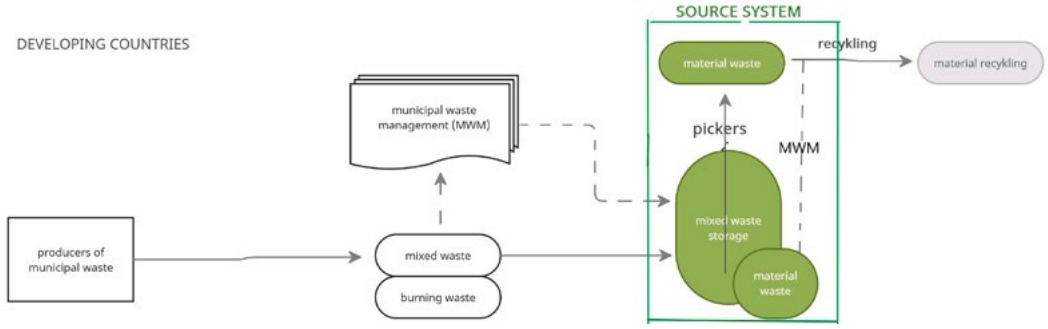

Figure 2. Municipal waste as CPR in developing countries

Source: author's work.

Only a few authors (Cavé, n.d.-b; Pires Negrão, 2014) recognise the dual nature of municipal waste management. On the one hand, there is an appropriation of desirable raw material waste (there is an appropriation of resource units). As with the CPR model, there is a reduction in the amount of resources used, but only in the waste of raw materials. On the other hand, the more of this waste we want to acquire, the more municipal waste must be created. As a result of acquiring raw waste, there is an increasing amount of negative-value residual waste that is handled by municipal services (if at all) in the absence of any alternatives. In Ostrom's model, if the replacement rate is insufficient in relation to the number of units of the appropriated resource, the resource becomes destroyed. In analysing municipal waste, this relationship is different. The amount of raw material waste withdrawn grows in line with the amount of waste generated (deposit). At the same time, since appropriators are only interested in raw material waste, the amount of negative-value waste increases (resource stock). Thus, unlike in Ostrom's model,

the risk of depletion does not exist here. Instead, there is a risk of uncontrolled growth of mixed waste with no economic value-mixed waste. There is, therefore no 'tragedy of the common good' in the traditional sense. However, increasing waste is undeniably a social 'tragedy' on the local and global scale.

Municipal waste as a common good in developed countries

Waste management systems in developed countries are strongly formalised and cover most (usually all) of the generated municipal waste. Independent pickers obtaining raw materials from waste are marginal here. Selectively collected waste from inhabitants is transported to specialised installations, where waste is treated safely, e.g. preparing the raw material fraction for sale. In the installation, raw materials are obtained both from selectively collected waste and from mixed waste (in small parts), green waste is composted, alternative fuel is produced from sorting residues, and only residual waste is landfilled.

However, parallel to recycling in a formal system (obtaining raw materials in installations), a number of formal and informal activities are being carried out. They aim to reduce the amount of waste and its negative impacts. As Kate O'Neil (O'Neill, 2018) demonstrates, such actions outside the system are becoming increasingly popular in developed countries, in contrast to the increasing formalisation of systems in developing countries. Appropriators of resource units can apply not only to raw waste but also to other types of waste that have value. This value can be financial and non-financial, individual or social. Non-financial benefits are mainly driven by social and environmental motivations, such as the desire to share with others or the need to protect the environment. Such activities generating non-financial benefits most often come down to extending the life cycle of products or reducing waste. Individual financial benefits are mainly associated with waste that is recyclable or reusable.

Generation of municipal waste accompanying consumption and is a continuous process. Therefore, municipal waste may be considered as a renewable source of raw materials and energy, although using it in such a way requires treatment: collecting by pickers or selecting in installations. However, the continuous production of waste in unlimited quantities will result in an effect that corresponds to the effect of congestion. "Safe" levels of environmental pollution will be reached more quickly, and more people will not be able to dispose of their waste. An analogous situation occurs with the use of waste collection and treatment facilities. They have the only limited technical capacity to treat the mass of the waste. Thus, the more waste we generate, the

sooner the technical capacity to treat it for subsequent appropriators will run out. In this sense, therefore, it can be said that no one can be excluded from generating waste, but the use of the system (installation) is rivalrous. Thus, any conservation action of reducing waste or its negative impacts is a collective action. So conservation activities can include:

- composting of biodegradables by residents,
- buyback centres where residents bring their waste there, which is a high-quality material that can be recycled without further processing,
- waste pickers who collect relatively small amounts of valuable raw materials, usually scrap metals or beverage cans, and less frequently glass or paper, and deliver them to buyback centres,
- using waste for artistic purposes,
- zero waste action groups,
- reducing food waste through community fridges and composters,
- reusing waste in aid and charity projects,
- repair cafes,
- clothing swaps,
- 2nd hand markets and curbside disposal,
- recycling of other waste (garage sales or collection of certain types of waste from the formalised system).

A very diverse group of appropriators carries out these activities:

- collective entities (companies) and individuals,
- formalised and non-formalised organisations, such as homeowner associations, municipalities, or community action groups (e.g. zero waste movements),
- with different forms of ownership (private or public),
- with different territorial coverage (local, regional, cross-border, or international).

Figure 3 illustrates municipal solid waste as a common good in developed countries.

Each of the conservation activities generates specific externalities – other than those generated by untreated waste, which reduces the benefits of the conservation activity. This may be prevented by optimising installations and waste treatment methods, e.g. by appropriate location or adjusting the type of plant to the waste stream in a given area. For a given national system, optimisation means selecting the types and capacities of treatment facilities and locating them in such places that they would cause the least negative externalities. Moreover, the installations should be matched the kind of a collected material waste to the production needs. In practice, there will always be types of waste (whether arising from consumption or production using

waste) for which there will be no use and which will threaten living organisms. Therefore, there will be customs and social norms in any real system, often transposed into law. This may include obligations to dispose of particularly hazardous substances or bans on their use (Kurz, 2006). The effects of resource withdrawals and successful conservation efforts depend not only on institutions, as Ostrom argues (Ostrom, 2019), but also on technology and knowledge of how to transform available resources into something more useful (Berge, 2003).

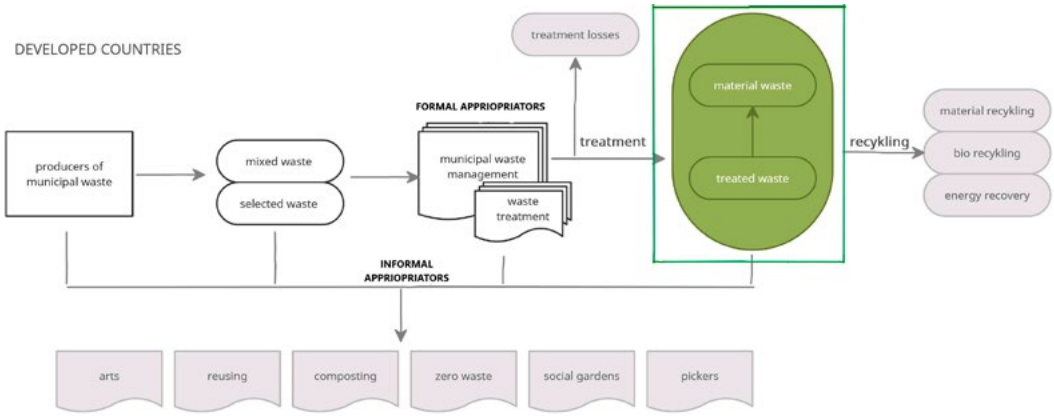

Figure 3. Municipal solid waste as a common good in developed countries
Source: author's work.

Conclusions

The application of the SES analytical scheme enables a much broader analysis of municipal waste than just raw material waste in developing countries. However, so far, it has been applied only to the common actions of appropriation of material waste from the mixed waste stream, in a situation where the role of the formalised waste collection and management system was insignificant. In this system of the common good, only the material waste is a resource, and the actors are mainly groups of informal pickers. Although such an approach corresponds to common goods understood as CPR, it refers to a very small part of the waste problem and does not apply to the developed waste management system.

The paper proposes a different approach to waste as a common good. The common actions are not resource appropriation for consumption but resource appropriation for conservation purposes. In this view, appropria-

tion applies to all waste, not just material waste, as long as it has some value for the appropriators. In this way, conservation activities include any actions that minimise the negative impacts of waste, are appropriation activities too. Thus, the number of appropriators are significantly increased: formal system institutions and informal activities carried out by among others households, businesses, NGO's, social groups, pickers or artists. The differences between the approaches present in the literature and proposed in this paper are below.

Table 1. The differences between waste as a CPR in the developing and developed countries

SES analytical framework-elements	developing countries	developed countries
non-excludability	in consumption (using) material waste	in production (of waste)
rivalry		in using installations/environment
common action	appropriation material waste from the mixed waste stream	conservation activities
source stream	mixed waste	mixed waste+selected waste
deposit	residual waste (harmful)	all municipal waste with its externalities
resource units	material waste	1) any waste with value for the appropriators (financial or non-financial) 2) any actions that minimise the negative impacts of waste
actors:appriopriators	informal pickers	1) formal: municipal waste management 2) informal: households, businesses, NGO's, social groups, pickers or artists, and others
actors: producers of waste stream	local producers of municipal waste	local producers of municipal waste
governance system: legislation and formal municipal waste management	insignificant	significant

Source: author's work.

The proposed approach also enables removal of the discrepancy between literature's model of municipal waste as CPR and Ostrom's model. This discrepancy is that if we appropriate material waste from the waste stream, we generate increasing amounts of worthless and harmful waste. Thus, there is no typical "common tragedy" of resource depletion, but increasing harmful waste (environmental pollution) is a tragedy. The proposed approach eliminates this problem by including the activities reducing waste externalities into conservation activities. Such a new approach allows to be applied to the

analysis of the waste problem not only locally, as before, but also nationally and even globally.

The article presents only a preliminary concept of municipal waste as a common good. The proposed approach can be applied to analyse other common goods with negative social utility. However, this topic requires further research.

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ENVIRONMENTAL POLICY AND MANAGEMENT

POLITYKA EKOLOGICZNA I ZARZĄDZANIE ŚRODOWISKIEM

Borys **BURKYNSKYI** • Natalya **ANDRYEYEVA** • Hanna **TIUTIUNNYK**

STRATEGIC MANAGEMENT OF INVESTMENT AND INNOVATION ACTIVITIES IN THE FIELD OF ENVIRONMENTALLY SAFE LAND MANAGEMENT

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ABSTRACT: The purpose of the study is to form a methodology for strategic management of investment and innovation activities in environmentally safe nature management based on the analysis of world experience. The study's methodological approach is based on the step-by-step SMART-research, economical-ecological analysis, systematic investment and innovation activities assessment, PESTLE-, SWOT-analyzes, and definition of ecologically safe strategies.

The proposed study formulates the author's vision of combining methods of foresight methodology in the field of environmentally safe land management, SMART-method and Quintuple Helix (5 helix) for sustainable development of methodology for strategic management of investment and innovation activities in the field of environmentally safe land management. Furthermore, the proposed methodological approach will promote the development of applied tooling to develop systems of strategic management of investment and innovation activities of environmentally safe land management.

In contrast to the existing methodological approaches in land relations, the developed methodology of strategic management of investment and innovation activities in ecologically safe land management is based on a comprehensive combination and use of foresight tooling.

KEYWORDS: Foresight, SMART, Quintuple Helix (5 helix), PESTLE, strategic management, environmentally safe land management

Introduction

According to the scientific works of domestic and foreign scientists, the study was developed the author's concept of strategic management of investment and innovation activities in the field of environmentally safe land management – this is an effective process with regard to strategy formation, which provides the realisation of the mission, goals, objectives focused on the long-term results and future development of environmentally safe land management and took into account the variability and correlation with the internal and external environment through the development/implementation of environmentally safe innovations and their investment in order to create competitive advantages.

The methodology of the work is based on a modern approach to foresight research, which involves the complex use of modern economic and management methods. Regarding the problems of nature management, the authors recommended using a group of methods: Smart research, economic and environmental analysis, systematic assessment of investment and innovation activities, PESTLE, SWOT analyses.

Problems of the regulation of land relations have recently become especially actual when the best practices in the functioning of the land resource sphere have undergone large-scale changes both in Ukraine and throughout the world.

Models of ecologically safe lands as organic lands, green zones (environmental top low emission zone), green spaces (land that is partly or completely covered with grass, trees, shrubs, or other vegetation includes parks, community gardens, and cemeteries) are fixed in electronic databases of EUROSTAT (figure 1-4, table 1, 2).

According to technical reports, scientific papers and Eurostat data, statistics on ecologically safe lands of other types, namely green urban areas, are presented in table 1, figure 1. The largest number and highest rate of green area per capita are in Croatia, Poland and Italy.

Table 1. Green urban zones in the cities of Ukraine and the EU countries

No.	Administrative formations		Green urban areas, ha	Population	Green area per capita, m^2
1	Croatia	Zadar	3696.8	71471	517.24
2	Poland	Krakow	20121.1	761873	264.1
3	Italy	Padua	2167.1	210401	103.00
4	Germany	Hamburg	6800.0	1541823	44.10
5	Poland	Poznan	2004.2	550742	36.39
6	Sweden	Malmo	1077.5	307758	35.01
7	Hungary	Szeged	541.4	162183	33.38
9	Denmark	Archus	1000.0	319094	31.34
10	Slovenia	Maribor	690.9	240555	28.72
12	Austria	Linz	515.4	189889	27.14
13	Ukraine	Odessa	2678.3	1013159	26.43
14	Finland	Helsinki	1518.8	595384	25.51
15	Germany	Halle	588.0	233705	25.16
16	Netherlands	Utrecht	665.4	316275	21.04
17	Netherlands	Amsterdam	1511.3	857713	17.62
18	Germany	Berlin	5890.1	3501872	16.82
19	Ukraine	Belgorod-Dniester	82.1	48967	16.77
20	Ukraine	Izmail	101.8	73500	13.85
21	Poland	Lodz	849.1	718960	11.81
22	Slovenia	Ljubljana	260.7	280607	9.29
23	Italy	Milan	1133.4	1262101	8.98
24	Italy	Bari	174.5	313213	5.57
25	Ukraine	Yuzhne	13.6	32679	4.16
26	Romania	Oradea	87.6	196367	4.46
27	Ukraine	Chornormorsk	31.58	59261	5.33
28	Spain	Barcelona	53.1	179405	2.96

Source: author's work on the basis of data from EUROSTAT and the State Service of Ukraine for Geodesy, Cartography and Cadastre of Ukraine as of January 01, 2016 and [13-16].

Table 2. Percentage of public green spaces (parks and gardens) in cities

City	Percentage	Year	Source
Oslo	68.0%	2018	Bymiljøetaten, commune of Oslo
Singapore	47.0%	2011	Council of National Parks
Sydney	46.0%	2010	New South Wales Planning Department
Vienna	45.5%	2014	Vienna Annual Statistics 2014
Chengdu	42.3%	2017	Bureau of Statistics Chengdu
Zurich	41.0%	2018	Green city of Zurich
Shenzhen	40.9%	2016	Shenzhen Statistical Yearbook
Nanjing	40.7%	2018	Nanjing Statistical Bureau
Helsinki	40.0%	2018	City of Helsinki
Hong Kong	40.0%	2018	Department of Agriculture, Fisheries and Protection; Department of Surveying and Mapping, Department of Lands
Stockholm	40.0%	2015	Stockholm city
Rome	38.9%	2017	Roma Capitale
Los Angeles	34.7%	2016	Assess the needs of Los Angeles County parks and recreation
London	33.0%	2015	Information about Greenspace for Greater London
Seoul	27.8%	2016	Seoul Metropolitan Government
New York	27.0%	2010	New York City Department of Urban Development
Dublin	26.0%	2018	Dublin City Council
Johannesburg	24.0%	2002	State of the Environment Report, Johannesburg 2009
Cape Town	24.0%	2016	The city of Cape Town
Lisbon	22.0%	2018	Camara Municipal de Lisbon
Guangzhou	19.8%	2018	Guangzhou Statistical Yearbook 2019
Edinburgh	19.0%	2016	ESRI
Brussels	18.8%	2015	IBGE
Moscow	18.0%	2017	Department of Natural Resources
Warsaw	17.0%	2015	Main office of geodesy and cartography
Shanghai	16.2%	2017	People's Government of Shanghai
Montreal	14.8%	2013	City of Montreal, Directorate of large parks and dunes
Amsterdam	13.0%	2018	Statistics Netherlands / TNO
Toronto	13.0%	2018	The city of Toronto
Milan	12.9%	2016	Commune of Milan

City	Percentage	Year	Source
Austin	11.0%	2018	The Trust for Public land ParkScore 2018
Barcelona	11.0%	2019	Department of Statistics. Barcelona City Council
Melbourne	10.0%	2016	Victorian Planning Office
Paris	9.5%	2013	IAU дele-de-France
Buenos Aires	9.4%	2018	Statistics and Censors
Tokyo	7.5%	2015	Bureau of Urban Development
Bogota	4.9%	2017	Administrative Department of the Defensorium del Espasio Pubblico
Taipei	3.4%	2017	Parks and street lighting office, Taipei city
Istanbul	2.2%	2015	Istanbul Municipal Municipality

Source: (Natura 2000 protected areas. Eurostat, 2021).

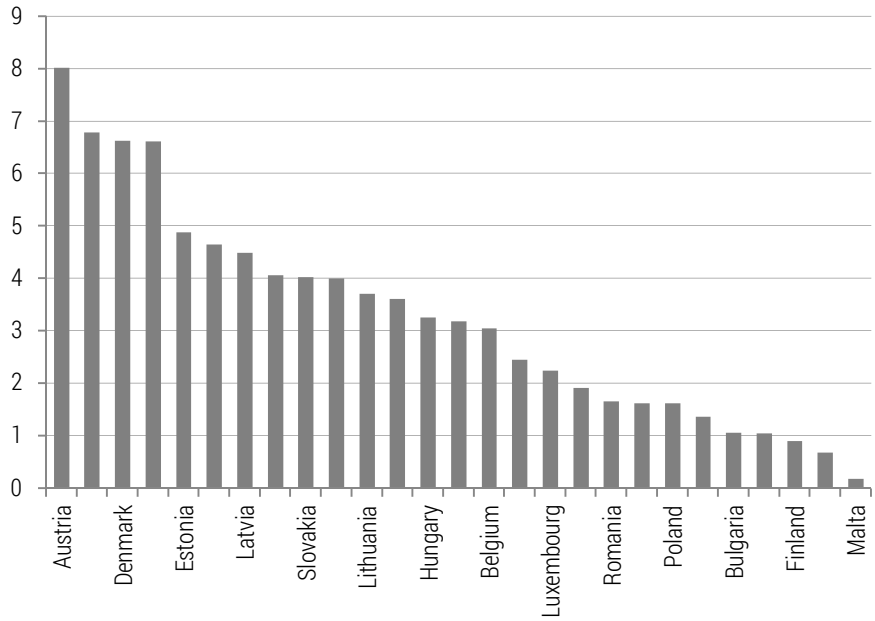

Figure 1. Share of areas of organic territories to the total territory of the country in 2019 in the EU, %

Source: author's work based on EUROSTAT.

The number of cities with a high share of green zones remains low at 0-35%, only in two cities it is 75 percent or more, and in seven cities – 65-75%

of the total area of the studied city. When considering the totality of cities in each country with a large area of green urban zones, the first place is occupied by France (12 cities and almost 80% of green zones in the city); Finland – 4 cities, more than 70% of green recreational zones in Oulu (The EEA workspace, 2021). According to the rating of green areas of the European Union, the first five metropolitan areas are occupied by the cities: Belfast, Nice, Wiesbaden, Ruse, Oulu; the second five: Genoa, Karlovy Vary, Tour, Riga, Barcelona; the third five: Herlen, Porto, Stockholm, Giurgiu, Cork; the fourth five: Linz, Stargard, Tallin, Yuryugge, Panevezys; the fifth five: Budapest, Hair, Banska Bystrica, Odense, Luxemburg (figure 2).

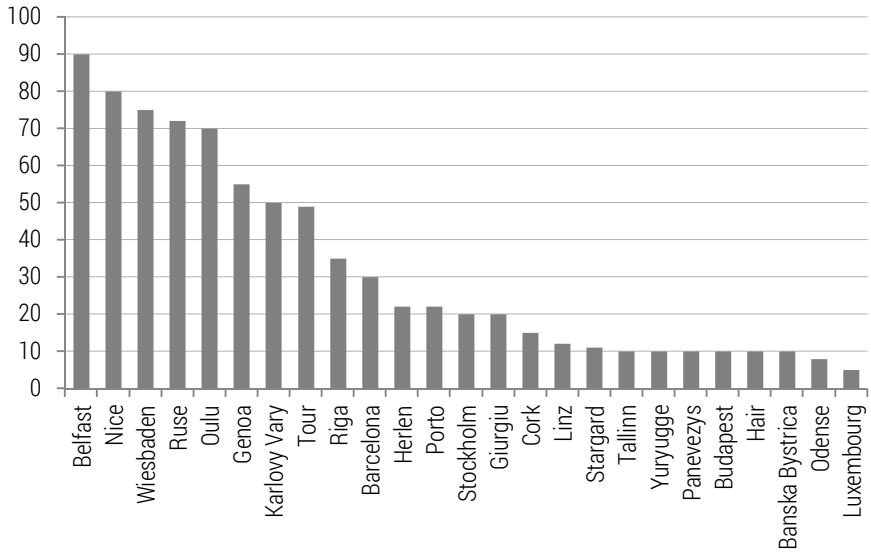

Figure 2. Rating of cities in the EU by share of green zones in 2021

Source: author's work based on (The EEA workspace, 2021).

Figures 3, 4 show ecologically safe lands in Ukraine and EU countries, based on categorical subordination of lands such as organic and recreational.

The largest share of lands of the nature reserve fund is in Austria, Slovenia, Croatia. Ukraine is characterised by the largest zones in the Western (Rivne, Lviv regions) and Southern parts of Ukraine (Kherson, Zaporizhzhia, Dnipropetrovsk, Odesa and Mykolaiv regions).

As of January 01, 2020, the percentage of protected areas in Ukraine is 6.77% of the total area of territories, which is 4085862.37 ha but is much smaller than in most European countries, where the average percentage of protected areas is 21% (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021).

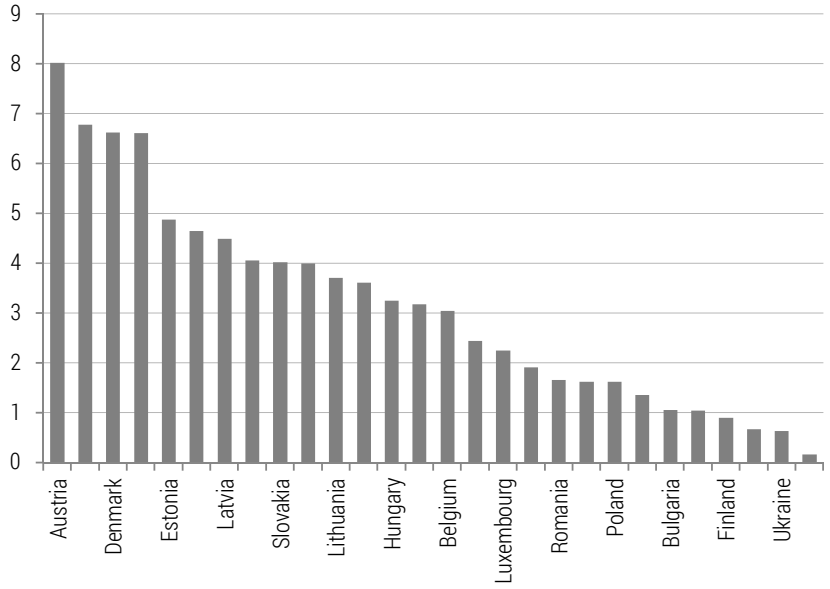

Figure 3. EU and Ukraine organic areas for 2019, ha

Source: (Federation of organic movement of Ukraine, Eurostat, 2021).

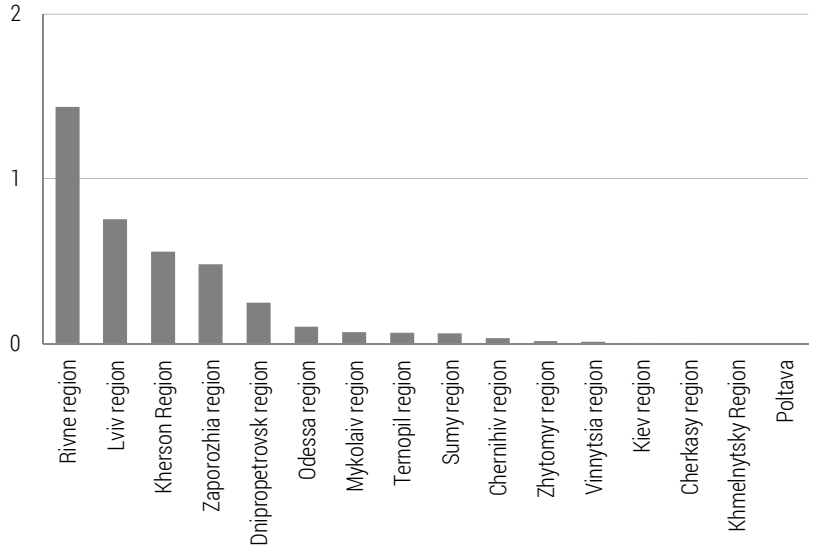

Figure 4. Share of the area of territories and objects of the nature reserve fund by regions of Ukraine in 2019, ha (State cadastre of territories and objects of the nature reserve fund of Ukraine, 2021)

Source: formed by the authors based on (Ministry of Environmental Protection and Natural Resources of Ukraine, 2021).

The share of environmentally safe territories in Ukraine of the total area of the country's territory has critically low scores compared to the EU. For example, Ukraine ranks 27th among the 27 countries surveyed in terms of green urban zone per capita; the percentage of area of the lands of the nature reserve fund of the country's total territory in Ukraine is 3.1 times smaller than in the EU.

According to the abovementioned analytical data, it can be said that statistical information and its components on environmentally safe lands are not characterised by sufficient diversity and content. Qualitative content of databases is absent.

Considering modern approaches to the EU Common Agricultural Policy and Green Deal Policy, measures and tooling for implementing strategic priorities of management of investment and innovation activities of ecologically safe land management, improvement of methodological support of the system of environmental regulation of land relations are especially resonant. Today in Ukraine and some countries of the world, there is a need to form a new system of regulation of land relations, related not only to the development of the land market but also taking into account the dominants of sustainable development and socio-ecological economic aspects of the life of the society. In this context, the methodology and practice of strategising in an ecologically safe land management system will become especially important.

The corresponding development of investment and innovation activities is the development of more technological and innovative economic entities, which primarily causes competitiveness and accelerates innovative development. Encouragement to increase investment in research and development, scientific and technological innovations should be aimed at business entities engaged in environmentally safe land management development. Investing in the creation of various research institutes, innovative resources, and technological reserves will support the transformation of scientific and technological achievements, as well as the development of business incubators, scientific and technical consulting, and other scientific and technical institutions, as well as the transformation of scientific and technological achievements in the direction of ecologically-oriented nature management and natural environment protection. It is appropriate to support business entities in the full use of different platforms for the transfer of technology and technological advances, as well as to accelerate the transformation and technological advances.

Entities of ecological and economic activity are interested in improving the use of modern technologies, increasing the competitiveness of manufacturers of goods. Therefore, households and enterprises need equal state aid. The state, first of all, has an interest in the transition to Industry 4.0 (auto-

mated manufacturing, where all processes are managed in real-time and taking into account changeable external conditions) because it is a way of development without violating international obligations.

Natural resources need uniform and sustainable management, improving the efficiency of their use and introducing innovations by enterprises. Management systems need to be constantly improved through more effective institutions, rules and standards for the management of natural resources, incentive mechanisms, clearly defined property rights, managed relations between the state and business, and management of rent payment (ERD 2011/2012: European Report on Development, 2021).

The use of Foresight forecasting methodology will acquire a specific interest in the context of environmentally safe land management through the adaptation and step-by-step use of many strategic management methods in the system of rational nature management. The article does not cover the whole range of problems in the formation of regulation of the ecologically safe land management in connection with their diversity and systemic heterogeneity; some scientific positions are debatable. At the same time, according to the authors, the proposed methodological approach will promote the development of applied tooling for the development of systems for strategic management of investment and innovation activities of environmentally safe land management.

Analysis of recent studies

Strategic management is the basis for optimising environmentally safe land management, decision-making and the key to the positive development of the relevant economic sphere. The essence of the development of modern strategic management requires mobility, rapid pace and wide coverage by power structures of the definition of clear goals and tasks, which must be correlated with the tasks of sustainability, rational use of natural resources, inclusiveness. Strategic management is a simplification process, balancing, improving the functioning and coordination of strategic and tactical management tasks. Strategic management of the sphere of ecologically safe land management should take into account scientifically-based approaches, creation and implementation of innovative technologies, external and internal factors of the influence over the development, restoration and preservation of environmental quality and sustainability of soils, rational and efficient use of water resources (Borovik and Tanklevska, 2019, p. 122-123).

The directions to increase land resources reproduction efficiency and the modal formation strategy of ecologically balanced measures system for their effective employment are defined by Stepanenko et al. (Stepanenko et al.,

2021). Wang et al. explore the coupling relationship between land use and rural development to improve the environmentally friendly level of land use and attain accelerated rural revitalisation (Wang et al., 2019). Damien et al. review some of the forthcoming challenges that the agricultural sector should address to confirm its significant progress towards land-use sustainability (Damien et al., 2017). De Wrachien describes the main physical, social and economic features of land use planning projects, along with their environmental impact and the constraints of sustainable development. The importance and role of institutional strengthening, sound financial and managerial frameworks and the availability of human resources are analysed, along with research thrust, technology transfer and networking improvement (De Wrachien, 2002). Mishina et al. say that reducing environmental pollution is possible only with the use of clean and environmentally friendly sources of energy. Increasingly renewable energy sources have been mentioned as the most economically advantageous and the most expensive at the initial implementation stage. An important issue is investment and innovation support for the sphere of environmentally friendly land use and the development of its strategic management (Mishina et al., 2020).

A small number of scientific concepts are characterised by the presence of investment and innovation aspects of strategic management.

Development, implementation, and realisation of strategic goals require the formation of alternative strategies, control, regulation, and adjustment of the entire strategic management system in environmentally safe land management (figure 5).

Strategic goals in the field of ecologically safe land management and the general direction of the strategy should be focused on the use of innovative technologies with the help of which it will be possible to monitor the quality of land pollution. However, this is quite an investment-cost technology. Thus, the issue of investment security and attractiveness with the encouragement of participants and stakeholders for further development of this area plays an important role in implementing and promoting strategies.

Such innovative technologies can be sensor equipment with the function of an electromagnetic signal generation that will determine the characteristics of the land area and transfer them to the information database of regulatory bodies for land protection or land survey using GIS technology.

Climate change poses new threats to the health of vegetation and crops. Ensuring their sustainability in such conditions requires measures for better protection of plants from pests and diseases and the introduction of innovations. In its Farm-to-Fork strategy, the EU Commission pays close attention to new innovative methods, including biotechnology and the development of bio-based products. The development of proposals focuses on innovation,

with a special focus on adaptation and mitigation of climate change, agri-environmental issues, sustainable landscape management and land management, conservation and sustainable use of biodiversity.

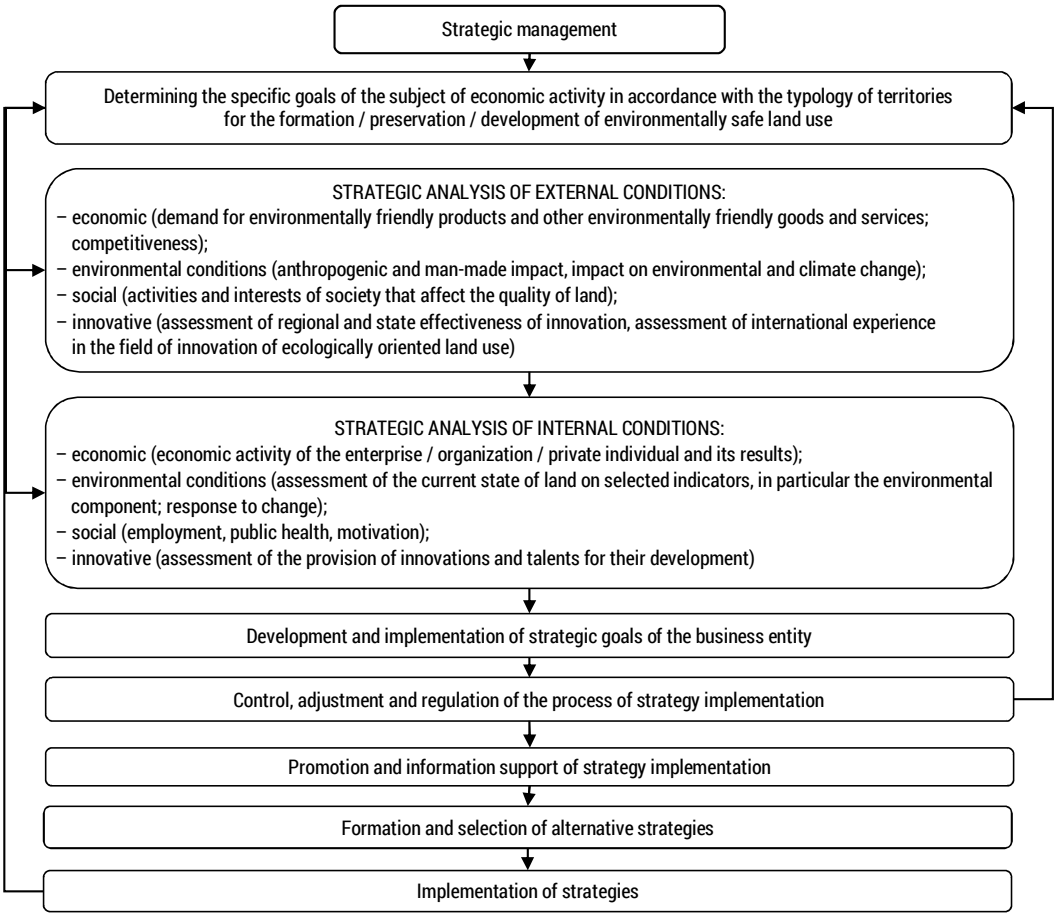

Figure 5. Monitoring and evaluation of the effectiveness of the strategic management system in the field of environmentally safe land management

Source: author's development using (Borteichuk, 2013., p. 2; Paladchenko and Molchanova, 2018; Yermakova, 2019, p. 14-18).

Support for innovative and sustainable solutions concerning packaging using environmentally safe, reusable and secondary materials is essential. The main goal of the Strategy and the EU Green Course priorities is to develop solutions to restore soil health and function.

Innovative development and knowledge transfer is key task of the EU Commission. It takes place through cooperation with member states to

strengthen the role of the European Innovation Partnership "Agricultural Productivity and Sustainability" (EIP-AGRI). Involving farmers and rural areas in cooperation is a key factor in providing employment, business and investment in rural areas, as well as in improving the quality of life. The European Fund is investing in innovation and cooperation in the regional context.

The strategy of sustainable financing mobilises the financial sector to more sustainable investments, in particular in agriculture, promotes investment support to improve the sustainability and accelerate the environmental and digital transformation of farms (A farm to fork Strategy for a fair, healthy and environmentally-friendly food system, 2020, p. 9-17).

The use of innovative technologies allows taking the necessary measures to delineate the boundaries of contaminated areas, leading to the storage of contaminated adjacent areas, including their natural state. In addition, information on land damaged by pollutants will be used to create a database for transforming land into environmentally safe, returning to its natural state or termination of usage.

Particular attention is to be paid to monitoring not only the quality of land resources but also the possible costs of restoring the land. As a result of the effectiveness of the land management system in Ukraine, it will be possible to stop using contaminated areas that are economically inefficient and dangerous.

Concerning investment activities for the management and development of environmentally safe land management, it provides for reimbursement of up to 30% of the cost of certification of organic production and reimbursement of up to 30% of the cost of purchasing the permitted plant protection products and fertilisers, seeds, planting material and feed (On state support of agriculture of Ukraine, 2004). In the desired form, the investment system for the formation, development and preservation of ecologically safe lands should provide for the creation and systematic renewal of regulations, an environmental audit of territories to improve the procedure for assessing the ecological state of the environment comparing environmental safety with economic opportunities.

According to the description of investment and innovation activities in the field of ecologically safe land management, it can be seen a coherent process and intertwining of the properties of both components (figure 6).

Scientific support for the strategy of environmentally safe land management should be based on several principles:

- systematicity, based on the consideration of land management as an interconnected ecological and innovative system;
- environmental friendliness, in particular, land valuation taking into account the ecological condition of natural resources;

- self-reproduction of the land, which causes the lack of use of artificial means of intensification of land management formation;
- voluntary participation of landowners and land users in the processes of the greening of land management;
- priority of local management, namely the emphasis on local conditions, with the subsequent concentration of environmentally safe zones and their appropriate management;
- complexity caused by taking into account economic, environmental, social needs, interests, requirements of business entities;
- openness and transparency of the strategising process and promotion;
- feedback and information support (Tiutiunnyk and Kupinets, 2020, p. 26).

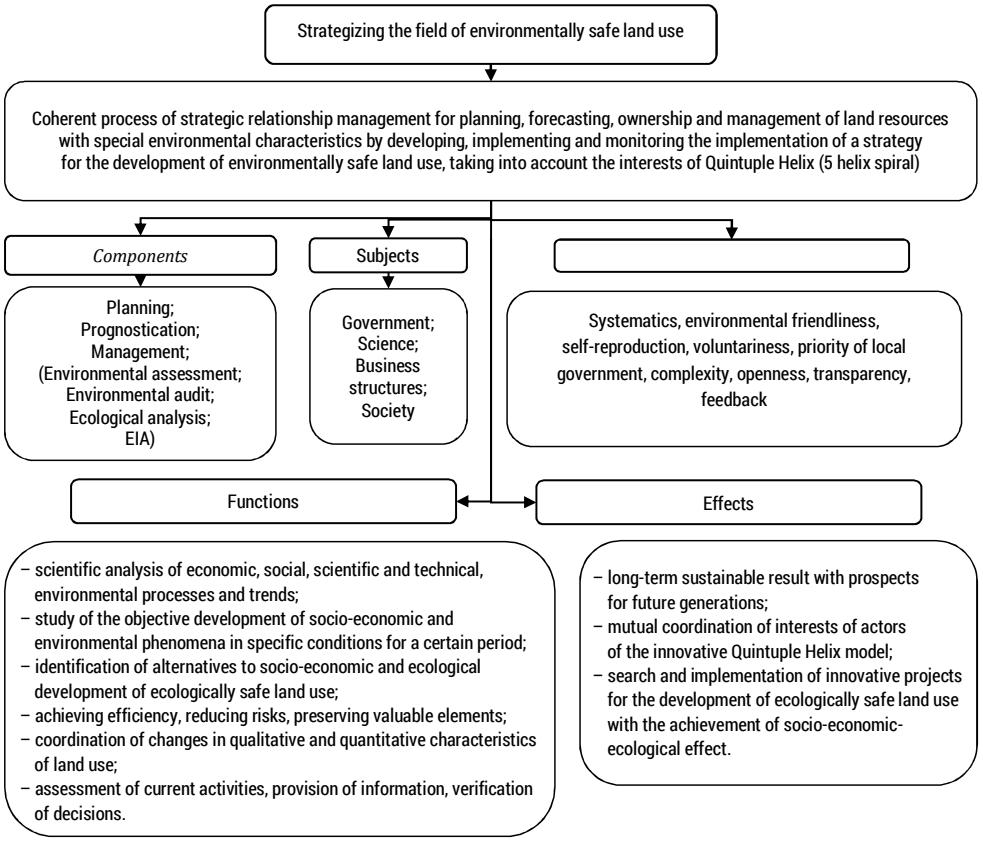

Figure 6. Logical and structural scheme of strategising the sphere of ecologically safe land management

Source: author's development using (Sierov, 2000, p. 606; Campbell et al., 2015; Svyrydova, 2016, p. 75; Bulysheva and Andryeyeva, 2018, p. 157).

The balance and support of the two (innovative and ecological) components will lead to a comprehensive ecological-economic and innovative effect, the possibility of international cooperation with EU countries and maintaining the necessary pace for the development of environmentally safe land management and climate change mitigation.

Research methods

In his research, the world-famous scientist Popper proposed representing a set of varieties of the Foresight-method in the form of the Foresight-diamond (Popper, 2008). Diamond has about 44 methods. In recent years, the variety of quantitative and qualitative methods used for foresight and forecasting has increased sharply. In addition to the well-known Foresight methods, such as expert groups, scripts and Delphi, more advanced methods have been introduced in Foresight. At the same time, traditional methods have also been improved using new technologies and applications.

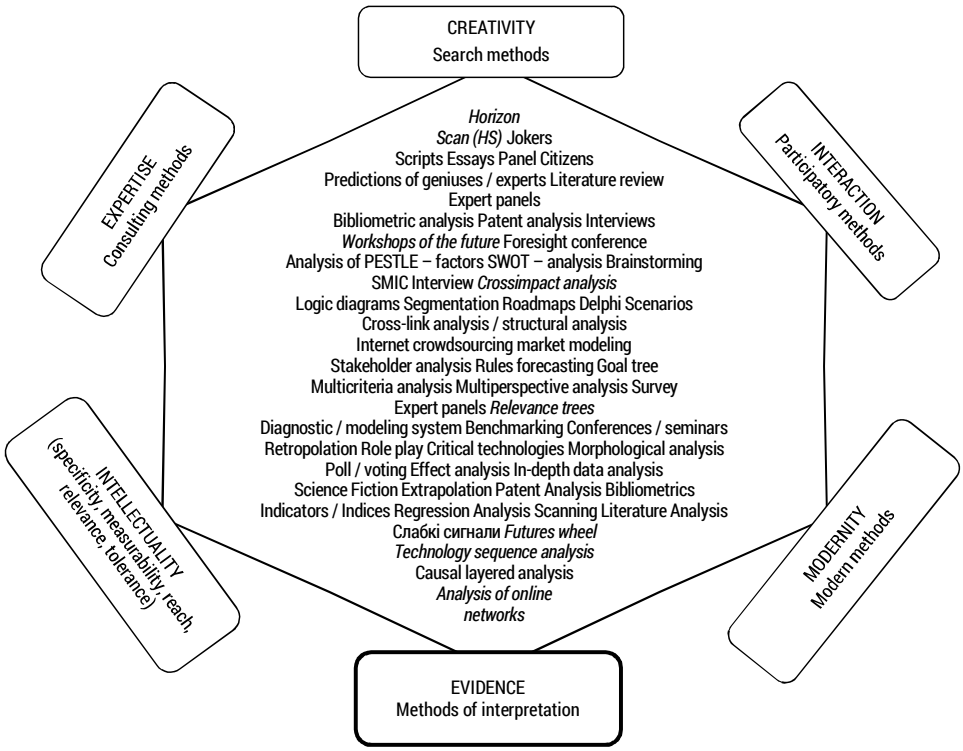

Figure 7. The star (heptagram) of the foresight

Source: author's improvement (italics) using (Bulysheva and Andryeyeva, 2018, p. 156; Zanyzdra, 2020, p. 105; Paladchenko et al., 2010; Saritas and Burmaoğlu, 2015).

These methods can be characterised as modern (up-to-date), particularly the analysis of megatrends, technology forecasting, science and technology policy methods, technological planning, and cross-impact. The total number of methods is more than 68. The star (heptagram) of the foresight is shown in (figure 7).

The foresight method can be described as intelligent (a special place in which takes the SMART method). It provides the study and presentation of many plausible (relevant) and unpredictable ways that can form and develop an uncertain future (reachability).

Forecasting is based on structures (measurability), disciplined and mutually complementary methods (specificity) – verified, repeated and provide different ways of seeing and processing.

Foresight is inherently common and seeks diversity (tolerance) – that is, the systematic involvement of long-term stakeholders to promote mutual learning, collective vision and joint actions to reflect current and future perspectives [Morrison, 2010; Saritas et al., 2015, p. 3). In addition, foresight raises stakeholder awareness of new trends, events and challenges.

Results of the research

According to the authors, environmentally safe land management should be understood as the process of ensuring the greening of land relations, based on the principles of preserving and improving the qualitative and ecological condition of the environment in the context of the priorities of the Sustainable Development Goals.

The procedure for implementing the foresight methodology in the field of ecologically safe land management in the study is presented at the traditionally separated stages, adapted to the peculiarities of the field of environmentally safe land management, management of its investment and innovation activities (figure 8). As part of the study, the authors proposed a methodological approach to implementing foresight forecasting and strategising of environmentally safe land management, which got the approval on the example of the Odesa Region within the Black Sea Region of Ukraine.

Relevant stages of the methodology of strategic management of environmentally safe land management and foresight forecasting are:

Analysis of existing information using SMART indicators based on the Quintuple Helix methodology (5 helix):

- investment potential of land protection (Government), Economic activity (Entrepreneurship);
- scientific and innovative potential in the field of environmentally safe land management (Science);

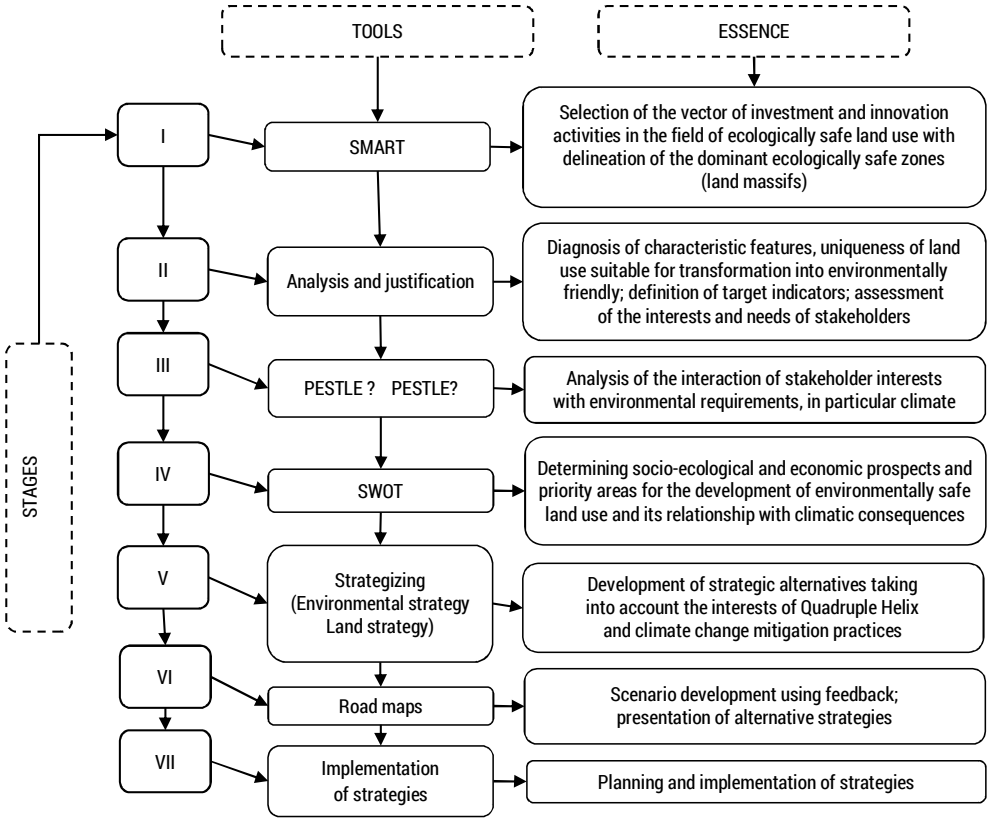

Figure 8. Stages and tooling of foresight methodology in the field of environmentally safe land management

Source: author's development using (Bulysheva and Andryeyeva, 2018, p. 159; Yermakova, 2019 p. 29; Procedure for developing regional development strategies and plans of measures for their implementation, as well as monitoring and assessment of the effectiveness of implementation, 2015).

- agroecological, climatic potential of land management and territories suitable for transformation (Environment);
- degree of anthropogenic impact (Public sphere) on the existing environmentally safe land management and suitable for transformation, the choice of development of the vector of investment and innovation activities. The methodological approach is presented in previous studies (Andryeyeva and Tiutiunnyk, 2020, p. 62);
- Development of a database upon indications for assessing the needs in the field of environmentally safe land management;
- Monitoring the state of the environment in accordance with the interests of stakeholders and climate change mitigation requirements;

- Drawing of perspectives and choice of priority directions concerning optimisation of the development of the sphere of environmentally safe land management;
- Formation and substantiation of strategic alternatives of the sphere of land management with special environmental characteristics taking into account the interests of Quintuple Helix (5 helix);
- Presentation of the scenario of formation, development and preservation of environmentally safe land management with the analysis of socio-economic and ecological results from the introduction of the eco-innovative component. Assessment of the impact of the development of environmentally safe land management on climate change.
  Planning and implementation.

Stage I

The synergy of the innovative and ecological components in the field of environmentally safe land management as mutual complementation correlates with the characteristics of the SMART method by scientists Ortega., McCann, Perianes-Forte, Cervantes, Larosse and Sanchez (Ortega et al., 2013). Due to the lack of a cadastral database of ecological qualitative and quantitative characteristics of land management and the irregularity of data, a key element of the SMART process is the use of public opinion, data and technology from social media, online tools (Bakhshi and Mateos-Garcia, 2016). Involvement of beneficiaries and users, public consultations, expert recommendations, submission through web tools are defined as important components of the selected method according to the research of Delaney and Osborne (Delaney and Osborne, 2013).

According to the analysis of information sources, the SMART method was selected as the basic method for foresight forecasting. Calculations were carried out within the framework of the preliminary author's research of the regions of Ukraine "Methodological approaches to determining the dominants of the regional investment and innovation policy of nature management" (Andryeyeva and Tiutiunnyk, 2020, p. 62) (table 3, figure 9).

Table 3. Comprehensive assessment of the dominant position in the context of investment and innovation regional nature management policy of the Black Sea Region (by groups of indicators of Smart Specialization)

Region	Economic activity and investment potential of environmental protection	Scientific and innovative potential in the field of nature management	Environmental performance according to SDG	Natural resource potential
Mykolaiv region	1.5	3.5	2.1	2.6
Odessa region	1.4	5.6	2.0	3.8
Kherson region	0.9	4.4	2.6	3.1

Source: calculated on the basis of (Andryeyeva and Tiutiunnyk, 2020).
Note: green zones are strong, yellow are moderate, orange are neutral and red are weak.

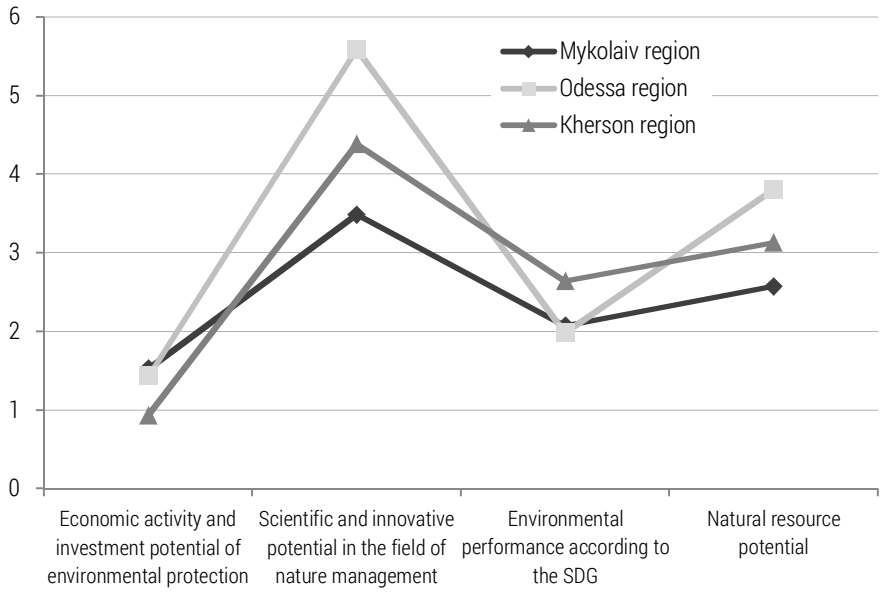

Figure 9. Comprehensive assessment of the priority of implementation of Smart-projects in the field of nature management of the Black Sea Region of Ukraine

Source: developed based on table 7.

Due to the lack of necessary indicators specified in the description of the stages of methodology and the availability of a number of necessary information only on land fertility in the Black Sea regions as a basis for the develop-

ment of environmentally safe land management and based on previous studies, there were made the conclusions (table 4, figure 10).

Table 4. Soil area by humus content for 2020 in the Prymorskyi Region of Ukraine

Soil area by humus content for 2020, %							Weighted average, %
Humus content	very low < 1.1	low 1.1-2.0	medium 2.1-3.0	Elevated 3.1-4.0	high 4.1-5.0	very high> 5.0	
Odessa region	0.0	0.3	15.8	48.3	28.9	6.7	3.77
Kherson region	11.07	26.62	51.72	10.56	0.03	0.0	3.62
Mykolaiv region	7	3.3	34.3	45.5	9.8	0.1	3.0

Source: developed based on (Regional report on the state of the environment in Odesa Region, 2020).

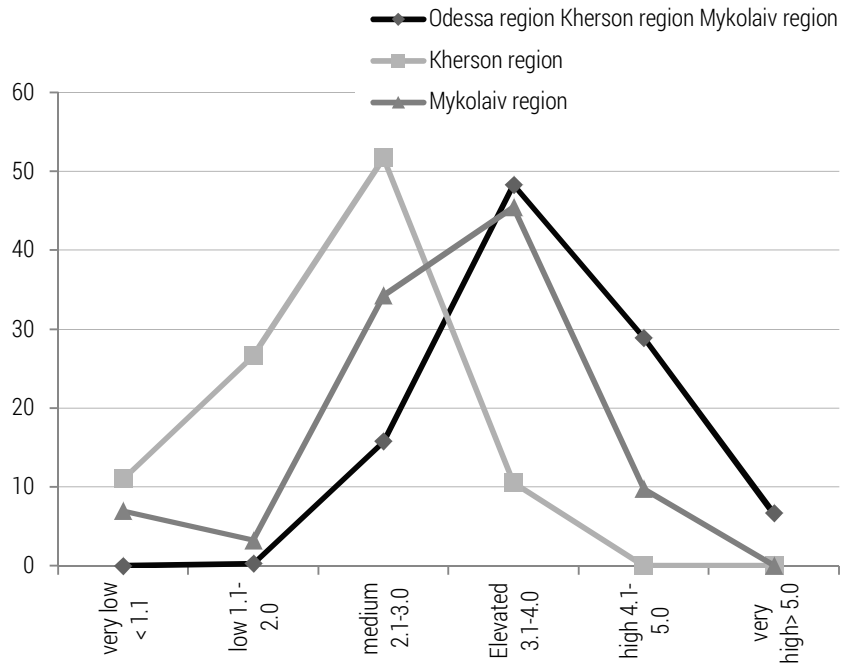

Figure 10. Concentration of humus content for 2020 in the Prymorskyi Region in soils
Source: developed based on table 8.

As a result of approbation of the author's technique on the statistical basis of the Black Sea Region of Ukraine, it was revealed that the dominant region would be Odesa Region, despite a number of problematic issues and necessary tasks to be solved, then Kherson and Mykolaiv regions.

Stage II. The definition of target indicators with the assessment of stakeholder interests

Sustainable Development Goals (SDG) and the optimal state of land management was carried out at the stage of analysis and justification. This stage may comply with the SMART method, as well as it was a separate process. The target indicator (according to the methodology) can be correlated with the indicators of the dominant region, in this case, Odesa Region and/or be determined based on international standards and target indicators of SDG (2 – Overcoming famine, 4 – Quality education, 6 – Clean water and proper sanitation conditions, 7 – Renewable energy, 8 – Decent work and economic growth, 9 – Innovation and infrastructure, 11 – Sustainable urban development and community, 13 – Combating climate change, 14 – Preservation of marine ecosystems, 15 – Preservation of terrestrial ecosystems).

Stage III

Provides for using an adapted matrix of analysis of external strategic factors and an extended version of PEST-analysis – PESTLE-analysis (table 5).

Table 5. PESTLE-analysis of environmentally safe land management

Factor code	Deciphering the factor	Characteristic	Factors of ecologically safe land use
P	Political	Intentions and means of implementation of the development of ecologically safe land use by public authorities	Political factors in the field of environmentally safe land use: • System of support (benefits, compensations, compensations) of landowners, land users with ecologically safe lands; • Ecologically oriented policy of land use; • Distribution of powers of authorities and systematisation of the branch directly related to environmentally friendly use and functioning of land; • The level of control and supervision over compliance with the law, the level of corruption, the level of possibility to implement appropriate measures.
E	Economic	Investment attractiveness of ecologically safe land uses as a basis for the production of quality products and ecological safety in relation to environmental degradation	Economic factors of ecologically safe land use: • Economic and monetary evaluation of ecologically safe lands with the use of ecological component as a basis for increasing investment attractiveness, rent; • Demand and production of environmentally friendly products; • Income/expenses of landowners and land users from the formation and transformation of environmentally safe land uses; • Settlement of forms of ownership in the land market; • Availability of compensation and other economic incentive mechanisms to reimburse the costs of creating and operating environmentally safe land use.

Factor code	Deciphering the factor	Characteristic	Factors of ecologically safe land use
S	Social	The socio-educational and cultural level of landowners and land users, reasonable urbanisation	Social factors in the field of environmentally safe land use: • The level of educational training of specialists, the provision of the educational base; • Social conditions and protection of employees; • Ecological worldview, awareness, awareness, feedback, ecological culture, traditions; • Inclusiveness as multifunctionality of natural resources and inclusion of all segments of the population; • Directions of anthropogenic impact, nature and form of land management; • Reasonable development of urban processes.
T	Technological	The level of implementation and functioning of the innovation component, its impact on the environment and the development of environmentally friendly land use.	Innovative factors in the field of ecologically safe land use: • availability of technological equipment; • compliance with modern trends and best world practices; • inclusiveness in use; • safety and performance for the environment.
L	Legal	Regulatory and legal field of formation, development and functioning of ecologically safe land use and the sphere of use of the respective lands	Legal factors in the field of environmentally safe land use: • Development of a regulatory framework that covers both general issues of environmentally safe land use and in accordance with each category of land and their scope; • Improving existing land legislation with a focus on the environmentally safe use of land resources.
E	Ecological	Interaction of the state of the natural environment on ecologically safe land use	Ecological factors of ecologically safe land use: • The impact of the development of environmentally safe land use on climate change mitigation; • The impact of green hydrogen production on the state of land use and development of H2 reserves; • The current state of agro-climatic features of the environment for environmentally safe land use;

Source: author's development using (Bulysheva and Andryeyeva, 2018, p. 164).

The analysis of the best practices of the EU and the world community shows the need for a comprehensive review of indicators. Furthermore, it should be noted that the investment and innovation policy closely intersects with the Energy and Hydrogen Development Strategies.

According to the Concept of Green Energy Transition of the Ministry of Energy and Environmental Protection of Ukraine, renewable energy sources and innovativeness in nature management (Decarbonization of the economics, 2021). According to the European Hydrogen Strategy presentation, such sources supply the latest energy resource to the European market, namely green hydrogen. The EU has identified Ukraine as a priority partner in the implementation of the European Hydrogen Strategy. In the summer of 2020, Ukraine and Germany launched an energy partnership, particularly in developing hydrogen energy and its integration into the network.

There are four regions in the south of Ukraine where powerful bases for generating solar and wind energy have been formed, which can already be used to produce and export green hydrogen. In addition, the southern regions of Ukraine are also suitable because there is a demineralised water generator system from which hydrogen will be obtained. These are Odesa. Kherson. Mykolaiv and Zaporizhzhia regions.

The process of obtaining the H_2 molecule from ordinary water by electrolysis is referred to as the transition from conventional carbon fuel to environmentally friendly hydrogen as a new global energy trend and a strategic priority of rational environmental management (Is Ukraine ready to become an exporter of "green" hydrogen to Germany?, 2021). However, hydrogen can be produced not only in the subsoil and through the use of water but also in the soil layer. The presence of hydrogen ions (H-ions) in the soil cover and exchangeable hydrogen and aluminium ions in the absorbing complex causes an acidic reaction in the soil due to their incomplete neutralisation. The root system of plants releases hydrogen ions and organic acids that also acidify the soil. Soil microorganisms can produce and consume H_2 due to metabolic processes, thus actively participating in the molecular hydrogen cycle in nature. Natural hydrogen production depends on environmental conditions, such as humidity, temperature, presence and composition of microorganisms and in different areas, its value will be different.

Production of hydrogen from the soil cover will not only solve the problem of replenishing the necessary energy resources. However, it will also solve a problem for preventing the oxidation of particularly valuable soils (chernozems). Such measures correlate with the transformation of land into environmentally safe. After all, the decrease in the content and qualitative composition of humus is associated with anthropogenic processes of agrogenic soil cultivation, but hydrogen emissions cause a significant impact. Soils affected by hydrogen intensively change their properties: the mobility of many elements changes; humus transforms more mobile. It leads to the removal of humus outside the soil profile (Chakmazian, 2016).

Research of the sphere of environmentally safe land management in such an innovative way and assessment of quality indicators of land management that affect the life of flora/fauna, humans and climate allows to form a zoning system and economically justify the possibility of hydrogen production on the relevant territories and mitigate the impact on climate change (Tiutiunnyk, 2021).

Stage IV. The analysis of the interaction of stakeholders' interests with the environmental requirements is characterised by using a SWOT analysis

The implementation of such measures, in particular their plans and mechanisms for developing regional development strategies, in which they are set, is determined in Ukraine in accordance with the "Procedure for developing regional development strategies and action plans for their implementation, as well as monitoring and evaluating the effectiveness of the specified regional strategies and plans of measures".

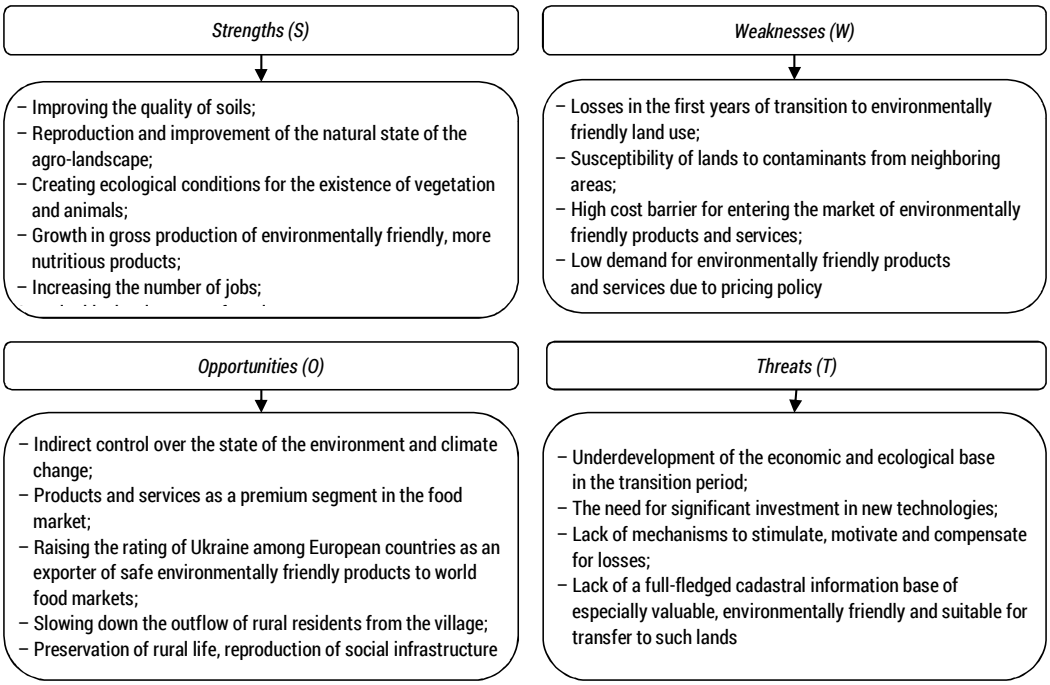

Figure 11. SWOT-analysis of the effectiveness of formation, development and operation of environmentally safe land management

Source: author's development using (Tiutiunnyk and Kupinets, 2020, p. 93-94; Procedure for developing regional development strategies and plans of measures for their implementation, as well as monitoring and assessment of the effectiveness of implementation, 2015; Yermakova, 2019. p. 126-127).

The regulatory legal act also indicates the need to monitor and assess the effectiveness of implementing these regional strategies and action plans, particularly based on smart specialisation, through SWOT analysis. It establishes a link between internal (strengths and weaknesses) and external (opportunities and challenges) factors (Procedure for developing regional development

strategies and plans of measures for their implementation, as well as monitoring and assessment of the effectiveness of implementation, 2015) . These factors are of strategic importance for the development of the region. The SWOT analysis results are used to identify and select strategic and operational development goals of the region. Trends and main problems of socio-economic development of the region, including the results of SWOT-analysis, were identified based on SMART-specialization (see figure 11).

Stage V

On the example of the Odesa Region, the authors proposed a Strategy for developing environmentally safe land management that can be used (as an example) in other regions of Ukraine and the world.

Note that ecologically safe lands, according to their qualitative characteristics, can be attributed to particularly valuable lands according to Article 19 and Article 150 of the Land Code of Ukraine (Land Code of Ukraine, 2001). However, in the land legislation, there are no criteria for assigning plots to the appropriate categories. The intended purpose of land management is determined with the help of data from the State Land Cadastre, which are currently insufficient and belong to outdated information, land management documentation, statistical data and others. Note that there are no cartographic materials (cadastral plans, maps) of such soils. As a result, there is no possibility of their use in the context of the region. In modern land management practice, there is no zoning of territories. The boundaries of plots suitable for conversion into ecologically safe ones are not delineated, making it impossible to fully preserve them as a framework for the ecological sustainability of territories.

All types of information sources used for land classification and further use can only state the current condition of the land but not be the basis for its intended purpose. It is especially true of ecologically safe lands, as the land area can belong to several categories of land at the same time. Therefore, its formation requires a number of survey works and the creation of a separate information platform. After carrying out organisational measures, it is possible to assign the land plot claiming the role of ecologically safe, to a separate category of especially valuable lands, to give it the corresponding intended purpose, to establish the regulatory order with the definition of the behaviour of subjects of land legal relations.

The cadastral database of ecologically safe lands, which includes indicators of survey works and systematic monitoring by the relevant services and public authorities, should be coordinated with landowners and land users' information and communication tool. Informational data at the beginning of the formation, use of land area requires the introduction of information on

information and communication platforms, along with reports on the agri-environmental condition of the land.

In the context of actualising the issue of climate change and the need to increase its sustainability, protecting the health of citizens and ensuring the interests of business entities, an important task is to monitor the consequences of economic activities, especially on land. After all, non-rational and non-ecological land management generates significant emissions of nitric oxide – the third greenhouse gas in order of importance, with the potential for global warming. An environmentally safe land management system has lower nitrogen emissions per hectare than conventionally treated and contaminated soils.

It means that cadastral databases currently, in addition to ecological-toxicological, soil-agrochemical, agrophysical, physicochemical, agrochemical, economic indicators, need to be filled with information on qualitative climatic characteristics correlated to the relevant land zone/massif (Tiutiunnyk and Kupinets, 2020, p. 28).

According to the information of the territorial bodies of the State Service of Ukraine for Geodesy, Cartography and Cadastre of Ukraine, there are more than a million hectares of degraded, unproductive and man-made contaminated lands that require conservation and restoration. In particular, in the Odesa Region, land resources for their economic use are characterised by insufficient environmental and economic sustainability under the definition of the coefficient of ecological stability of the agricultural landscape. Suppose the territories of degraded and man-made contaminated lands have decreased, the areas of unproductive and disturbed lands have significantly increased. It affected the implementation of measures to improve the state of Ukraine's lands. Most attention is paid to improvement and recultivation, but this does not improve the overall situation.

However, Odesa Region is one of the three regions on the territory of Ukraine that are not polluted to dangerous limits. Therefore, the use of environmentally sustainable technologies will be most appropriate. Furthermore, the degree of their contamination with radionuclides, heavy metals and pesticides is lower than the MPC. Therefore, it is easier to grow on them environmentally friendly products for baby, medical and preventive nutrition.

In Odesa Region, there is significant scientific and innovative potential in the field of nature management. Odesa also occupies a dominant position in the context of investment and innovation regional nature management policy of the Black Sea Region (by groups of Smart Specialization indicators), despite a number of problematic issues and necessary tasks to be solved.

Table 6. Strategy for the development of environmentally safe land management

1. Purpose and objectives of the Strategy	
The purpose of the Strategy is to develop economic and organisational support for the formation, development and operation of environmentally safe land use by creating favourable conditions for: • Improving the quality and quantity of land with environmentally friendly use; • Changes in the concept of ecological, economic and monetary valuation of land and increasing the value of environmentally friendly land use; • Effective investment and innovation activities in the field of environmentally safe land use.	Tasks of the Strategy: 1. Formation of the basic and improvement of the existing normative-legal field concerning the ecologically safe use of lands, their creation, development and functioning; 2. Development of land quality management system as part of monitoring and zoning, in order to ensure compliance of soil quality with established standards of Ukraine and the EU; 3. Monitoring of ecologically safe lands for classification and zoning (transformation of suitable lands), formation of cadastral database and cartographic representation; 4. Training and raising the educational level, qualification of existing staff in the field of nature management, in particular environmentally safe land use, international cooperation; 5. Carrying out organisational and economic measures to prevent pollution of existing environmentally safe lands and transformation, rehabilitation, regeneration (conservation), improvement of unproductive and degraded lands; 6. Increasing investment attractiveness and introduction of qualitatively new ecologically safe technologies of formation and preservation of ecologically safe land use; 7. Development of regional programs for the protection and restoration of land quality; 8. Development of motivational mechanisms for environmentally safe land use, the transition to an environmentally friendly way of management; 9. Improving the existing system of ecological, economic and monetary valuation of land using the environmental component; 10. Development and support of research on the impact of environmentally safe land use on climate change, making proposals and recommendations to the legal framework, land valuation system, organisation of the management process; 11. Formation of an information and communication platform to improve management in the field of environmentally safe land use.
2. Strategic directions and principles of the Strategy	
The economic vector of development of ecologically safe land use provides economic growth through income from ecologically safe better products and services, prevention of costs for restoration of natural ecosystems, benefits and basis of healthy life of future generations, competitiveness in world markets; The ecological vector of development of the sphere of ecologically safe land use provides preservation and prosperity of a qualitative natural condition of ecosystems, improvement of climatic features;	Principles of Strategy: 1. systematic, based on the consideration of ecologically safe land use as a socio-economic-ecological system; 2. voluntary participation of landowners and land users in the process of creating or transforming land-use into environmentally safe; 3. environmental assessment, scientific and technological progress and management, all land requirements need to be environmentally sound, taking into account the environmental status of natural resources; 4. complexity, due to taking into account economic, environmental, social needs, interests, requirements of business entities; 5. openness and transparency of activities in the field of ecologically safe land use; 6. feedback, with the help of innovative communication tools, a combination of internal and external actors in the field of environmentally friendly land use; 7. directed sustainable development, which implies the transition of production of certain agricultural products to the formation of life-saving complexes and taking into account the priorities of the Sustainable Development Goals;

The social vector of development of ecologically safe land use involves the creation of new jobs, healthy and quality food and livelihood in the future.

8. motivation – continuous stimulation of the population's interest in ecological and economically efficient management;
9. economic feasibility – any actions are economically feasible, and rational using the law of demand and forecasting, income, as a result of their implementation, exceeds costs and allows to make a profit at the planned level;
10. scientific validity, which means that all activities carried out on land use in the organisation of agricultural production must be scientifically justified by the degree of modern achievements of scientific and technological progress.

3. Stages of development and implementation of the Strategy

Stages of Strategy development:
- Monitoring, research and systematisation of quantitative and qualitative information of ecologically safe lands and suitable for transformation into such;
- Analysis of modern economic and environmental problems of land use, prerequisites, trends in the dynamics of ecologically safe lands;
- Development, substantiation, coordination of the goals of the Strategy for the development of ecologically safe land use;
- Definition of directions and substantiation of tasks of Strategy with the indication of the corresponding measures of its realisation;
- Promotion, adjustment, adoption of the Strategy;
- Implementation and control.

Stages of Strategy implementation:

Stage 1 (3-5 years): conducting research on the impact of environmentally safe land use on climate change, outlining the value of land as an important component of the overall state of the ecosystem and the well-being of future generations; improving the land valuation system based on the environmental and climatic components; development of the institutional basis in the field of ecologically safe land use; formation of new and improvement of existing regulatory framework, its correlation with EU legislation and standards; coordination of interests of external and internal subjects of ecologically safe land use; increasing the investment attractiveness and innovative equipment of ecologically safe land use.

Stage 2 (5-7 years): development of ecologically safe land use taking into account ecological, economic, social needs, interests, requirements of present and future generations; motivational, state, marketing support; development of educational-scientific, personnel, working potential; development of a quality system of management, control and supervision of ecologically safe land use; development of international cooperation.

4. Tools (means) for implementing the Strategy

Monitoring;
Certification of lands;
Information and communication tool;
Information and communication platform;
Cadastral database;
Environmental audit;
Ecological examination;
Climate research;
Zoning;
Classification of lands;
Assessment of lands taking into account the ecological and climatic component;
Motivational mechanisms;
Foresight methods of development and implementation of the Strategy.

5. Strategic alternatives

The strategy of innovative ecologically safe land use – the strategy is based on improving the quality of land use through the introduction of innovative tools as an information and communication tool and information and communication platform of land relations on the formation, use and operation of environmentally safe land use.

Traditional land-use strategy – fulfilment of the existing state requirements for ecologically oriented land use, expansion of areas of ecologically safe land use, but without taking into account the ecological component in the assessment of lands and possible climatic consequences.

Strategy of intensive ecologically oriented land use – development and implementation of the latest innovative component in the field of environmentally safe land use, improvement of quantitative and qualitative indicators of land condition, implementation of changes in the regulatory framework and land valuation system.
6. Implementation and monitoring of the Strategy implementation
The task of implementing the Strategy should be assigned to the branch of executive power with representatives of the public, business structures, landowners and land users.
The task of monitoring the implementation of the Strategy should be assigned to the State Service of Ukraine for Geodesy, Cartography and Cadastre, territorial bodies of the State Geocadastre, Regional State Fertility, Ministries and agencies in accordance with the purpose of environmentally safe land use.
The results of the Strategy will be highlighted in the relevant reports on the state of the environment at all hierarchical levels.
7. Results
Improving the quality characteristics of soils (bioproductivity, humus formation), improving the state of biodiversity, groundwater;
Reducing the ingress of harmful substances into soils, water, atmosphere;
Mitigation of climate change and improvement of climate indicators;
Improving the quality of food, creating healthy living conditions;
Stabilisation and improvement of the ecological, environmental situation in the countryside, development and landscaping of rural areas;
Stopping the outflow of rural residents from the countryside, the development of self-employment, the preservation of rural settlements and rural lifestyles, the reproduction of social infrastructure, the development of inclusiveness;
Increasing the competitiveness of the country as an exporter of environmentally friendly products and services, generating income, increasing investment attractiveness;
Development of educational, innovative and research spheres in the direction of practical use, introduction of innovative methods of land use organisation and their development.

Source: author's development using (Tiutiunnyk and Kupinets, 2020. p. 28, p. 77; Bulysheva and Andryeyeva, 2018; Yermakova, 2019).

The draft strategy for environmentally safe land management development is given in Table 6 and is based on the concept of sustainable development.

Stage VI. Provides for the development of a Road map for a specific area

The Road map for the development of ecologically safe land management is developed with a *strategic goal* in mind: to improve the quality and quantity of land with ecologically oriented use, change the concept of ecological, economic and monetary valuation of land and increase the value of environmentally safe land management, effective investment and innovation activities in the field of environmentally safe land management.

The Road map reflects the priorities for developing environmentally safe land management, responsible entities, deadlines, sources of funding. The main beneficiaries of ensuring environmentally safe land management

development are the government, science, business structures, and society. Achieving a strategic goal contains the following sub-goals (figure 12).

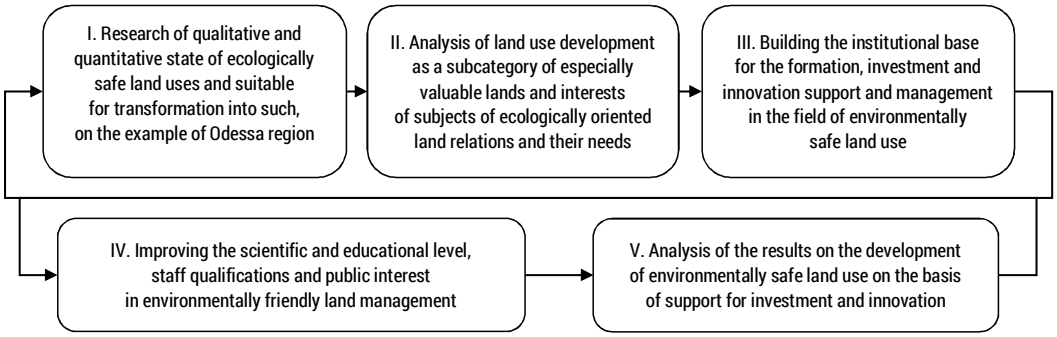

Figure 12. Sub-goals of the strategic goal of development of environmentally safe land management

Source: author's development (italics – monitoring and control of results).

Risks of the Road map implementation may include the following:

- *Environmental risks*: pollution from neighbouring areas, transboundary pollution, seismic phenomena, accelerating climate change, destruction of the general quality of ecosystems, landslides, mudslides, desertification, other extreme environmental and climatic phenomena.
- *Economic risks*: market changes, lack of economic motivational mechanisms, economic crises, low demand for environmentally friendly products and services, insufficient and uncoordinated mechanism of investment and innovation support.
- *Social risks*: rapid urbanisation, reduction of state support for research, education and innovation, insufficient awareness and environmental culture of society.
- *Technology-related risks* are associated with emergencies, man-made disasters.

The authors proposed a Road map for the leadership of the Odesa Region. This initiative is supported by the leadership of the Odesa Regional State Administration of Ukraine.

Conclusions

High-tech development of the modern world and its new opportunities opened by scientific and technical achievements and the development of information networks that allow obtaining immediate information, wide availability of modern technologies and change in the role of human resources

increases the need for greater effectiveness economic and environmental efficiency of management. It encourages the transition to an innovation-oriented path and the importance of the development of its environmentally oriented model of strategic management. However, this decision largely depends on how the implemented innovations are provided with the necessary amount of investment resources.

Statistical information and its components on ecologically safe lands are not characterised by sufficient diversity and completeness. Qualitative completeness of databases is completely absent. According to the available data, it can be determined that the share of ecologically safe territories in Ukraine of the country's total area has critically low indicators compared to the EU. Ukraine ranks 27th out of 27 countries surveyed in terms of green urban zone per capita; the percentage of the land area of the nature reserve fund from the country's total territory in Ukraine is 3.1 times smaller than in the EU. The percentage of protected areas in Ukraine is 6.77% of the territory's total area, which is much smaller than in most European countries, where the average percentage of protected areas is 21%. The reorientation of the economic system to innovation requires the involvement of the necessary amounts of both external and internal investment, different in type and form.

In the context of the current transformation of the world and domestic society on the greening of the economy at the macro-, mezo- and micro levels, the development of theoretical and methodological approaches and principles for strategic management of investment and innovation land management policy will be of particular importance.

At the same time, it should be noted that innovation and investment processes in the field of nature management should be considered comprehensively, based on logically selected and economically sound performance indicators of the entity, with due regard for a synergistic effect.

An objective relationship characterises the innovation and investment components of economic spheres. Innovation cannot achieve its goal without proper cash flow. Environmental investment is the catalyst for eco-innovation. Based on the goals and objectives of the study, the authors obtained the following scientific results:

Methodological developments and their general characteristics regarding the possibility of their use in the innovative process of planning and development of environmentally safe lands are analysed. Recommendations for their improvement are given. The choice of conducting the strategy process based on the foresight method as the main tool for identifying scientific and technical priorities is substantiated. Improving the foresight diamond as a Star (heptagram) of the foresight is proposed.

The system of strategic management in the field of ecologically safe land management is developed. The essence of strategic management of investment and innovation activities in the field of environmentally safe land management is revealed.

The importance of synergetic development of innovation and investment aspects of ecologically safe land management is substantiated. A logical-structural scheme of strategising the sphere of ecologically safe land management has been developed.

The methodological approach to the strategic management of investment and innovation activity in the field of ecologically safe land management is developed. The stages and tooling of the foresight methodology in ecologically safe land management are substantiated with the help of SMART-method indicators based on Quintuple Helix (5 helix).

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The contribution of the authors

Burkynskyi B. V. developed a strategic management system in the field of environmentally safe land management, comparative characteristics of statistical data Ukraine – EU countries.

Andryeyeva N.M. substantiated methodological approach of the study is based on the step-by-step SMART-research, economical-ecological analysis, systematic assessment of investment and innovation activities, PESTLE-, SWOT-analyzes, the definition of ecologically safe strategies.

Tiutiunnyk H.O. assessed the potential of countries and regions as a component of investment and innovation policy of land management; developed structure of strategising the sphere of ecologically safe land management, the star (heptagram) of the foresight, etc.

Andryeyeva N.M.&Tiutiunnyk H.O. developed a methodological approach of combining methods of foresight methodology in the field of environmentally safe land management, SMART-method and Quintuple Helix (5 helix) for sustainable development of methodology for strategic management of investment and innovation activities in the field of environmentally safe land management.

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LOCATION DETERMINANTS OF CITY LOGISTICS CENTRES IN THE CONCEPT OF SUSTAINABLE DEVELOPMENT

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ABSTRACT: The decision-making processes for planning an environmentally compatible infrastructure are extremely complex, as are the logistics processes themselves. The concepts for the location of urban logistics centres have been compared with the ecological danger zones in Poland. In this way, areas with a high degree of environmental degradation, particularly unfavourable from the point of view of the location of new logistics centres, were identified. The decision on the location of the planned project should be based on a previously developed, special procedure for assessing investment implementation and its impact on the natural environment. The study aims to indicate the infrastructure of city logistics centres as one of the necessary and most effective factors determining sustainable development. As a rule, infrastructure can be created in two ways. The first one recommends building the enterprise and then its infrastructure, while the second one recommends the opposite approach. From the point of view of the infrastructure of sustainable development, the second approach seems appropriate, allowing for the effective implementation of the sustainable development strategy. The first approach may only lead to a decline in the meaning of sustainable development in mentality and social awareness (Ratajczak, 2000). The variety of approaches in the literature on the subject defining the concept of sustainable development infrastructure covers both the area of economy, society and the environment. Significant from the point of view of future generations seems to be the environmental aspect related to the creation of urban logistics centres in the era of sustainable development. One of the essential properties of the natural environment is equilibrium, which occurs when the outflow and supply of energy and matter in nature are balanced. The natural environment is in constant interaction with humans; to prevent its gradation, measures are taken to prevent damage to the physical environment or natural resources. There are also activities to reduce the risk of losses or encourage the efficient use of natural resources, including measures to save energy and use renewable energy sources (Tokarski, 2020).

KEYWORDS: infrastructure and environment, logistics centres, sustainable development

Introduction

One of the leading development trends of logistics centres is the development of city logistics. The more common clusters of distribution centres can facilitate the management of supplies related directly to the supply of residents and enterprises, using the planning and optimisation of logistics processes. There is no uniform definition of City Logistic as it covers various economic, ecological or environmental aspects. The concept of City Logistic is understood as a collective concept for many concepts of urban freight transport; it describes all activities related to the creation, control and optimisation of the flow of goods and information in industrial zones. The objectives of all these concepts focus on relieving the internal urban infrastructure as well as increasing the cost-effectiveness of urban freight transport while maintaining the same quality of supply. The bundling of different freight channels is one concept that is being attempted in freight centres.

One of the modern solutions that use new organisational forms to improve processes is logistics centres. A logistics centre that is an independent business entity that provides logistic services (transport, reloading, storage, distribution and picking of loads) generally has:

- separate area and infrastructure (roads, squares, parking lots, engineering structures and buildings),
- technological equipment for movement and storage as well as management (control) devices,
- qualified personnel,
- an organisation appropriate to the type and size of the logistic task.

The main goal of building and organising logistic centres in the economy is to: dispose of specific material goods, in the necessary quantity, in the desired place, at the right time and at the lowest possible cost.

This goal is achieved by the following functions of logistics centres (Jędra, 2011):

- reloading of transfer goods from many suppliers,
- storage of goods from many suppliers and intended for many recipients,
- distribution and completion of loads intended for multiple recipients,
- transport of goods, usually small recipients,
- many auxiliary functions (processing, packaging, repair).

Due to various types of logistics centres in countries leading in economic development, the article focuses on those that fulfil distribution functions in the logistics chain. As there are no logistic centres of European significance in Poland yet, you can choose from the solutions developed in the European Union countries with greater freedom. It is necessary to establish not only centres of national importance but also to create 2-3 centres of European

importance, constituting the distribution base for many important products in the neighbouring countries (Skowron-Grabowska, 2010).

The concept of Polish logistics centres should be linked to what is happening in neighbouring countries. It should be closely related to the combined and multimodal transport system, the development of the express service network, and the optimisation of warehouse locations. It's time to depart from the current practice of organising local centres for individual branches, namely: creating combined transport terminals on railway areas, bases of road transport services on highways, specialised bases in sea or river ports. The future belongs to logistics systems based on centres located in one place. The best location is, of course, in places with easy access to various international communication arteries (road, rail, water, air) with high capacity (Lipińska-Słota, 2009).

Legal and environmental requirements for the implementation of the investment

Logistics centres, both during the construction phase and later during operation, will significantly impact the surrounding natural environment. Therefore, before making a construction decision, an indispensable part of the prepared project should be an ecological analysis performed on the same principles as economic, financial or technical analyses. Therefore, it is necessary to develop a procedure for checking each project in terms of its potential environmental impact. In the first stage, all data on the planned activity should be collected, including data on ecological aspects. They will be used in the next stage when classifying the planned project according to the lists of activities depending on the degree of an environmental hazard. During the next step, you should get answers to the following questions:

- What might the impacts be, and how significant?
- What measures could be proposed to reduce the negative effects of the impact?
- What are the possible recommendations?
- Does the planned project meet ecological standards resulting from national, international or other legal regulations?
- Are there any possibilities to reduce the harmful effects of the planned project?

It is an essential part of the procedure and should consequently lead to a document containing all the data relevant to the project. It must also answer whether the effects of the activity are acceptable or not. The next step is an ecological inspection to check whether the agreed conditions are met, leading to creating a compliance document. It also includes potential comments

and conclusions. This document is the basis for possible ecological monitoring after the facility is commissioned.

Such environmental impact assessment procedures, usually more extended, are required, for example, when concluding credit agreements with the European Bank for Reconstruction and Development, which "supports in all its activities environmentally friendly and sustainable development". In addition, local authorities often request comprehensive research on the impact of new investments on the natural environment of areas earmarked for new infrastructure and various organisations, especially ecological ones, under the sign of "Greenpeace". Accurate information on the environment and the effects of human activities is very important. It is the basis for creating, implementing, monitoring, and enforcing legal regulations and environmental policy. They also constitute the basis for public participation in the decision-making process on environmental protection and, consequently, strengthen democratic institutions.

The association of Poland with European Communities and their member states obliges the Polish side to adjust the law, including the law in environmental protection, to the EU requirements. The Union has published relevant legal acts in environmental protection in the so-called "White Book" in the form of directives, regulations and decisions (Ogonowska, 2003).

After the adoption of the first Act on the protection and shaping of the environment on January 30, 1980, there was a legal basis for a comprehensive assessment of the state of the environment throughout the country. The draft of the new economic plan for the years 1983-1985 and the spatial development plan of the country until 1995, which was prepared at that time, gave rise to the need for a comprehensive approach to this assessment in spatial terms. Work on the development of the spatial diagnosis of the state of the environment was undertaken by the Planning Commission at the Council of Ministers, and its contractor was the National Spatial Development Team (Kassenberg and Rolewicz, 1985).

The areas of ecological threat were introduced in Appendix No. 4 to Resolution No. 21/83 of the Council of Ministers on the draft of the National Social and Economic Plan for the years 1983-1985. Every year, until 1994, the validity of the then introduced delimitation was extended.

The purpose of designating such a category of areas was to distinguish areas with a high concentration of threats and to accurately recognise the state of the environment and the need for measures to protect it (due to limited resources) in order to contribute to stopping further degradation in these regions of the country, and then start the process of restoring them required environmental quality. The diagnosis included:

- state of water hazard and protection,

- state of protection of the earth's surface and its resources,
- state of danger and air protection,
- condition of forests,
- the state of conservation of nature and landscape.

The assessment was performed using the cartographic method, consisting of the mutual overlaying of state maps of individual elements of the environment and drawing conclusions for the spatial synthesis of the discussed phenomenon. The basic criterion for classifying an area as an endangered area was:

exceeding the permissible normative states of at least two elements of the environment, or

multiple or particularly troublesome (toxic) exceeding the permissible normative state of one element.

Based on the analysis at that time, the following were distinguished:

1. Ecological threat areas (OEZ), that is 27 areas of threatened ecological balance.
2. Areas of conservation nature and landscape protection with a disturbed natural balance – 23 National Parks.
3. Health resorts in danger of losing their medicinal values due to the disturbance of the natural balance – 23 Spas.

The result of classifying an area as ecological threat areas were clear restrictions formulated in the NPSG 1986-1990 Project as prohibitions:

- localisation of new and extension of the existing environmentally noxious facilities of the Agricultural Plant and in protected areas;
- locating new and expanding large industrial investments (employing over 200 people) in the distinguished agglomerations (Gdansk-Gdynia, Warsaw, Lodz, Katowice, Cracow);
- location of new water-absorbing facilities and facilities that discharge onerous sewage in the southern and central part of the country.

After environmental threats are placed on the map of Poland, there is clear zoning of the distribution of the endangered areas (Prystrom, 2013).

- Zone 1. The zone of integration of ecological danger zones, located in the southwest and south of the country, where the different areas are or overlap. The strategy of operation in this zone should be based on total protection of the environment, to which all socio-economic decisions must be subordinated.
- Zone 2. Bipolar coastal and sea risk zone, from Szczecin to Gdansk. The strategy for the operation of this zone should be based on the activities of the entire country to protect the Baltic Sea, as a significant amount of pollution comes from the country's interior.

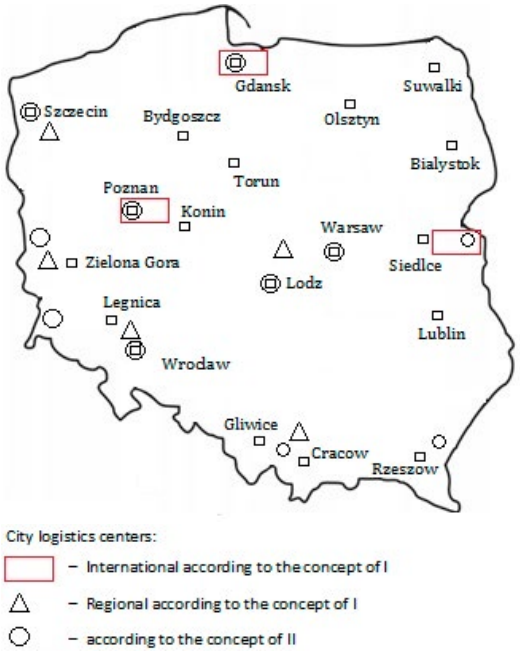

Figure 1. Regions of the location of logistics centres in Poland

Source: author's work.

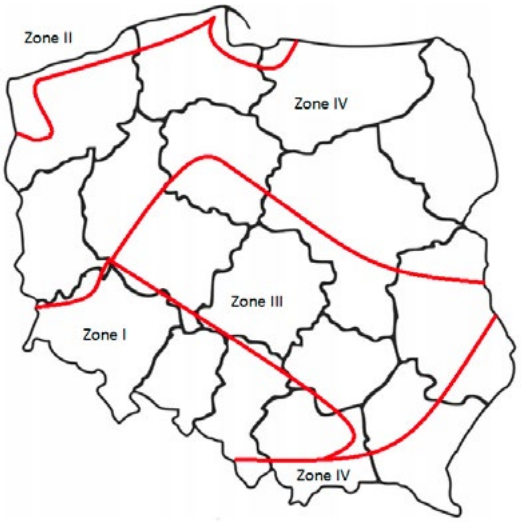

Figure 2. Ecological danger zones in Poland

Source: author's work.

- Zone 3. Dispersed OEZ in Western, Central and Eastern Poland. As threats are local, actions may consist in overcoming local threats and barriers to development.
- Zone 4. No OEZ, covering the north, north-east and south-east of the country. This zone requires, first of all, protection against the spread of pollution and threats to this area.

In 2018, the areas of ecological threat covered 35,208 km^2 (a total of 11.3% of the country's area), and 13.3 million people lived there, i.e. 34.5% of the country's population. Out of these 27 areas, 4 were considered to be extremely degraded areas; they are Upper Silesian Industrial District, Legnica Industrial District, Cracow City Complex, Bay of Gdansk and Zatoka Pucka (Czarnecki et al., 2020).

For several years, the largest program financed by the Funds, the Infrastructure and Environment program 2014-2020, has been implemented in Poland and the European Union. The areas of support and the types of projects that can be implemented relate to low-emission economy, environmental protection, counteracting and adapting to climate change, transport and

energy security, and protection of health and cultural heritage (Infrastructure and Environment Program, 2021). Thanks to the balance between investment activities in infrastructure and support aimed at selected areas of the economy, the program is to effectively implement the assumptions of the Europe 2020 strategy, with which its main goal is related – supporting the economy that uses resources efficiently and is environmentally friendly, and fosters territorial and social cohesion (Zalewska, Świetlikowski, 2017).

Concepts for the location of urban logistics centres in Poland and risk areas

Choosing the right location for a logistics investment should be preceded by a detailed analysis of a given region's potential. The construction plan is always associated with access to strategic road routes that connect the largest agglomerations in the country. City logistics centres enable the creation of optimal warehouse facilities in the supply chain of potential contractors, near industrial centres, with access to experienced employees, in the immediate vicinity of the most important communication nodes.

The location of logistics centres for the territory of Poland is closely related to the existing and planned transport corridors, which are connected with international transit routes located in Poland, running towards Eastern Europe and Asia. The construction of highways without suitable distribution sites would only create channels for the transfer of goods from abroad, thus not including Poland in the economic network of Europe, with transport directed primarily at its eastern partners. The location of logistics centres also depends on the development area and the radius of the cooperation.

Concerning Polish conditions, we can distinguish Logistics Distribution Centres (Kott, 2012):

- international (with an area of 100-150 ha and a range of 500-800 km),
- regional (with an area of 20-50 ha, range 50-80 km),
- local (with a development area of 10 ha and a range of 5-8 km),
- industry,
- indirect.

In the proposed concept (a concept I), the necessary minimum seems to be the establishment of 4 centres of the highest rank in Poland, International Logistic Distribution Centres in the vicinity of Poznan, Gdansk, Siedlce and Rzeszow. However, it must be admitted that their construction will require a lot of effort on the part of the central authorities of the country and the clear help of the EU partners. In addition, Regional Logistics Distribution Centres are needed in the region of Szczecin, Zielona Gora, Wroclaw, Cracow and Lodz (Jędra, Borowiak, 2010). The presented proposal for the location of logistics

distribution centres in Poland (figure 1) does not have to be treated as the only concept, but it is supported by Poland's new tasks that appeared when opening the trade borders between Western and Eastern Europe.

A similar concept (concept II) lists 11 areas (figure 1) where logistics centres of prime importance should be located, without indicating regional and broader international. As they require huge investments (over US $ 7 billion), one experimental region should be selected as a testing ground where the construction of a logistics centre could be started with the prospect of including it in the European network of logistics centres. Due to its location near important communication routes and economic activity, the Poznan agglomeration seems to be such a region. Simultaneously with the creation of this main centre, sub-centres of the lower level could be created in other regions (Budner, Pawlicka, 2020). As mentioned before, 2 or 3 centres of international importance should be created. When comparing the two concepts, it can be seen that opinions are divided when it comes to the number of logistic centres of the highest rank in Poland.

The concept of urban logistics centres was created in conjunction with the development of urban logistics, which is a tool for solving problems of the functioning of highly urbanised areas – microregions such as urban agglomerations. It consists of taking a comprehensive look at freight traffic in cities. It covers considerations related to supply, waste disposal, as well as problems arising from air pollution, noise, accidents and traffic jams. Its aim is to reduce traffic congestion in city centres with unchanged transport efficiency. The partners of this concept are, on the one hand, retail companies and logistics service companies, and, on the other hand, municipalities (districts) that define the framework conditions. Such urban logistics centre concepts can be realised by creating a distribution centre on the outskirts of cities with convenient access. They are supplied by various producers whose products are intended for individual recipients. Merchandise distribution centres can also cooperate with a larger number of service providers. Due to the concentration, commercial enterprises located in city centres are efficiently supplied by a smaller number of vehicles, thanks to which, at the same time, environmental relief is achieved (Kryś, 2019).

The location and shaping of logistics centres require in-depth pre-design studies and considering many criteria related to location, spatial and functional development, infrastructure, information flow, and financial possibilities. It should be emphasised that the overriding criterion in relation to the above-mentioned ones is in compliance with ecological requirements.

The logistics centres will significantly impact the environment during the construction phase and during future operations. The main risks will be air pollution, noise, vibration and waste. An important area with a significant

impact on environmental pollution is the transport system and road and air transport. It consumes non-renewable energy and causes more pollution than industry. Internal combustion engines emit many substances harmful to the environment, such as carbon monoxide, hydrocarbons, nitrogen oxides, soot, sulfur dioxide, lead compounds, etc. Transport, especially road transport, is also one of the most onerous noises and vibration sources. Despite causing noise at higher levels, air and rail transport are assessed as less burdensome than road traffic because their impact affects a relatively smaller number of people living near airports or in areas along railway lines. However, the vicinity of logistics centres will become very onerous areas in this respect due to the increase in traffic intensity and its continuity (round-the-clock transport). The functioning of logistics centres can be compared to the functioning of small towns. Therefore, there is the problem of waste as well as the problem of wastewater treatment. Some centres, especially those with hazardous materials or larger amounts of various fuels, will pose an environmental problem. All these factors, as well as many others, must be taken into account and are very important elements in the design of logistics centres, as well as arguments "for" and "against" when designating sites for their construction.

The comparison of the concept of the location of centres (figure 1) with the ecological threat areas (figure 2) made it possible to distinguish those places on the map of Poland where the degradation of the natural environment is far-reaching and which are particularly unfavourable from the point of view of the location of logistics centres. These are mainly the vicinity of Cracow and Wroclaw located in the first danger zone, then Gdansk and Szczecin from the second zone, and then the vicinity of Lodz and Poznan lying in the third zone. Therefore, when deciding on the location and shaping of the centres, the situation should not worsen and be in line with the European Union's environmental protection requirements.

Conclusions

The concept of sustainable infrastructure is developing. While traditionally, it has been associated with environmentally friendly or green infrastructure, it is becoming more noticeable and obvious in other, non-environmental dimensions. To summarise the considerations on the effective creation of sustainable development infrastructure, it should be shaped in harmony with nature, in order to ensure the continuity of the biosphere's most important processes and to maintain the environment in a state that provides optimal conditions for human existence. The degree of infrastructure development determines whether a given economy will retain or attract new foreign

capital and whether a qualified workforce capable of generating technical progress will remain in a given country or seek more favourable work and development conditions in other countries. The basic goal of the development of each area is to provide its inhabitants with the highest possible standard of living. This is related to the pursuit of infrastructure investments, new economic entities and jobs, as well as goods and services that meet the needs of members of the local community while preventing or counteracting the harmful effects of human activity on the natural environment (Burchard-Dziubińska et al., 2014).

The role of logistics centres is to create conditions for the efficient flow of materials, mitigate and eliminate the disadvantages that logistics activities have on its environment, and support and initiate positive trends and tendencies in the development of business activities, elementary (but not only) in the area of logistics. Currently, the location and development of logistic investments of the City Logistic type is considered a tool that allows to increase the efficiency of logistics processes, the level of customer service, create quality in supply chains and reduce logistics costs. Logistics centres are also considered to be a significantly effective way to restructure areas in the downturn phase – they are treated as investments reviving the local economy and attracting new businesses. One of the most characteristic development trends of logistics centres is the development of city logistics – concentration of distribution resources in one place will in principle facilitate the management of supplies related to the supply of individuals, as well as companies within these agglomerations – by planning and optimising logistics processes.

Choosing the right location for a logistics investment should be preceded by a detailed analysis of a given region's potential. The construction plan is always associated with access to strategic road routes that connect the largest agglomerations in the country. Panattoni logistics centres enable the creation of optimal warehouse facilities in the supply chain of potential contractors, near industrial centres, with access to experienced employees, near the most important communication nodes.

The location of logistics centres for the territory of Poland is closely related to the existing and planned transport corridors, which are connected with international transit routes located in Poland, running towards Eastern Europe and Asia. The construction of highways without suitable distribution sites would only create channels for the transfer of goods from abroad, thus not including Poland in the economic network of Europe, with transport directed primarily at its eastern partners. The location of logistics centres also depends on the development area and the radius of the cooperation. The ability of transport companies to provide high-quality services is of signifi-

cant importance in the case of decisions regarding the location of a new transport and warehouse investment in Poland.

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ECO-INNOVATION DEVELOPMENT IN SELECTED EUROPEAN AND ASIAN COUNTRIES: A COMPARATIVE ANALYSIS

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ABSTRACT: The development of eco-innovation is driven by globalisation processes, technological progress and climate change. It is also directly related to the pursuit of sustainable development, as well as to the reduction of negative impacts on the environment and the efficient use of natural resources. Monitoring progress towards sustainable development requires the systematic measurement of eco-innovation. An important theoretical and practical challenge is to develop methods and indicators to measure eco-innovation. Currently, there are different systems for measuring eco-innovation, which makes international comparative analysis difficult. This article aims to conduct a comparative analysis of the development of eco-innovation in selected European and Asian countries. The study uses a critical literature review as well as a comparative analysis and synthesis method based on the ASEM Eco-Innovation Index. The study provides evidence that there are a number of differences in eco-innovation between European and Asian countries. Measuring eco-innovation is particularly important in planning and implementing instruments to stimulate environmental innovation across countries.

KEYWORDS: eco-innovation, measuring, indicators, ASEM Eco-Innovation Index

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Introduction

The increasing role of sustainable development forces the need to change the current model of socio-economic development to a more sustainable one. These development trends are a priority not only in the activities of the United Nations (UN) or the Organization for Economic Cooperation and Development (OECD, 2012) but also in the politics of other organizations, such as the European Union, Asia Society, African Union.

The implementation of sustainable development is associated with a fundamental change, considering a systemic and integrated interdisciplinary approach (Borys, 2011, Poskrobko, 2013, Famielec and Famielec, 2016). Sustainability efforts require the integration of short and long term economic, social and environmental goals in line with the current global Sustainable Development Goals (SDGs) strategy (United Nations, 2015). These actions are reflected, among other things, in combating climate change and promoting a low-carbon and resource-efficient economy. In the face of current global challenges, it is necessary to take action for sustainable development, especially in terms of sustainable economic development, social progress and environmental protection.

Eco-innovation plays a particularly important role in supporting sustainable development, which are seen not only as a catalyst for facilitating these changes, but also as a key element of policies and activities for sustainable development (Cai and Li, 2018, Akiner et al., 2019). The overall objective of eco-innovation is to reduce negative environmental impacts, to create new market opportunities, products, services or processes focused on improving environmental performance (e.g. saving energy and other resources and reducing pollution and waste) (OECD, 2009). Green innovation is a type of innovation that can not only benefit consumers and businesses, but also significantly reduce negative environmental impacts. Eco-innovation is defined as the introduction of any new or significantly improved product, process, organizational change or marketing solution that reduces the consumption of natural resources (including materials, energy, water and soil) and reduces emissions of harmful substances throughout its life cycle (Donis et al., 2021, Díaz-García et al., 2015). In all cases, the producer and the consumer play an important role in the successful diffusion of eco-innovation.

Eco-innovation is, therefore, an important area of business competitiveness and directly affects financial returns; however, its scale and implementation depend on, among other things, the industry, legislation and standards, as well as consumer sensitivity and environmental awareness (Horbach et al., 2012, Triguero et al., 2013, Urbaniec, 2016). Their implementation aims not only to reduce negative environmental impacts but also to decrease

material and energy costs to increase competitiveness (Porter and Van der Linde, 1995). Despite the numerous and varied definitions found in the literature, eco-innovation can also be defined as innovation that leads to an improvement in environmental quality and has been implemented to increase the environmental performance of enterprises (Díaz-García et al., 2015).

Despite growing interest in eco-innovation, it is still a relatively under-researched area. Above all, it lacks a widely accepted definition and a coherent theoretical concept (Urbaniec et al., 2021, Türkeli and Kemp, 2018). Furthermore, there is no standard approach to measuring the effects of eco-innovation. In turn, the availability and quality of environmental data vary from country to country and region to region. Considering eco-innovation at the macroeconomic level, it should be pointed out that in practice and the literature, there are different theoretical approaches for measuring and analyzing eco-innovation, e.g. for European countries and for Asian countries. This is also linked to countries' efforts to achieve sustainable development, as well as to reduce negative environmental impacts and use natural resources efficiently. Monitoring progress towards sustainable development requires the systematic measurement of eco-innovation (Park et al., 2017). Therefore, an important theoretical and practical challenge is to develop methods and indicators to measure and analyse eco-innovation at the macroeconomic and microeconomic levels.

The aim of this article is to conduct a comparative analysis of the development of eco-innovation in selected European and Asian countries. The main research question is what difficulties or advances in eco-innovation exist in selected European and Asian countries? The method used was a critical literature review as well as a comparative analysis and synthesis method based on the ASEM Eco-Innovation Index. This analysis provides a comprehensive overview of the developments of eco-innovation development based on the same methodology. The study contributes to the literature on measuring eco-innovation performance by analysing the determinants of eco-innovation in different countries.

The paper is organized as follows: The next section presents the analytical framework for measuring eco-innovation. Section 3 deals with the research methodology, including data collection and analysis methods. Subsequently, the research analysis results are presented, focusing on the eco-innovation progress of Asian economies based on the indicators of the ASEM Eco-Innovation Index. The final section summarizes the main results of the analysis, provides a discussion and identifies directions for future research.

Literature review

Eco-innovation is the subject of various theoretical approaches. There is no single universally accepted definition of eco-innovation in the literature, and existing concepts differ in their research scope (Türkeli and Kemp, 2018). Eco-innovation is characterised by much greater variation than traditional innovation, as they are often based on technical processes (environmental technologies), and their effects are usually unpredictable. Many definitions of eco-innovation in literature and economic practice vary in scope and degree of detail. Generally, they are concerned about innovations that bring benefits to the environment.

Eco-innovation first became the subject of research already in the late 1970s (Urbaniec, 2015). A broader definition of eco-innovation was formulated in the second half of the 1990s and includes "all measures of relevant actors (firms, politicians, unions, associations, churches, private households) which; develop new ideas, behavior, products and processes, apply or introduce them and which contribute to a reduction of environmental burdens or to ecologically specified sustainability targets" (Rennings, 2000). Eco-innovation is not limited to innovations in products, processes and marketing methods but also includes innovations in social and institutional structures. Eco-innovation is, therefore, not necessarily a global novelty or the result of a deliberate business activity or strategy (Arundel and Kemp, 2009). It can therefore be argued that any innovation that contributes to environmental benefits over relevant alternatives is an eco-innovation (e.g. environmental technologies, organisational innovations, product and service innovations and green system innovations) (Arundel and Kemp, 2009, Türkeli and Kemp, 2018, OECD, 2009). A similar definition has been used for the Eco-Innovation Scoreboard (Eco-IS) developed by the Eco-Innovation Observatory (EIO) in the European Union. According to the EIO, eco-innovation is defined as any form of innovation aiming at significant and demonstrable progress towards the goal of sustainable development, either by reducing environmental impacts or achieving more efficient and responsible use of resources, including both intended and unintended environmental consequences of innovation, as well as not only environmental technologies but processes, systems and services (EIO, 2013).

The Eco-innovation Scoreboard (Eco-IS) provides an overview of EU Member States' eco-innovation performance. It aims to measure different aspects of eco-innovation by using 16 indicators grouped into five dimensions: eco-innovation input, eco-innovation activities, eco-innovation output, resource efficiency outcomes and socio-economic performance (Arundel and Kemp, 2009, Bernard et al., 2020, Colombo et al., 2019). The Eco-IS score

enables the identification of the strengths and weaknesses of eco-innovation in each EU country. By promoting a holistic view of economic, environmental and social performance, the Eco-IS complements other approaches to measuring country innovation, such as the Global Innovation Index (Bernard et al., 2020).

Regarding the growing role of eco-innovation, especially in the context of the global SDGs, various organisations are making efforts to measure eco-innovation. While measurement of eco-innovation at the OECD and EU levels are rather frequently explored (Colombo et al., 2019, Wegrzyn, 2013, Pakulska, 2018), however, methodologies developed for Asian countries are relatively rarely examined (Park et al., 2017). Given the different existing methodologies, there are difficulties in comparing European and Asian countries.

Therefore, this study focus on analysing indicators for European and Asian countries based on the ASEM Eco-Innovation Index (ASEI), which was developed by the ASEM SMEs Eco-Innovation Center in the Republic of Korea (Park et al., 2017, Jang et al., 2015, Jo et al., 2015). The ASEM Eco-Innovation Index shows how well individual countries are performing in the various dimensions of eco-innovation and enables analysis of their strengths and weaknesses (Park et al., 2017). The ASEM Eco-Innovation Index aims to promote a holistic view of economic, environmental, and social performance. However, ASEI has limitations in measuring indicators due to limited data availability in Asian countries.

The development of a research methodology to measure eco-innovation has been the focus of many researchers (Triebswetter and Wackerbauer, 2008, Arundel and Kemp, 2009, Horbach, 2016). This contributes to the search for new measurement tools in economic practice. However, few studies have examined eco-innovation at the national level, but most have been conducted in developed countries (i.e. European countries), excluding Asian countries (Jo et al., 2015). Considering this research gap, focusing on eco-innovation based on the methodology used in the ASEM Eco-Innovation Index may provide an opportunity to compare the level of eco-innovation in Europe and Asia.

Eco-innovation plays a particularly important role in supporting sustainable development, which are seen not only as a catalyst for facilitating these changes (Urbaniec, 2015, Smol et al., 2017, Colombo et al., 2019), but also as a key element of Asian countries' policies for sustainable development (Cai and Li, 2018, Akiner et al., 2019). Although many countries are taking various steps to achieve the 17 SDGs by 2030, overall progress in Asian countries is rather slow. There has been relatively little progress in reducing inequality, promoting responsible consumption and production or achieving peace, justice and strong institutions. Advances on gender equality and building sus-

tainable cities and communities are also insufficient. Therefore, greater support is needed to significantly accelerate progress or reverse trends on most of the 2030 Agenda's environmental targets (UN ESCAP, 2020). Asian countries have already taken significant steps in some areas. For example, the region's total renewable electricity capacity has increased nearly fivefold since 2000, faster than any other region in the world. In addition, there are specific conditions in each country resulting from the applied economic instruments used and the historical path of industrial development.

The literature review on the theoretical approaches to measuring and analysing the effects of eco-innovation shows that there is no uniform method of measurement and indicators. The specificity of the methods and the level of detail require appropriate adaptation to the particular case. However, it should ensure comparability of the results of eco-innovation activities. The difficulty of measuring eco-innovation effects lies additionally in the fact that they are associated with uncertainty in eco-innovation effects. By measuring eco-innovation at the national level, comparisons between countries can be made, and environmental policies can be fostered. This is particularly important in planning and implementing instruments to stimulate eco-innovation across countries (Donis et al., 2021). Measuring eco-innovation also contributes to a better understanding of overall sustainability trends and raises public awareness of environmental management.

Research methods

This study focuses on conducting a comparative analysis of the development of eco-innovation in selected European and Asian countries. The research made it possible to answer the research question: what difficulties or advances in eco-innovation exist in selected European and Asian countries? For this study, annual data for 2016-2018 were used that describe the ASEM Eco-Innovation Index. The ASEM Eco-Innovation Index covers both ecological, economic and social aspects. Therefore, a comprehensive tool for measuring eco-innovation in ASEM member states was constructed. In addition, the ASEM Eco-Innovation Index includes input-based indicators measuring the outlays of innovative processes and output-based indicators that test the results of innovative activities (Albino et al., 2014). It is equally important to include the impact of eco-innovation in the ASEM Eco-Innovation Index (Park et al., 2017). The ASEM Eco-Innovation Index includes a total of 19 different indicators, which have been grouped into 4 components (ASEIC, 2018):

- Eco-innovation Capacity,
- Eco-innovation Supporting Environment,

- Eco-innovation Activities,
- Eco-innovation Performance.

All these indicators are measured by different indicators on social, economic and environmental issues (table 1).

Table 1. Components and indicators of ASEM Eco-Innovation Index

Component	Indicators
Eco-innovation Capacity	1. Potential to improve national competitiveness 2. General innovation capacity of nation 3. R&D Capacity for Environmental Science 4. Number of Researchers in Environmental Science 5. Awareness level of company`s sustainable management
Eco-innovation Supporting Environment	1. Government expenditure on green R&D 2. Impacts of environmental regulations on corporate competitiveness 3. Corporate priority level of sustainable development 4. Generation Capacity of Renewable Energy
Eco-innovation Activities	1. Number of companies with green technology 2. Participation level in environmental management 3. Industry-academic cooperation on environmental R&D 4. Share of Green patents 5. Level of renewable energy distribution
Eco-innovation Performance	1. Quality of life related to environmental impacts 2. Greenhouse gas emission intensity 3. Environmental sustainability level 4. Employment rate in green technology industry 5. Green Industry Trade Market Size

Source: ASEIC (2018).

Components will be discussed in the next section. However, it is worth noting that these four components highlight the complexity of eco-innovation as they describe the inputs, outputs and impacts of eco-innovation (Park et al., 2017).

The data for the analysis concerns the five Asian countries and five European countries that are members of ASEM (Asia-Europe Meeting), which is an intergovernmental partnership of member countries from Asia and Europe. The analysis covers the following countries: Japan, New Zealand[1], Singapore, Australia, the Republic of Korea, Norway, Denmark, Sweden, Switzerland and Germany. These are leading European and Asian countries in eco-innovation. The research timeframe was selected due to the availability of the data. The ASEM Eco-Innovation Index has been continuously developed since 2012, but not all ASEM member countries were included initially.

[1] Australia and New Zealand belong to the geographical region of Oceania, while under ASEM they are classified as Asian countries.

Hence, when comparing the eco-innovation level in European and Asian economies, data for 2016-2018 based on the ASEM Eco-Innovation Index was used.

The study employed the following research methods: a literature analysis and critique, comparative analysis method and synthesis method. Through the use of comparative analysis, the study offers a qualitative perspective on the current achievements in the implementation of eco-innovation. It contributes to the debate on eco-innovation in Asian countries. Based on the ASEM Eco-innovation Index data, the analysis provides a comprehensive overview of changes in the development of eco-innovation in selected Asian countries. In order to assess the quality of the research, the choice of research methods in the article was determined by meeting two research criteria: reliability and validity. These criteria were provided using publicly available secondary data on the eco-innovation index for Asian countries.

Results of the research

A comparative analysis of the main components based on the ASEM Eco-Innovation Index will be conducted to investigate the strengths and weaknesses of eco-innovation development in selected European and Asian countries. At the first stage, the Eco-innovation Capacity component was analysed in 2016-2018 in Norway, Denmark, Sweden, Switzerland, Germany, Japan, New Zealand, Singapore, Australia and the Republic of Korea. Based on the figure below, it can be observed that this component has higher values in European countries compared to the Asian countries included in the analysis. Germany is an exception, although the share of the potential to improve national competitiveness (measured by WEF Global Competitiveness Index) and the general innovation capacity of nation (measured by INSEAD Global Innovation Index) was relatively high (Schwab, 2018, Dutta et al., 2019). Switzerland's position, in turn, is a result of its high position in terms of both indicators mentioned above. It is also indicated that Switzerland should be considered as the country with the highest eco-innovation capacity among ASEM Member States (Becker et al., 2021). In the case of Asian countries, the leading position of Australia can be observed, even though it ranks relatively low in terms of both the potential to improve the country's competitiveness and the general innovation capacity. The measurement of this component is hampered by the other three indicators and the scoring method adopted for them. Moreover, it is worth noting that in previous years other indicators were also used to measure Eco-innovation Capacity. It is therefore difficult to clearly assess the difficulties and progress of the analysed countries with regard to the first component.

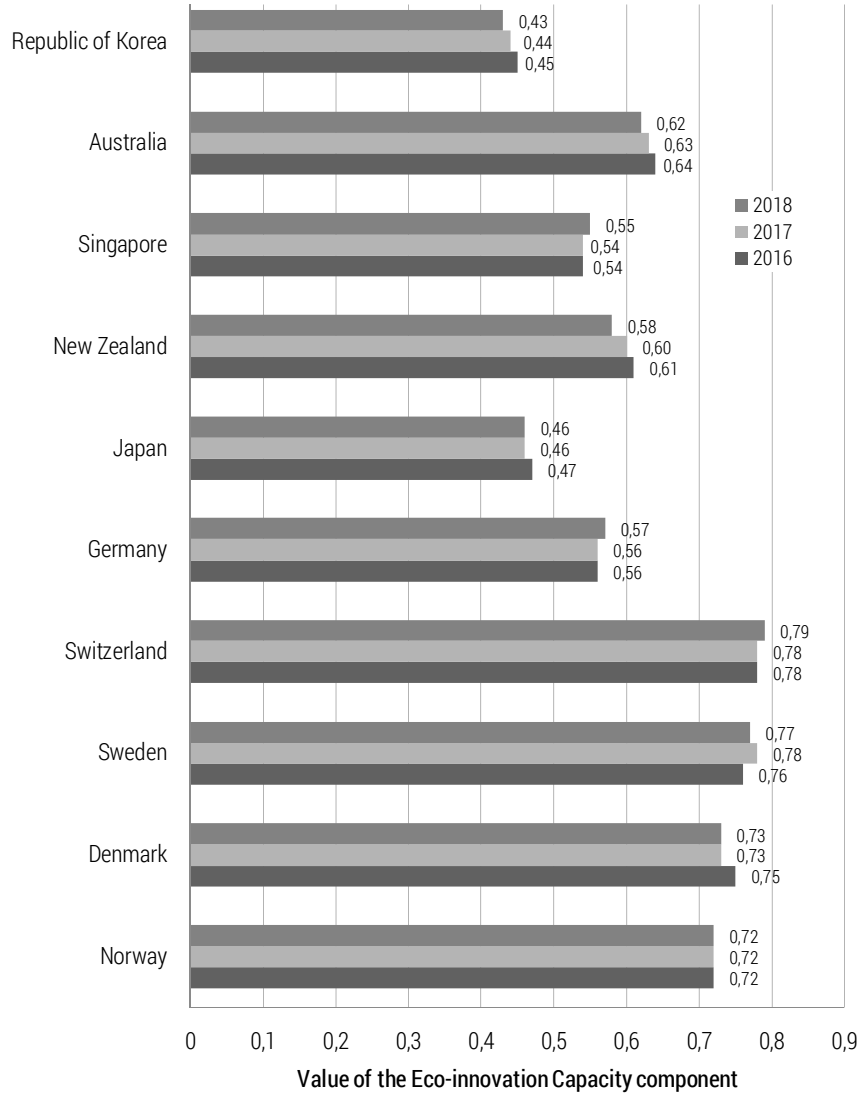

Figure 1. Eco-innovation Capacity component in selected countries in years 2016-2018
Source: author's work based (ASEIC, 2018).

Similar difficulties are encountered in assessing the Eco-innovation Supporting Environment component, which focuses more on institutional factors. The impact of environmental regulations on the competitiveness of enterprises and the corporate priority level of sustainable development indicators was adopted as the scoring method for the IMD survey index value. The lack of an up-to-date ASEIC database makes it difficult to both track progress and country-specific difficulties in implementing this component. From

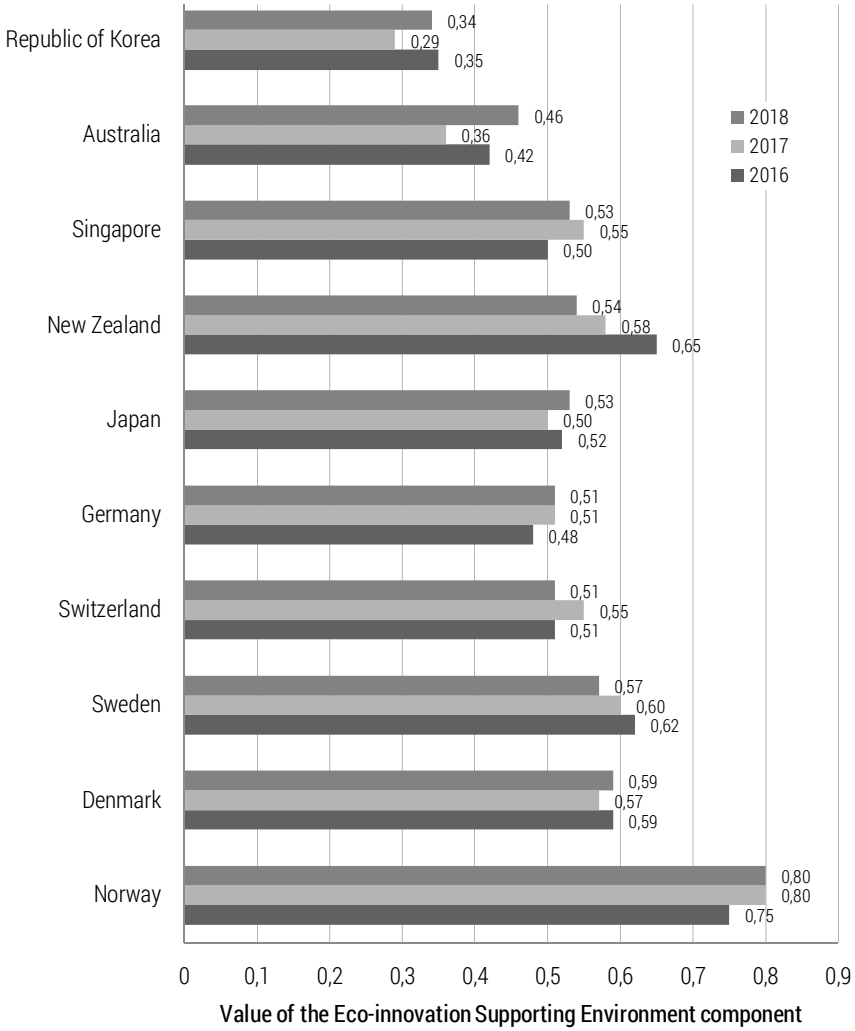

Figure 2. Eco-innovation Supporting Environment component in selected countries in years 2016-2018

Source: author's work based (ASEIC, 2018).

the countries analysed, it appears that the Eco-innovation Supporting Environment component achieved the highest values in 2016-2018 in Norway, followed by New Zealand (figure 2). Norway's high performance was influenced by its renewable energy policy as well as the high share of the generation capacity of renewable energy indicators (Egging and Tomasgard, 2018). New Zealand has also taken a number of steps to transform the energy sector and develop renewable energy to achieve ambitious goals in this regard (Verma et al., 2018).

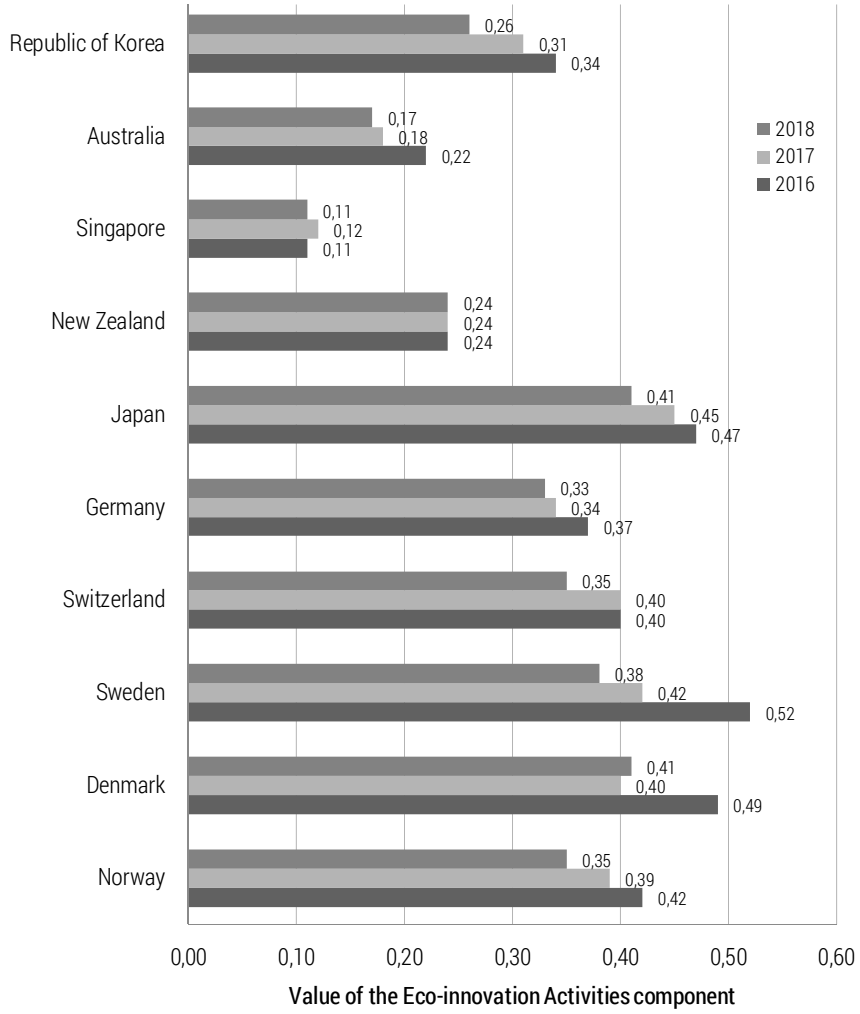

Figure 3. Eco-innovation Activities component in selected countries in years 2016-2018
Source: author's work based (ASEIC, 2018).

All the analysed countries achieved the lowest values in the Eco-innovation Activities component among all 4 components of the ASEM Eco-Innovation Index. The highest values in 2018 were recorded by Japan and Denmark (figure 3). Japan's leading position was due to the relatively high share of participation level in the environmental management indicator (World Bank, 2021). Japan also has a very good result in the number of companies with green technology indicators, measured as the number of companies with patent applications for the past five years (WIPO, 2018). In addition, Japan, along with the United States, China, the Republic of Korea and Germany, is among

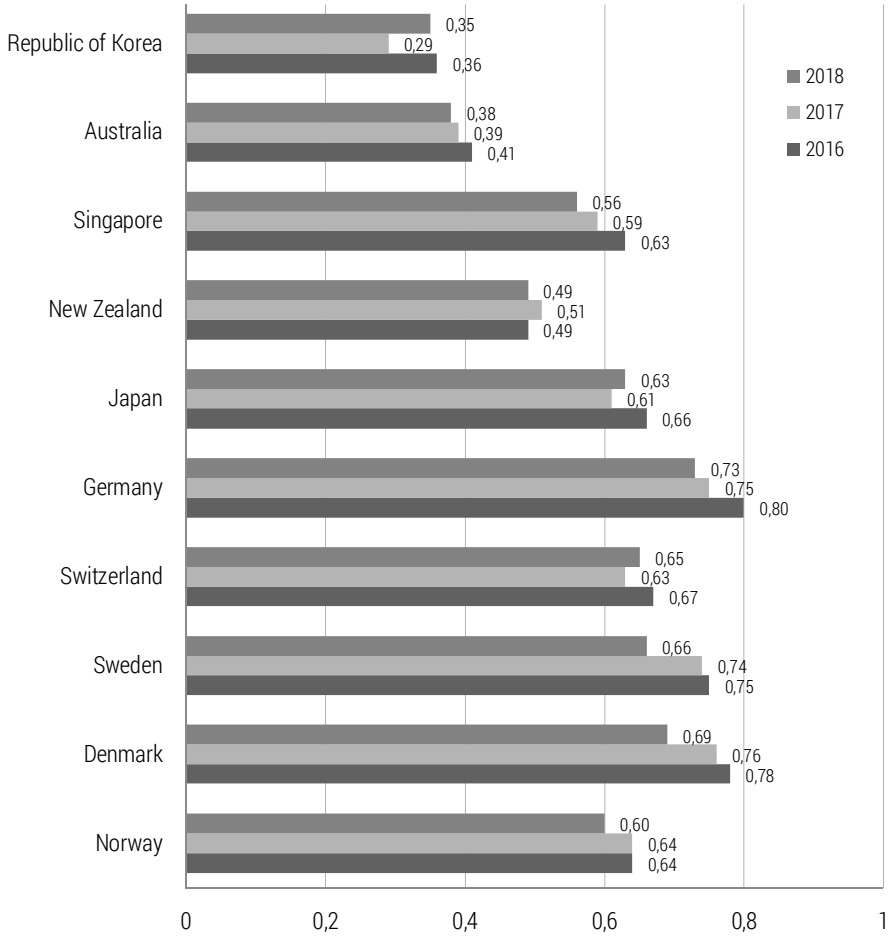

Figure 4. Eco-innovation Performance component in selected countries in years 2016-2018
Source: author's work based (ASEIC, 2018).

the countries with the highest number of green patents (Urbaniec et al., 2021). Denmark also boasts a very good result in the level of renewable energy distribution indicator and participation level in environmental management indicator (The World Bank, 2021).

The discrepancy between the analysed Asian countries and the European countries can be noticed again in the case of the Eco-innovation Performance component. European countries achieved higher values of individual indicators assigned to this component. The exceptions are Japan and Singapore, which obtained similar results to Norway and Switzerland (figure 4). Asian countries achieved weaker results in the Quality of Life Index in relation to the European countries included in the analysis (Numbeo, 2021). European

countries also score better on the environmental sustainability indicator (EPI, 2018). Therefore, Asian countries should pay more attention to these indicators to improve their performance than European countries.

The presented components of the ASEM Eco-innovation Index allow for the assessment of the level of eco-innovation, as well as the identification of strengths and weaknesses in development eco-innovation in selected European and Asian countries. The weakest point of the analysed Asian and European economies was found to be the Eco-innovation Activities component, which requires the implementation of green technologies, as well as developing cooperation at different levels and building a platform for dialogue between industry and science. The best results were achieved in Eco-innovation Capacity, which is influenced by the continuous improvement of competitiveness and focus on innovation development.

Based on the average values for all components in the countries analysed, it can be observed that European countries perform better in terms of eco-innovation (figure 5).

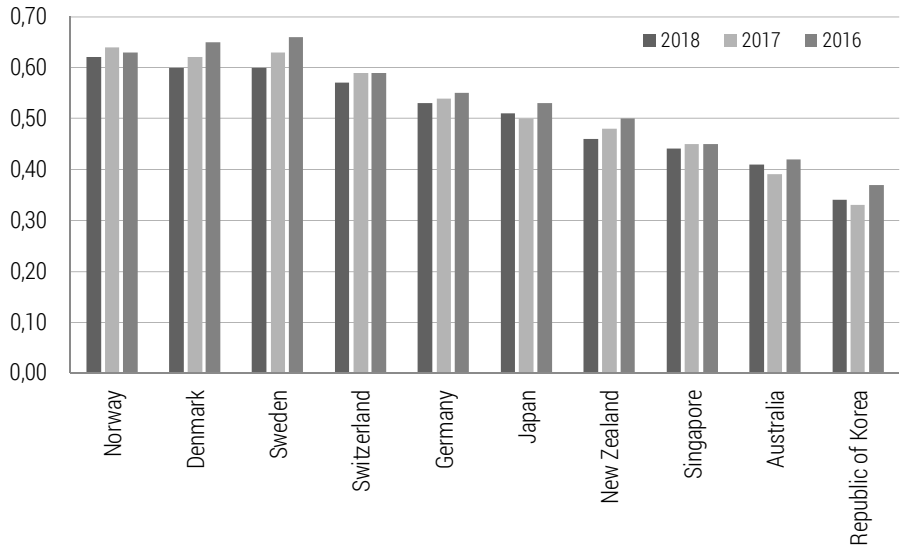

Figure 5. ASEM Eco-Innovation Index in selected countries in years 2016-2018
Source: author's work based (ASEIC, 2018).

However, this is not a fully quantifiable picture of the potential for developing eco-innovation and sustainable development. This is due to changes in the indicators describing the components that make up the ASEM Eco-Innovation Index. Furthermore, the lack of a database of up-to-date data for all ASEM member countries makes it difficult to track changes in eco-innova-

tion. It is also a challenge to determine the progress and difficulties of individual countries in achieving particular indicators due to limited access to comparative data.

Conclusions

The research analysis showed that the ASEI index has a great potential to measure eco-innovation. The findings provide insights into the key areas, objectives and applications of the eco-innovation index indicators for European and Asian countries based on ASEM Eco-innovation Index. This research facilitates the comparative analysis of selected economies in the area of eco-innovation. The index results can contribute to the development of eco-innovation strategies at the national level and by relevant actors. At the same time, our analysis showed that the level of eco-innovation development in individual European and Asian economies belonging to ASEM varies greatly. One of the factors that seem to have a decisive influence is the different level of socio-economic development of these countries.

The main contribution of this study is to benchmark and assess developments in eco-innovation in selected European and Asian economies. Another added value of the analysis carried out is that it broadens the knowledge of research on the measurement of eco-innovation by including the ASEA Eco-innovation Index indicators, which is rarely examined in the literature. In addition, the research analysis showed that the ASEI index has a strong potential to contribute to the Sustainable Development Goals (SDGs), especially in relation to the SDGs on sustainable industrialisation and sustainable consumption and production.

Like any scientific article, this one is not without limitations. An important limitation was the access to complete and up-to-date data, which conditioned the temporal scope of the analysis to 2015-2018. Furthermore, although the ASEM Eco-Innovation index was first published in 2012, it does not cover all ASEM member countries. In addition, the analysis covered selected European and Asian countries belonging to ASEM. However, it is worth noting that these countries have different levels of socio-economic development and face various economic, social and environmental challenges that determine the development of eco-innovation (Jo et al., 2015, Park et al., 2017).

Given the future directions of the study, the temporal scope of the analysis should be extended. This would significantly deepen the knowledge of measuring eco-innovation in European and Asian countries. An interesting research area would also be an analysis for all Asian countries, which could reveal differences and progress in the implementation of eco-innovation.

It will certainly also be important to consider the impact of the COVID-19 pandemic on levels of eco-innovation, as the pandemic affects many aspects of economic, political and social life. Therefore, it is worth examining how the pandemic is affecting the development and implementation of eco-innovation not only in Asian economies but also in other countries around the world.

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The contribution of the authors

Justyna Tomala: conception – 50%, literature review – 50%, writing 30%, analysis and interpretation of data – 70%

Maria Urbaniec: conception – 50%, literature review – 50%, writing – 70%, analysis and interpretation of data – 30%

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Ewa **OŁDAKOWSKA**

WORN VEHICLE TYRES IN POLISH ROAD CONSTRUCTION – ECOLOGY, LAW, USE, AND ECONOMICS

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ABSTRACT: The recycling of worn tyres is enforced primarily by legal regulations, but it is also motivated by ecological and economic reasons. In Poland, recovery of rubber materials makes it possible to obtain materials of good quality and very broad applications, e.g. for plastic road surface or production of so-called rubber asphalt, used for the grindable layer of roads, as well as for innovative materials intended for filling bridge abutments of integrated bridges. The paper considers the financial aspect of using disintegrated rubber waste by analysing the cost of replacing the binder with different amounts of rubber dust (10%, 12%, 14%, 16%). With the assumptions made, the analysis allows for concluding that with an increase in the content of the rubber additive, the cost of the binder changes.

KEYWORDS: recycling, road construction, rubber, sustainable development

Introduction

The recycling of worn tyres is enforced primarily by legal regulations, but it is also motivated by ecological and economic reasons. In Poland, the recovery of rubber materials makes it possible to obtain good quality materials with a very wide range of applications. End-of-life tyres, due to their diverse composition: rubbers (natural rubber, nitrile butadiene rubber, ethylene-propylene-diene-monomer rubber), fillers, antioxidants, antiozonants, and curing agents (Fazli & Rodrigue, 2020) are resistant to biodegradation, photochemical decomposition, and thermal degradation (Fukumori et al., 2002, Karger-Kocsis et al., 2013). Nevertheless, they can be successfully recycled to recover energy (Amari et al., 1999, Ramarad et al., 2015) or perform pyrolysis (Shah et al., 2007). They are also used as a fuel source in cement furnaces or as fuel for the production of steam, electricity, paper, lime, and steel. Unfortunately, burning tyres as fuel release dangerous gases and recovers only 25% of the energy used to make rubber (Van Beukering & Janssen, 2001). In addition, pyrolysis of waste tyres decomposes the rubber component into soot, zinc, sulphur, steel, oils, and gas, and the high operating costs of pyrolysis plants limit the widespread use of this method (Ilkılıç & Aydın, 2011). Several environmentally friendly recycling techniques have been developed, such as triboelectric separation, foam flotation, and laser breakthrough spectroscopy. However, those methods are expensive, and the recycled rubbers vary in purity, size, shape, and surface topography quality (Adhikari et al., 2000, Fang et al., 2001, Singh et al., 2017). Vulcanised rubber wastes are difficult to recycle, nevertheless as very durable, strong, and flexible materials, they may be used as fillers in the production of composites (Medina et al., 2018) or components of asphalt mixtures (Kaloush, 2003, Plewa, 2014, Radziszewski et al., 2017, Sybilski, 2009).

The aim of this paper is to approach the problem of worn tyres in a broader scientific-practical and financial-economic context, taking into account the legal framework and ecological aspects.

Legal aspects of using worn vehicle tyres in the construction

With the increasing number of vehicles on the roads each year, the number of tyres in circulation is also increasing. In 2018 alone, those were over 274,000 tonnes of tyres (274,448 to be exact) (Statistics Poland) that are expected to be disposed of in the future. It will take more than 100 years for worn tyres to decompose, so it is important to put the mechanisms allowing to reuse them in 100% in place.

As implemented in the national legislation systems, the principles of waste management are closely related to the general principles of environmental law applicable at the international level.

In Poland, the management of waste rubber from worn vehicle tyres is regulated by laws that follow three important EU directives:

1) Landfill 1999/31/EC (Council Directive 99/31/EC of April 26, 1999, on the landfill of waste), which bans the landfilling of whole vehicle tyres from July 2003 and of disintegrated parts from July 2006, and obliges all Member States to implement these bans.
2) End-of-Life Vehicle 2000/53/EC (Directive 2000/53/EC of the European Parliament and of the Council of September 18, 2000, oend-of-lifefe vehicles) sets out how end-of-life vehicles should be dealt with, imposing on European vehicle manufacturers an obligation to recover 85% and recycle 80% of the vehicle mass from 2006, and to recover 95% and recycle 85% from 2015, respectively. According to the directive, the vehicles should have all tyres removed before scrapping.
3) Waste Incineration 2000/73/EC obliges cement plants to use the worn vehicle tyres as an alternative fuel to impose higher limits on harmful waste gas emissions of NO_x up to 800 mg/m^3 (Journal of Laws 2014 pos. 1546).

The first Polish law compliant with (Council Directive 99/31/EC of April 26, 1999, on the landfill of waste), which prohibited the storage of worn vehicle tyres, was the Act of April 27, 2001, on waste (Journal of Laws 2001 No. 62, pos. 628). Another act regulating their management was the Act of May 11, 2001, on the duties of entrepreneurs with respect to the management of certain types of waste and product fees (Journal of Laws 2001 No. 63, pos. 639). It set out the principles for determining and collecting the product fee – in order to prevent waste generation, limit its negative impact on the environment, and ensure a high level of waste recovery and recycling. Another act, the so-called "cleaning act", was the act of February 7 2003 (Journal of Laws No. 7, pos. 78, from 2003), introducing the obligation to recycle the worn tyres from 2004. The target was set at 15% in 2007, where tyre retreading was not considered recycling but recovery. Further legal acts of significant importance for worn tyre management were: The Act on international trade in waste of July 30 2004 (Journal of Laws No. 191, pos. 1956, from 2004) and the "wreck" act (consistent with (Directive 2000/53/EC of the European Parliament and of the Council of September 18, 2000, on end-of-life vehicles), Journal of Laws 2005 No. 25, pos. 202) concerning end-of-life cars.

Examples of the use of worn vehicle tyres in Polish road construction

The use of worn, used tyres in the Polish road construction industry includes the production of the so-called rubber asphalt (AMG), used for the asphalt grindable layer of the road. Vehicle tyres are subjected to the same weather factors as road surfaces, and their composition and properties make rubber a good modifier for asphalt. The "rubber asphalt" is a mixture of road asphalt and disintegrated rubber from vehicle tyres (at least 15% by weight), which swells when reacting with hot asphalt. Disintegrated rubber from vehicle tyres can be introduced in two ways, dry or wet. The dry method consists in adding rubber granulate to the mineral mixture in order to replace part of the aggregate, while the wet method consists in modifying the binder with rubber dust beforehand and introducing the finished rubber and asphalt binder into the mineral mixture. The addition of rubber to asphalt improves road quality, ageing resistance, and durability, as well as increasing traction between the surface and the tyre while lowering noise levels and reducing the braking distance for cars. Such technology is already used in the USA, Spain, the UK and China. Several tens of kilometres of roads in Poland (in several locations) were also built. This technology is characterised by improved parameters (in relation to other existing technologies) in terms of:

- longer service life,
- resistance to thermal cracking (mixtures used for the grindable layer do not crack at all at low temperatures, or cracks develop much more slowly, and the layer maintains its structural integrity almost to the very end),
- lower values of stiffness modulus and higher stress relaxation capacity,
- increased resistance to fatigue cracking and rebound cracking,
- increased resistance to permanent deformation caused by high temperature,
- improved anti-slip properties (the rubber particles on the surface of the aggregate grains increase friction between the tyre and the road), resulting in shorter braking distance,
- noise reduction (the layer, thanks to its structure, reduces the noise level from vehicles by 2-5 dB on average).

Another application of worn tires in Polish road construction is their use in the form of rubber granulate in the poroelastic pavement. In the period from May 1, 2018, to April 30, 2021, a project with the acronym SEPOR (Safe, Environmentally Friendly Poroelastic Road Pavement) has been implemented with the aim of developing an innovative poroelastic road pavement, characterised by very low noise, water permeability, suppression of liquid fuel spill fires, as well as good rolling resistance, and anti-slip properties. The

poroelastic pavements are pavements that are currently in the experimental phase, and so far, it has not been possible to develop this type of pavement with the required durability. The consortium implemented the project: Gdańsk University of Technology, Białystok University of Technology, MTM S.A. from Gdynia. The 7FP PERSUADE (Poroelastic Road Surface: an innovation to Avoid Damages to the Environment) project, started in 2009, ended in 2015 as a step in improving the poroelastic pavements. The project involved two partners from Poland: Gdańsk University of Technology and the Road and Bridge Research Institute in Warsaw. The poroelastic grindable layers allow for a significant reduction in traffic noise (even up to 12 dB in comparison with the commonly used traditional SMA11 type pavements) and may prove to be more effective and less expensive than acoustic screens, especially in urban conditions.

Moreover, the poroelastic pavements make it difficult, if not impossible, for liquid fuel spills to spread fire, which makes them the pavements for use in tunnels, service stations, and terminal areas. The research in a number of SEPOR projects aims to improve mixture composition, use of new binders made from highly modified asphalts, and a detailed study of the influence of the manufacturing process on the durability of poroelastic pavement, as well as the strengthening of the connection between the poroelastic pavement and the layer below. It should eliminate the problem of the interlayer connection being torn apart by tangential forces occurring at the contact between the layers. Moreover, the anti-slip properties of the road pavement have been optimised. The experimental sections were built and subjected to typical traffic loads and weather conditions as part of the project.

The development of non-expensive, environmentally friendly, and innovative materials derived from recycled vehicle tyres for backfilling the bridge abutments is the aim of another project funded by the National Centre for Research and Development and carried out by a consortium of four partners: Rzeszów University of Technology, Promost Consulting, Remost Dębica, Geotech Rzeszów. The project's duration is the two stages – a research stage that fell between August 2015 and February 2018, and an implementation stage covering six months: March-August 2018.

The financial aspect of using the disintegrated worn car tyres for asphalt binders modification

The use of rubber dust to modify asphalts is undoubtedly a significant improvement in their properties, the "second life of the tyre", and the associated financial relationships.

In order to establish these relationships, the cost calculations have been carried out for substituting the binder with rubber. The original percentage of the binder contained in asphalt mixtures of the types of AC 11 and SMA 11 asphalt concrete, designed for the grindable layer of road pavements loaded with KR3 and KR4 traffic, has been used to evaluate the cost of the binder. The asphalt mixtures have been designed following (WT-2 2014). A mixture of aggregates (lime dust, broken sand 0/2, grit 2/5.6, grit 2/8, grit 4/8, grit 8/11) of constant granulometric composition and road asphalt 50/70 has been used for their construction. The list of compositions of asphalt mixtures is presented in table 1.

Table 1. List of compositions (share in %) of asphalt mixtures

Type of material	List of compositions (share in %) of asphalt mixtures		
	AC 11 50/70 KR 3-4	SMA 11 50/70 KR 3-4 (I)	SMA 11 50/70 KR 3-4 (II)
Asphalt	5.80	6.60	7.20
Limestone dust	7.50	10.27	8.40
Broken sand 0/2	28.30	6.53	15.80
Grit 2/5.6		23.33	4.60
Grit 2/8	37.70		
Grit 4/8		10.27	25.10
Grit 8/11	20.70	43.00	38.90
Total	100.00	100.00	100.00

Source: author's work.

The cost analysis of binder modified with various content of rubber dust (in the amount of 10%, 12%, 14%, 16% in relation to binder weight) has been performed using prices included in the monthly information (Informacja miesięczna …) and quarterly information (Informacja o cenach …) of "Sekocenbud" publishing house. The price of granulate has been established upon the basis of sale offers (unit prices fluctuated around 700 PLN per Mg). The price does not include the purchase and external transport costs, which should be calculated individually according to the actual conditions. The unit price of the binder is 1940 [PLN/t]. Lists of costs of replacing the binder with various amounts of disintegrated worn vehicle tyres are shown in tables 2, 3, and 4.

Table 2. List of costs of replacing the binder (originally used in mineral and asphalt mixture AC 11 50/70 KR 3-4) with various content of rubber additive

Type of material	Costs [in PLN] of replacing the binder (originally used in the asphalt mixture AC 11 50/70 KR 3-4) with rubber additive in amount of:				
	0%	10%	12%	14%	16%
Bitumen	112.52	101.27	99.02	96.77	94.52
Rubber additive	–	4.06	4.87	5.68	6.50
Total	112.52	105.33	103.89	102.45	101.01

Source: author's work.

Table 3. List of costs of replacing the binder (originally used in mineral and asphalt mixture SMA 11 50/70 KR 3-4) with various content of rubber additive

Type of material	Costs [in PLN] of replacing the binder (originally used in the asphalt mixture SMA 11 50/70 KR 3-4) with rubber additive in amount of:				
	0%	10%	12%	14%	16%
Bitumen	128.04	115.24	112.68	110.11	107.55
Rubber additive	–	4.62	5.54	6.47	7.39
Total	128.04	119.86	118.22	116.58	114.95

Source: author's work.

Table 4. List of costs of replacing the binder (originally used in mineral and asphalt mixture SMA 11 50/70 KR 3-4) with various content of rubber additive

Type of material	Costs [in PLN] of replacing the binder (originally used in the asphalt mixture SMA 11 50/70 KR 3-4) with rubber additive in amount of:				
	0%	10%	12%	14%	16%
Bitumen	139.68	125.71	122.92	120.12	117.33
Rubber additive	–	5.04	6.05	7.06	8.06
Total	139.68	130.75	128.97	127.18	125.40

Source: author's work.

Tables 2, 3, and 4 show that some savings can be made regardless of the rubber additive used (in the range considered). First, the rear savings in asphalt, and second, differences result from the prices of the materials. Replacing 10% of the binder with 10% of the rubber additive means the total cost of the binder is lower by 6.39% (in comparison with the values determined for the binder not subjected to modification). The 12% rubber waste content in asphalt is a 7.67% lower expenditure, while the use of 14% waste material is a cost reduction of almost 9% (8.95%). The presence of 16% of disintegrated rubber waste from worn vehicle tyres represents savings of 10.23%.

Tables 2, 3, and 4 are lists of binder costs, assuming that disintegrated rubber waste will be purchased at the price of 700 PLN per Mg and "introduced" into the binder in ratio, for example, 10% of binder – 10% of rubber additive. However, each mixture has a different binder content, and the use of rubber and asphalt binder salon requires redesigning the entire asphalt mixture each time. Besides, among the production costs, despite the significant share of costs and quantities of "input" materials, the manufacturing costs strictly depending on the temperature are also not insignificant. The typical mixture has a production temperature of 150°C, while the production temperature of the asphalt mixtures with rubber is 180°C. It looks similar for the range of effective compaction temperatures, which for the typical asphalt is between 95 and 115°C, while for asphalt modified with crumb rubber waste, it is between 120°C and 140°C. The literature (Stefańczyk & Mieczkowski, 2006) indicates that increase of production temperature of the asphalt mixtures beyond the limits of 140-160°C causes a number of negative ecological, technical, and economic phenomena, including in particular: pollution of the atmosphere with hydrocarbon fumes, overheating of the bituminous binder leading to unfavourable structural changes, premature ageing of the pavement, and excessive consumption of driving materials.

Conclusions

Rubber derived from worn vehicle tyres (the most numerous group of rubber waste) of very good strength, mechanical, acoustic, or thermal properties is being reused more and more often. Road construction offers many opportunities to use recycled materials. Among various ways of utilising rubber waste, there are asphalt mixtures with their addition, introduced by two methods, dry or wet. The dry method consists in adding rubber granulate to the mineral mixture in order to replace part of the aggregate, while the wet method consists in modifying the binder with rubber dust beforehand and introducing the finished rubber and asphalt binder into the mineral mixture. Another application of worn tires in Polish road construction is their use in the form of rubber granulate in the poroelastic pavement. Another possibility is to develop non-expensive, environmentally friendly, and innovative materials derived from recycled vehicle tyres for backfilling the bridge abutments.

The "second life" of a tyre is also a financial and economic aspect, which has been considered to replace the binder with the rubber. The analysis, with the assumptions made, allowed for concluding that with an increase in the content of the rubber additive the cost of the binder changes. Replacing 10% of the binder with 10% of the rubber additive means a total cost of the binder

is lower by 6.39% (in comparison with the values determined for the binder not subjected to modification). The 12% rubber waste content in asphalt is a 7.67% lower expenditure, while the use of 14% waste material is a cost reduction of almost 9% (8.95%). The presence of 16% of disintegrated rubber waste from worn vehicle tyres represents savings of 10.23%.

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STUDIES AND MATERIALS

STUDIA I MATERIAŁY

Anetta ZIELIŃSKA

THE LEVEL OF REVERSE LOGISTICS IMPLEMENTATION IN TERMS OF WASTE MANAGEMENT IN POLISH VOIVODSHIPS ACCORDING TO A MULTIVARIATE COMPARATIVE ANALYSIS

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ABSTRACT: In practice, reverse logistics in Poland refers to a narrow approach within the framework of the waste management problem. The voivodships have been obliged to implement reverse logistics processes more effectively through waste management. The article aims to diagnose the implementation level of waste management processes (part of reverse logistics) in Polish voivodships. The research used a multivariate comparative analysis that ranks voivodships according to waste management indicators. The research will result in preparing the ranking of voivodships listing the leaders and those unsuccessful in the implementation of waste management. Based on the research, Śląskie and Podlaskie voivodships were selected as the ones presenting the highest level of waste management implementation, whereas the lowest level was recorded for Lubuskie voivodship.

KEYWORDS: waste management, recycling, reverse logistics, multivariate comparative analysis

Introduction

Reverse logistics represents a current research area in theoretical and empirical terms. In Poland, reverse logistics refers to a narrow approach within the framework of the waste management problem in practice. Increasingly stringent national and transnational measures and regulations regarding waste and waste management are coming to the fore.

In the system of reverse logistics, the direction of activities takes place from the consumer towards the producer, through the implementation of such processes as (see de Brito, Dekker, 2003, p. 3-27; Wadhwa, et al., 2009, p. 462; Zielińska, et al., 2016, pp. 207-214):

- repairs and reuse – the re-introduction of an unchanged product to the system, while its quality cannot be lower than that of a new product,
- renovation (rejuvenation) – ensuring the appropriate quality of returns by dismantling, control and exchange of faulty elements, and also by technological modernisation, i.e. the replacement of old modules and components with the technologically better and more advanced ones,
- regeneration – bringing the appropriate quality required from new goods to the used goods by a total disassembly, detailed repair and the exchange of outdated parts,
- cannibalisation – recovering a relatively small number of parts and modules from the used product and subjecting them to the process of repair, renovation or regeneration,
- recycling – reprocessing the materials contained in returns during the production process to obtain material to be used along with its original purpose or with another one.

Since the end of the 20th century, the importance of reverse logistics has grown for several reasons:

- the amount of product returns can be very high, with some industries experiencing returns at over 50% of sales (Trebilcock, 2002, p. 31-45),
- end-of-life take-back laws have proliferated over the past decade in the European Union, requiring businesses to effectively manage the entire life of the product (Fishbein, 1994),
- landfill capacity has become limited and expensive. Alternatives such as repackaging, remanufacturing and recycling have become more prevalent and diable (Thierry et al., 1995, pp. 114-134).

Improving the recycling and remanufacturing rate of end-of-life products is necessary to reduce the negative impact of harmful substances on the environment and promote recycling and sustainable development. Recycling and remanufacturing activities carried out by enterprises are combined with

their traditional positive supply chain to form a closed-loop supply chain system (Daniel et al., 2009).

Approaching reverse logistics in terms of waste management requires clarification. Waste management in accordance with the Waste Management Act is "the collection, transport, processing of waste, including the supervision over such activities, as well as the subsequent handling of waste disposal sites and the activities performed as a waste seller or waste management intermediary" (Act of December 14, 2012, (3) section 1 point 2).

In Poland, public administration units, including voivodships, have been obliged to implement the processes of reverse logistics processes more effectively through waste management. Hence, voivodship authorities (voivodship parliaments) should undertake all possible measures to reduce the amount of generated waste. There is an urgent need to change the traditional approach of voivodship parliaments to waste management; they should be focused on reverse logistics activities, primarily the recycling processes. Nowadays, reverse logistics represents a remarkable part of logistics processes carried out by enterprises, which should be supervised and controlled, and the voivodship authorities should perform these tasks.

The article aims to diagnose the level of implementing waste management processes (as part of reverse logistics) in Polish voivodships. A multivariate comparative analysis was used in the research, based on the indicators describing waste management for voivodships (data provided by Statistics Poland). The research will result in preparing the ranking of voivodships listing the leaders and those unsuccessful in implementing waste management.

Literature review

Scientists started defining reverse logistics as early as the 1970s (Guiltinan et Nwokoye, 1975, Ginter et Starling, 1978). However, they paid attention to returns did not refer to them as the reverse flow logistics. According to Lambert, Stock, Ellram: "reverse logistics deals with the removal of waste material, which originates in the process of production, distribution and wrapping of goods. Typically, it is the activity such as securing temporary storage of these materials, their subsequent removal from the disposal site, processing, reuse or recycling" (Lambert et al., 2000). However, reverse logistics begins, where classic logistics end, it is associated with the creation of added value in the reverse direction in relation to the primary flow in logistics processes (Grant et al., 2017). Reverse logistics is defined as: "the process of planning, implementing, and controlling the efficient, cost-effective flow of raw materials, in-process inventory, finished goods and related information

from the point of consumption to the point of origin to recapture value or proper disposal" (Rogers, Tibben-Lembke, 1998). However, K. Hawks claims that it is "the process of moving goods from their typical final destination to capture value or proper disposal. Remanufacturing and refurbishing activities may also be included in the definition of reverse logistics" (Hawks, 2006). Finally, according to the American Reverse Logistics Executive Council, reverse logistics is a series of activities required to retrieve a product from a customer and either dispose of it or recover its value (Rogers, Tibben-Lembke, 2001, pp. 129-148).

The introduction indicated that Polish source literature approaches reverse logistics as waste and packaging management. According to J. Szołtysek "reverse logistics refers to all processes managing the flow of waste (including defected goods) and information (connected with these flows) from the place of their origin to the place of their destination in order to recover their value (through repair, recycling or processing) or an appropriate treatment and long-term storage so that such flows are economically effective and minimise negative influence of waste on the environment" (Szołtysek, 2009, p. 80). A. Mesjasz-Lech has a slightly different approach to reverse logistics since the main goal of reverse logistics through waste management is the size of waste flow in cities. The concept of a zero-waste city requires the activities of reverse logistics, as it is not possible to reduce municipal waste without the proper organisation of waste flows and infrastructure – reverse logistics function (Mesjasz-Lech, 2020, pp. 320-332). The author indicates the role to be played by public administration units in the flow of reverse logistics chain (e.g. voivodships).

Legislation regulating waste management at the voivodship level

Polish legislation on waste management in relation to the public administration unit, i.e. a voivodship, is based on the following documents:

- Act of December 14, 2012, on Waste (Journal of Laws 2021, item 779).
- Act of September 13, 1996, on Maintaining Cleanliness and Order in Municipalities (Journal of Laws 2021, item 888).
- Resolution No. 88 of the Council of Ministers of July 1, 2016, on the National Waste Management Plan 2022 (Monitor Polski 2016, item 784).
- Regulation of the Minister of the Environment of July 1, 2015 on the method and form of drawing up a voivodship waste management plan and an investment plan template (Journal of Laws 2015, item 1016).

It should be noted that Polish legislation has to be compatible with the provisions of the European Union law, in particular, the "Waste package" consisting of four directives:

- EU, 2018. Directive 2008/98/EC on waste, L. 851.
- EU, 2018. Directive 94/62/EC on packaging and packaging waste, L. 852.
- EU, 2018. Directive 1999/31/EC on the landfill of waste, L. 850.
- EU, 2018. Directive 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment, L. 849.

In recent years, Polish and EU legal regulations regarding waste management have been subject to ongoing modifications.

In Poland, in the Ministry of Climate and Environment, the problem of waste management remains within the responsibility of the Waste Management Department, which prepares, e.g., guidelines for drawing up voivodship waste management plans in terms of municipal waste and for preparing reports on the implementation of voivodship waste management plans.

The voivodship self-government (Voivodship Marshal's) performs the following tasks regarding waste management (Act of December 14, 2012):

1. Issues the decision approving the reclassification of hazardous waste into non-hazardous waste, or a decision of expressing an objection (Article 8 (5)).
2. Allows, by way of a decision, if, for the reasons of safety or in order to ensure the continuity of collecting infectious medical waste or infectious veterinary waste, it is required to collect this waste (Article 23 (4)).
3. Allows, by way of a decision, if the incineration of waste in installations or devices designed for this purpose is impossible for safety reasons, for the incineration of waste outside the installations or devices (Article 31 (1)).
4. Allows waste processing for projects that may always have a significant impact on the environment; processing for non-hazardous waste subject to recovery in the recovery process based on filling in the unfavourably transformed areas; processing for municipal installations (Article 41 (3)).
5. Issues decisions on approving instructions for operating a waste landfill, extracting waste, closing a waste landfill or its separate part, or a decision of expressing an objection (Articles 129-135, 144, 146, 148, 151).
6. Maintains a database on products and packaging as well as waste management (BDO Register – Product, Packaging and Waste Management Database).

Waste management plans are developed at the national and voivodship level. Voivodship waste management plans include (Act of December 14, 2012, Articles 34-35):

1. Waste management plans.

2. Forecasted changes in waste management, including those resulting from demographic and economic changes.
3. The adopted waste management objectives, including deadlines for meeting them.
4. Identifying municipal installations in the voivodship area.
5. Schedule for shutting down installations that do not meet the environmental protection requirements, the modernisation of which is not possible for technical reasons or is not justified for economic reasons.

Voivodship waste management plans have to remain in line with the assumptions of the National Waste Management Plan.

The purpose of the voivodship plans is to balance the capacity of waste treatment installations and to diagnose the tasks required to ensure integrated waste management. In turn, voivodship self-governments play an important role in implementing and controlling the product, packaging and waste management database, which will improve the waste management reporting process and reverse logistics processes.

Research methods

The empirical research presented below aims to assess the level of waste management implementation (reverse logistics) in Polish voivodships. The research applies a multivariate comparative analysis (MCA) for voivodships using waste management indicators according to the data provided by Statistics Poland. The research will result in ranking voivodships from the highest to the lowest level of implementing waste management processes as reverse logistics processes.

Data variety used in comparative analyses to describe the phenomenon of waste management as an element of reverse logistics implies the need for using multiple measuring units presenting different values. Consequently, it makes it impossible to compare the situation in various areas or even in the same area characterised by the changing intensity of particular phenomena types. For this reason, such methods have to be searched for which allow procedure objectification aimed at the general assessment of waste management condition; therefore, the method of multivariate comparative analysis, in the form of linear ordering, can be applied in this case (Zeliaś, 1989; Pluta, 1986; Pociecha, et al., 1988). Linear ordering, using a synthetic development measure (SDM), allowed ranking objects (voivodships) "from the best to the worst" (Walesiak, 2006; Walesiak and Gatnar, 2009).

The problem under study, i.e. the level of waste management implementation in a voivodship, is a highly complex issue. The classified objects (voivodships) are described using many indicators, resulting in difficulties

associated with assessing objects' similarity and thus their classification. The level of objects' similarity regarding one feature may be different from the similarity of the same objects in terms of another feature, thus the need to classify objects using formal procedures, allowing an objective analysis in the conditions of complexity characteristic for the waste management phenomenon (Zielińska, 2019, p. 341).

Unifying the nature of variables (indicators describing waste management) is the first step of a multivariate comparative analysis. Such unification is not conducted when all variables represent stimulants, i.e. affect the analysed collective phenomenon (the state of waste management) positively. If the set of indicators includes destimulants or nominants, it is required to convert them into stimulants[1].

The conversion of destimulants (D) into stimulants (S) using the quotient transformation was applied in the article (Walesiak, 1993, pp. 38-40):

$$S_{ij} = b\left[D_{ij}\right]^{-1}, \tag{1}$$

where:
S_{ij} – value of j-th stimulant observed in i-th object (voivodship),
D_{ij} – value of j-th destimulant observed in i-th object (voivodship),
b – constant value adopted arbitrarily, in calculations $b = minD_{ij}$.

Removing values of the studied variables (waste management indicators) and unifying orders of magnitude to allow their comparability (so-called normalisation) is the next step in the process of multivariate comparative analysis (Walesiak, 1988, pp. 63-71). The following normalisation formula was used in this case (Jajuga, Walesiak, 2000, p. 109):

$$z_{ij} = \frac{x_{ij} - \bar{x}_j}{s_j}, \tag{2}$$

where:
z_{ij} – normalized value of j-th of a given waste management indicator in i-th object (voivodship),
x_j – arithmetic mean of j-th of waste management indicator,
S_j – standard deviation of j-th waste management indicator,
x_{ij} – value of j-th waste management indicator observed in i-th object (voivodship).

[1] Waste management is described by the set of variables which may include: stimulants, destimulants and nominants. Stimulants represent the variables of which higher numerical values imply the desired changes of a given phenomenon. Destimulants are the variables of which higher values indicate undesirable changes in the studied phenomenon. The nominant features are characterized by a certain level of saturation, any deviations from which imply negative changes in the analysed phenomenon (Pluta, 1986).

The application of the normalisation formula to all waste management indicators was followed by developing a normalised data matrix (Z) used for further calculations (see Zielińska, Sej-Kolasa, 2004).

When the normalised data matrix is determined, the hierarchical classification applies the methods of linear ordering for the set of objects (voivodships). According to the adopted criterion, the aforementioned methods are applied to rank (order) objects or their sets. These methods can be applied only if a certain overriding criterion is adopted, following which it is possible to rank the objects from the "best" to the "worst". Synthetic development measure (SDM) is the tool in linear ordering methods, which is the function aggregating partial information included in individual indicators and is designated for each object from the sets of objects. In general terms, the aggregation formulas for indicator values can be divided into the model and non-model ones (for more see: Gatnar and Walesiak, 2004, pp. 351-355; Grabiński, 1984, p. 38).

The calculations were based on a non-model formula, where pi takes the mean normalised value of waste management indicators for an individual voivodship. The "best" country is the one taking max pi value, whereas the "worst" – min pi (see Zielińska, et Sej-Kolasa, 2004):

$$P_i = \frac{1}{m}\sum_{j=1}^{m} z_{ij}\,, \tag{3}$$

where:
P_i – synthetic development measure for i – th object (voivodship),
m – number of data describing waste management indicators,
z_{ij} – normalised value of j-th of a given waste management indicator in i-th object (voivodeship).

Not all waste management indicators were assigned ranks in the study because there is no information in the source literature or the conducted research that would describe the analysed indicators' role in assessing the implementation of reverse logistics (Zielińska, 2020, p.177).

Results of the research

The conducted analysis applied a multivariate comparative analysis using the possible to determine waste management indicators as part of reverse logistics for voivodships. The indicators were retrieved from the Statistics Poland database for 2019. As a result, 12 waste management indicators were selected to describe voivodships, as presented in table 1:

1. Mass of municipal waste generated per capita [kg].
2. Share of recycled waste compared to total waste generated per year (excluding municipal waste) [%].
3. Share of recovered waste compared to total waste generated per year (excluding municipal waste) [%].
4. Share of waste subject to neutralisation compared to total waste generated per year (excluding municipal waste) [%].
5. Share of municipal waste collected selectively from households compared to total waste [%].
6. Indicator of enterprises collecting mixed municipal waste [%].
7. Cost-effectiveness indicator of services for the collected municipal waste [PLN/t].
8. Mixed municipal waste collected per capita per year [kg].
9. Share of waste deposited in landfills as mixed municipal waste [%].
10. Share of revenues from waste management fees compared to revenues for the National Fund for Environmental Protection and Water Management [%].
11. Landfill capacity per capita [m^3].
12. Expenditure on fixed assets for recycling and the use of waste per capita [thous. PLN].

Table 2 presents the most important parameters of waste management indicators for voivodships in 2019.

The uniform preference postulate was conducted for the examined indicators (formula 1), for which the following indicators (numbers) were classified as destimulants (subjective assessment): 1, 4, 6, 8 and 9, nominants were not included among the analysed indicators.

Based on the findings presented in table 2, it is noticeable that the best levels of waste management indicators, in accordance with S or D variable, were recorded twice for the following voivodships: Małopolskie (this result was influenced by indicators No. 2-3), Lubelskie (indicators No. 5, 8), Mazowieckie (indicators No. 6-7).

For the purpose of further research, the normalisation of waste management indicators (formula 2) was conducted, i.e. the values of indicators were removed, and the order of magnitude was unified to allow comparisons.

Table 1. Waste management indicators for voivodships in 2019

voivodships/indicators	1	2	3	4	5	6	7	8	9	10	11	12
Dolnośląskie	404.5	2.9	0.4	2.7	29.7	5.1	565.0	293.2	45.3	42.3	3.271	666.9
Kujawsko-pomorskie	332.3	22.3	21.3	0.6	33.6	8.2	478.5	232.0	57.5	36.3	0.222	378.7
Lubelskie	234.1	2.1	1.9	46.6	43.8	6.3	575.5	142.4	59.3	34.7	0.268	702.0
Lubuskie	379.6	25.4	16.4	1.3	28.7	7.6	488.7	279.7	44.3	54.5	0.000	0.0
Łódzkie	332.9	5.4	1.7	81.7	34.7	4.9	489.4	224.5	38.8	66.6	0.262	15.2
Małopolskie	316.8	55.5	45.6	4.3	36.0	5.7	529.7	211.8	40.7	48.4	0.066	160.6
Mazowieckie	320.8	13.6	13.2	43.7	30.0	4.7	856.7	230.8	33.9	34.5	0.000	349.7
Opolskie	338.6	46.7	8.3	0.3	38.3	6.1	494.3	219.0	65.2	29.3	0.096	933.0
Podkarpackie	241.8	12.1	11.6	2.3	32.1	6.9	567.6	170.5	56.0	44.4	0.953	0.0
Podlaskie	283.2	31.5	8.6	1.0	34.4	7.1	477.6	194.1	14.1	44.0	2.865	0.0
Pomorskie	371.7	20.8	19.6	5.2	37.1	7.0	509.3	251.5	34.6	48.3	0.429	1 915.4
Śląskie	376.0	44.7	41.6	8.0	41.3	6.0	500.1	228.2	50.0	39.4	0.094	10 141.9
Świętokrzyskie	231.5	19.3	6.2	55.5	32.8	5.6	441.6	163.3	67.9	23.9	0.377	0.0
Warmińsko-mazurskie	305.7	8.8	8.8	5.3	24.9	8.3	573.1	238.2	42.7	58.3	0.664	0.0
Wielkopolskie	354.8	4.6	4.1	17.4	31.8	4.9	524.3	251.8	22.8	47.9	0.065	70.0
Zachodniopomorskie	390.6	10.1	9.3	70.2	29.2	8.8	479.3	287.1	16.8	65.5	0.059	356.0

Source: author's work based on Statistics Poland, Local Data Bank, https://bdl.stat.gov.pl/BDL/start [1-10-2021].

Table 2. The most important information for waste management indicators in the voivodships for 2019

Indicators	Arithmetic mean	Standard deviation	Nature of variables: S-stimulant D-destimulant	Levels max for S and min for D	Country with the the best level according to S or D variable
1	0.73	0.14	D	231.5	świętokrzyskie
2	20.36	16.63	S	316.8	małopolskie
3	13.67	13.19	S	316.8	małopolskie
4	0.17	0.27	D	338.6	opolskie
5	33.65	4.89	S	234.1	lubelskie
6	0.76	0.15	D	320.8	mazowieckie
7	534.42	94.79	S	856.73	mazowieckie
8	0.65	0.14	D	142.4	lubelskie
9	0.40	0.23	D	14.1	podlaskie
10	44.89	12.13	S	66.6	łódzkie
11	0.61	1.00	S	3.271	dolnośląskie
12	980.59	2,494.97	S	10,141.9	śląskie

Source: author's work based on Statistics Poland, Local Data Bank, https://bdl.stat.gov.pl/BDL/start [1-10-2021].

Finally, linear ordering taking the form of synthetic development measure was performed (SDM) (table 3).

Table 3. Synthetic development measure (SDM) for the voivodship level

Voivodship ranking	Voivodship	SDM	Voivodship ranking	Voivodship	SDM
1	Śląskie	0,47	9	Pomorskie	-0.08
2	Podlaskie	0,45	10	Świętokrzyskie	-0.13
3	Małopolskie	0,36	11	Dolnośląskie	-0.17
4	Lubelskie	0,17	12	Wielkopolskie	-0.190
5	Opolskie	0,16	13	Kujawsko-pomorskie	-0.191
6	Mazowieckie	0,10	14	Zachodniopomorskie	-0.319
7	Podkarpackie	0,08	15	Warmińsko-mazurskie	-0.321
8	Łódzkie	-0,07	16	Lubuskie	-0.34

Source: own compilation.

SMD results indicated that the highest level of waste management implementation was recorded in Śląskie Voivodship, presenting the highest level of "Expenditure on fixed assets for recycling and the use of waste per capita" indicator. It significantly differed from the level of other voivodships and, thus, significantly influenced the outcome. Podlaskie Voivodeship (ranked as the second) slightly differed from Śląskie Voivodship, which resulted from the dominant influence of the best level in the share of waste deposited in landfills as mixed waste (Podlaskie deposits the lowest volume of mixed waste in landfills). In turn, the lowest level of waste management implementation was recorded in Lubuskie Voivodeship, which presented the worst levels of indicators No. 11 and 12 and unfavourable levels of indicators No. 5 and 8. Lubuskie recorded the lowest overall expenditure on waste management (including no expenditure on fixed assets for waste management recycling) (Statistics Poland, 2020, p.18).

Conclusions

Based on the conducted comparative analysis for voivodships in accordance with waste management, the following conclusions can be formulated:

- no ranking was performed in the analysed set of indicators; however, there is a need for such ranking in terms of waste management importance being part of reverse logistics. As a result, among the analysed indicators, the ones related to the recovery and recycling processes should be assigned higher weights compared to others;
- directions of waste management activities, uniform for voivodships, in particular municipal waste management, should be identified;
- marshal's offices are not capable of balancing the processing capacity of municipal installations because ensuring the volume of waste for a full load of the installation will depend on the price for receiving waste, as well as the criterion of quality and efficiency of a given installation performance;
- an insufficient number of installations for waste recycling and incineration (waste incineration plants).

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USE OF ECOLOGICAL LIGHTWEIGHT AGGREGATES IN REINFORCED CONCRETE STRUCTURES

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ABSTRACT: The article discusses the possibility of utilising both wastes from CHP plants (Combined heat and power plants), i.e. fly ash, and PET plastic waste (polyethylene terephthalate), through processing into lightweight aggregate used construct reinforced concrete beam elements to protect the natural environment. Properties of the utilised lightweight artificial aggregates are presented. Selected results of experimental tests in load-bearing capacity and deformability of reinforced concrete beams made in the model scale are presented. An analysis of the test showed that, despite their lower resistance to crushing, artificial aggregate beam elements have the same load-bearing capacity as reinforced concrete beams made with recycled aggregate, with better flexural strength properties in some cases.

KEYWORDS: bendable elements; artificial aggregates; PET aggregate; recycling; lightweight concrete

Introduction

In 2013 the production of plastic waste worldwide amounted to close to 300 million tonnes and is steadily increasing. The largest quantities of plastic waste are produced on the Asian continent, amounting to 40% of the global production, connected with high population density. Next, the USA, Canada, and Mexico have 19.4%, with the European countries producing 20%. The lowest waste production occurs in Japan and amounts to as little as 4.4%. Analyses show that 40% of plastic waste is sent to landfills, 32% lands in seas and oceans, with only 14% undergoing recycling (Valavanidis, 2016).

By-products, i.e. fly ash and boiler slag, are produced in power plants and CHP plants as a result of coal combustion processes. Waste connected with electricity and heat production has been an environmental concern for decades because they largely end up in landfills. For example, in 2017, bituminous coal consumption in Poland was 74.6 million tonnes, and in 2019 was 68.8 million tonnes. As a result of combustion processes of such amounts of coal, leftover fly ash totalled 3.4 million tonnes (Rolka, Ślęzak, 2012; Statistical information, 2018; Statistical Yearbook, 2018, Statistical Yearbook, 2020).

Fly ash is one of the most important by-products of coal combustion, with years of work put into its utilisation. It is currently utilised to the largest extent in the building materials industry. The chemical and mineral composition of fly ash enables its application as a mineral additive in cement and concrete production as well as lightweight fly ash-based aggregates (figure 1). Its properties depend on multiple factors, including the type of combusted coal, the type of coal combustion installation, the method of preparation, and methods of capture, removal, and storage of ashes. In the case of cement, aggregate and concrete, the fly ash that is utilised to the largest extent is fly ash produced in bituminous coal combustion, i.e. silica fly ash (Rolka, Ślęzak, 2012; Giergiczny, 2007).

The diminishing natural resources are another factor contributing to the development of green construction, as well as to the production of aggregate from waste material. Each year the mining of natural aggregate exceeds 200 million tonnes, with a record level in 2011 when as much as 311 million tonnes of natural raw materials were produced. The decrease of natural resources results from high consumption, but it is also affected by increasing environmental protection requirements that block access to new resources.

Due to the diminishing amounts of natural aggregates and the increasing amounts of waste produced, as well as waste deposited in landfills and oceans, efforts are put into finding possibilities for its processing and reuse. In addition, the construction sector is big enough for it to be able to utilise

newly produced raw materials to a large extent. This results in increasing numbers of studies using waste and recycled materials.

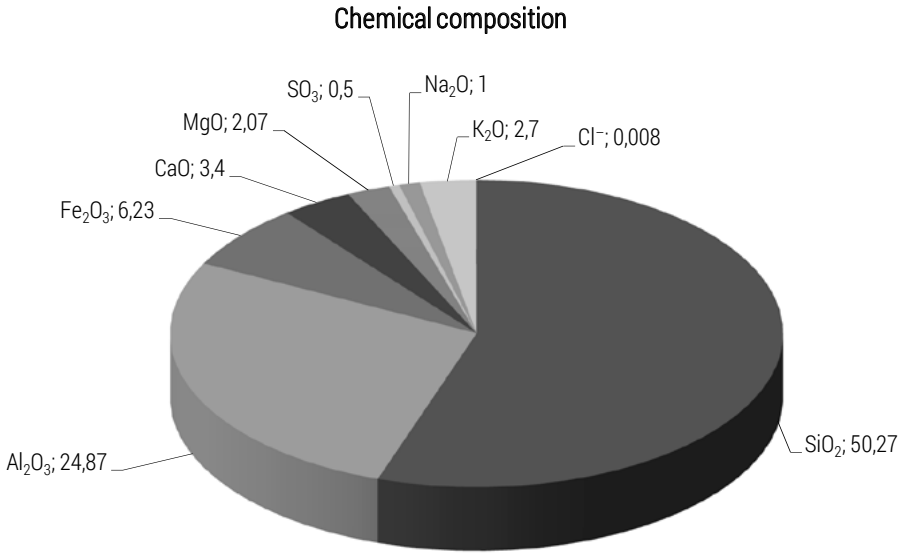


Figure 1. Chemical composition of fly ash [% mass]
Source: author's work.

For several years, scientists have been researching new types of lightweight aggregates. One of the ideas is to combine two types of waste materials of expanded polystyrene (EPS) and unprocessed fly ash (FA) on different properties of concrete (Moayyeri et al., 2016; Bengin, 2017; Ganesh Babu et al., 2005; Petrella et al., 2020). Most research on concrete containing unmodified expanded polystyrene (EPS) has revealed a decrease in concrete's durability and mechanical properties, increasing the amount of EPS particles in concrete. Some studies have reported the importance of using fly ash in concrete, saving a significant amount of energy and cost in cement manufacturing. It can also improve the engineering properties of concrete by replacing it with normal cement. In recent years researchers working in civil engineering have been engaged in investigations about the reuse of waste plastic in concrete construction (Geyer et al., 2017; Pacheco-Torgal et al., 2019; Czarnecki, 2019; Grygo, Łapko, 2012). Some publications focus on the production and performance of concrete with different types of recycled plastic as an aggregate or binder replacement or properties of concrete with recycled plastic fibres.

Materials and Methods

Properties of aggregates used in concrete mixtures

For the purpose of the tests, innovative lightweight recycled aggregate with a fraction of 16 mm was designed and used (figure 2). First, the aggregate was produced by processing used plastic bottles made from polyethylene terephthalate. In the next stage, aggregate adhesion to the cement matrix was improved by covering sand with a grade of 0-2 mm. The production process was carried out using a single-screw extruder equipped with four heat zones, presented in figure 3.

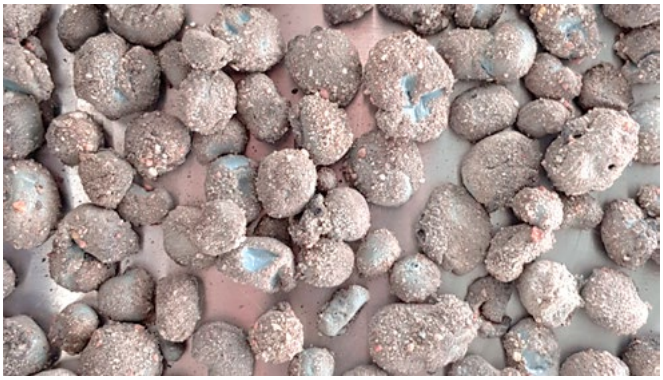


Figure 2. PET aggregate with a fraction of 16 mm obtained by processing used plastic bottles

Source: author's work.

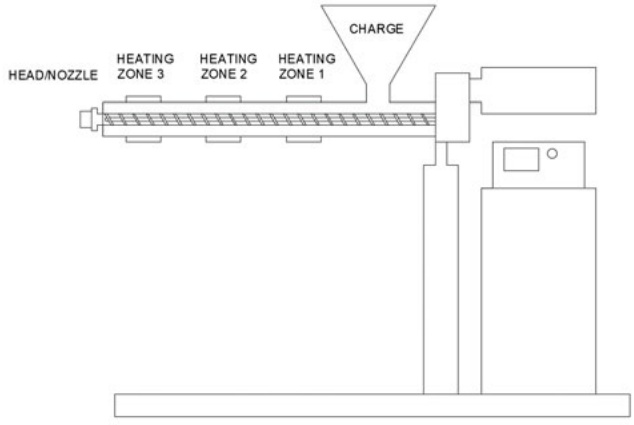


Figure 3. Scheme of the single-screw extruder used for the production of PET aggregate

Source: author's work.

Table 1. Properties of the aggregate obtained from PET bottle recycling (according to PN-EN 1097-6:2002, PN-EN 1097-3:2000, PN-76/B-06714/09, PN-76/B-06714/08)

Aggregate	Water absorption WA24	Density of dried grains	Saturated grain-density	Volume density	Lose bulk density	Voids	Porosity	Tightness
	%	Mg/m^3	Mg/m^3	Mg/m^3	Mg/m^3	%	%	%
PET	5.47	1.00	1.05	0.93	0.66	33.60	6.53	1.07
	3.67	1.00	1.04	0.97	0.65	35.02	3.04	1.03
	4.52	1.01	1.05	0.99	0.65	36.02	2.28	1.02
PET + fillers	3.18	0.97	0.97	0.86	0.46	49.14	10.75	1.12
	5.63	0.99	0.99	0.87	0.46	52.66	12.71	1.15

Source: author's work.

PET aggregate is characterised by very low bulk density at low grain porosity. The bulk density of non-foamed grains is at a level of 660 kg/m^3. In contrast, foamed aggregate deviates significantly from those available on the market, as the density value is 460 kg/m^3, maintaining low levels of absorbability (table 1). Another advantage of the plastic used for lightweight aggregate production is its thermal conductivity, whose value is 0.29 W/m·K.

Figure 4. Certyd aggregate with a grain diameter of 2-4 mm and 4-8 mm

Source: author's work.

Table 2. Properties of aggregates used for the tests

Type of aggregate	Unit	Certyd	Recycled aggregate
Fraction	mm	4/8	4/8
Shape	-	circular	crushed
Bulk density	kgm^3	700	2130
Compressive resistance	MPa	>5	-
Frost resistance	%	<2	< 3.3
Water absorption WA24	%	20	7.2
Radioactivity	Bq/kg	f1 ≤ 1.2 f2 ≤ 240	-

Source: author's work according to PN-EN 1097-6:2002; www.certyd.pl.

The paper also uses fly ash-based aggregate Certyd (figure 4), manufactured in the LSA – Lightweight Sintered Aggregate – technology using an innovative autothermal process of fly ash sintering from electro filters ash-slag mixtures. The main characteristic of aggregates of this type is their bulk density at a level of 620-725 kg/m^3, which results in the possibility to produce lightweight concrete with a density of 1400 kg/m^3. Apart from the low density, it is also characterised by good thermo-insulating properties, frost resistance as well as resistance to fungi, mould and pests.

Figure 5. Aggregate from concrete recycling

Source: author's work.

Recycled aggregate was produced by crushing rubble leftover from the demolition of Fabryka Przyrządów I Uchwytów (machine and tool manufacturer) in Bialystok (figure 5). The crushing was carried out on a Tamel S.A. crusher with an optimised size reduction ratio. Then the obtained aggregate was subjected to sieving in order to separate particular fractions.

Study design

Reinforced concrete beams 8×12×110 cm were produced from 6 mm and 8 mm B500A and BFRP (Basalt Fibre Reinforced Polymer) steel rebars, whereas pull reinforcements were produced from smooth 3 mm rebars in three series (figures 6 and 7). The first series comprises elements made with recycled aggregate marked "R". In the second series, marked "P", fly ash based aggregates Certyd were used. In the third series, marked "PR", aggregate produced by processing used PET bottles were used. Beams P-1, P-4, and R-1, with a degree of reinforcement of $\rho = 0.67\%$, had 2×6 mm top and 2×6 mm bottom reinforcements. Beams P-2, P-3, and R-2, with a degree of reinforcement of $\rho = 1.21\%$, had 2×6 mm top and 2×8 mm bottom reinforcements. In model beams, PR-1 2×8 mm and 4×8 mm bottom steel reinforcements were used, whereas series PR-2 contained basalt (BFRP) 2×8 mm and 4×8 mm bottom reinforcements (figure 8). Beams PR-1 and PR-2 had a degree of reinforcement of $\rho = 2.37\%$.

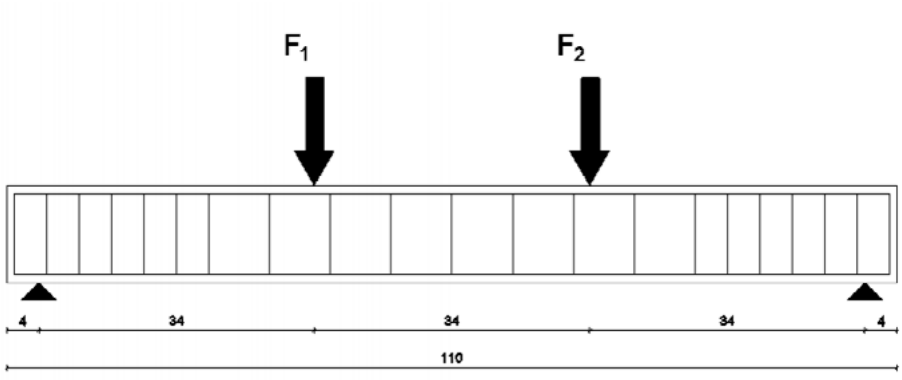


Figure 6. Scheme of the tested beams with load

Source: author's work.

Figure 7. Reinforcing frames of reinforced concrete beams – top basalt rebars, bottom steel rebars

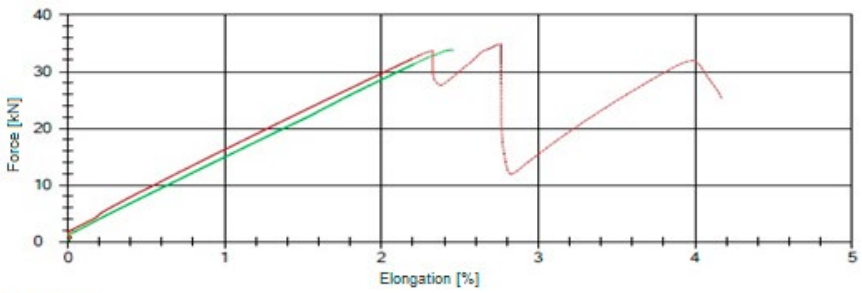
Source: author's work.

Basalt rebars are a composite product with a wide range of uses in construction. They are characterised by considerable resistance to the action of aggressive chemical environments and corrosion, as well as durability and low weight. Basalt rebars (BFRP) consist of fibres with diameters ranging from several to several tens of micrometres and a polymer matrix. They are manufactured in the pultrusion technology, ensuring the repeatability of the produced rebars, production continuity, and lower energy expenditures. The main ingredient is basalt fibres produced as a result of remelting of basalt rock, also called volcanic lava, at a temperature of 1400°C. The role of fibres is to ensure adequate, appropriate tensile strength of rebars, whereas resin is responsible for protecting the surface from damage, maintaining the appropriate distance between fibres, and transferring tensile stresses to them. According to (ACI 440.1R-15 Guide for the Design and Construction of Structural Concrete Reinforced with Fiber-Reinforced Polymer (FRB) Bars), proper cooperation between FRP reinforcement and concrete can be achieved

through three methods of rebar surface finishing. The first method is coating with modelling sand, the second – producing ribs in the same way as in the case of steel reinforcement, while the third – wrapping around rebar from the additional fibre layer (Grygo, Kosior-Kazberuk, 2017).

Test result:

Nr	Sample	m_E GPa	R_m MPa	A_{gt} %	$t_{badanie}$ s	d_0 mm	S_0 mm^2
1	1	47.2	1180	2.8	349.71	6.14	29.61
2	2	47.9	1200	2.5	339.27	6	28.27



Statistics:

Series n = 2	Sample	m_E GPa	R_m MPa	A_{gt} %	$t_{badanie}$ s	d_0 mm	S_0 mm^2
x	2	47.6	1190	2.6	344.49	6.07	28.94
s	1	0.505	14.3	0.2	7.38	0.09899	0.94
V [%]	47.14	1.06	1.21	8.27	2.14	1.63	3.26

Figure 8. Graph showing the tensile strength of BFRP rebars

Source: author's work.

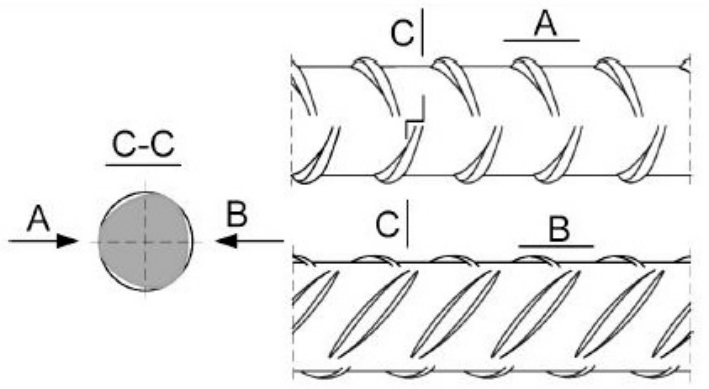


Figure 9. B500A ribbed reinforcing bars

Source: author's work based on PN-EN 12390-5:2009.

The yield strength of B500A steel is 500 MPa and has low malleability (figure 9). According to Polish Standards is A-IIIN steel, while according to Eurocode 2 – class A. It is characterised by parallel, transverse ribs, which may be placed in two rebar rows on both sides. The ribs are inclined in the same direction (PN-EN 12390-5:2009).

Three formulas for concrete mixture components were designed for the tests, using recycled concrete aggregate – series "R", fly ash based– series "P", and concrete produced by processing plastic from used PET bottles – series "PR". During the analysis, special attention was paid to the bulk densities of both aggregates, as they lead to differences in their contents as expressed in kilograms. The composition of concrete mixtures is presented in tables 3 and 4.

Table 3. Compositions of concrete mixtures in series "P" and "R"

Series Component	P-1	P-2	P-3	P-4	R-1	R-2
	Quantity [kg/m^3]					
Cement (CEM I 42,5 R)	270				260	
Water	221				170	
Sand 0-2 mm	680				585	
Aggregate 2-4 mm	336				528	
Aggregate 4-8 mm	168				712	
Admixture Chryso Omega	3.9				2.6	

Source: author's work.

Table 4. Formula of 1m^3 trial feed based on PET plastic waste aggregate

Series Component	PR-1	PR-2
	Quantity [kg/m^3]	
Cement (CEM I 42,5 R)	350	
Water	205	
Sand 0-2 mm	1032	
PET aggregate 16 mm	500	
Admixture Chryso Premia	7	

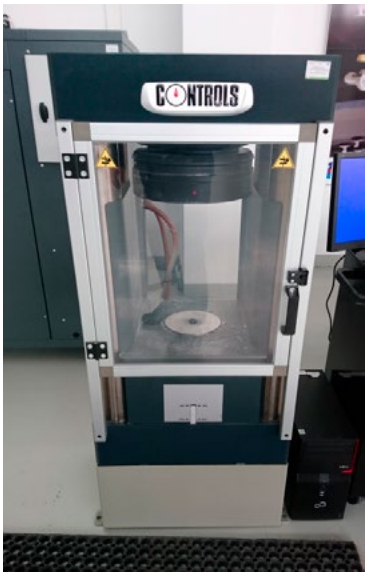
Source: author's work.

Measurements of deflection of the tested reinforced concrete beams were performed at the sample midspan using electronic sensors with an accuracy of 0.01 mm. Deflection values were recorded with the2 kN force

stroke. The results were recorded and processed in Excel. Tests of the load-bearing capacity of beams were carried out on a Controls destructive machine with the span of the applied load equalling 1/3 of the beam span. Figure10 shows the test stand for the model beams.

Figure 10. Test stand for reinforced concrete model beams

Source: author's work.



The compressive strength of hardened concrete was determined on cubical samples with a side length of 100 mm. Figure 11 shows the Controls destructive machine used to perform the compressive strength tests of the concrete samples.

Figure 11. The Controls destructive machine

Source: author's work.

Results and Discussion

Compressive strength tests of hardened concrete

The tests of compressive strength of concrete samples were carried out after the concrete had cured for 28 days, according to PN-EN 12390-3:2011/AC:2012. Compressive strength of cubical samples was calculated according to the following formula:

$$f_c = \frac{F}{A_c} \cdot \eta \,,$$

where:
f_c – compressive strength, in MPa (N/mm^2),
F – maximum force at destruction, in N,
A_c – cross-section area of the sample with compressive force, calculated based on the declared sample dimensions or based on its measurements, in mm^2,
η – ratio depending on the dimensions of the used forms; for cubical forms with a side length of 100 mm – η = 0.9.

The results for compressive strength for cubical samples in series P-1÷P-3, R-1÷R-3, and PR-1÷PR-3 are presented in table 5. Destruction of series PR is visualised in figure 12.

Table 5. Results of compressive strength tests of concrete after 28-day curing

Number	Series	Force	Compressive strength f_{ci}	Average compressive strength f_{cm}
		[kN]	[MPa]	[MPa]
1.	P-1	335.40	30.19	29.50
2.	P-2	317.20	28.55	
3.	P-3	330.60	29.75	
4.	PR-1	242.50	21.83	22.03
5.	PR-2	239.55	21.56	
6.	PR-3	252.20	22.70	
7.	R-1	533.50	48.02	47.81
8.	R-2	513.00	46.17	
9.	R-3	547.00	49.23	

Source: author's work.

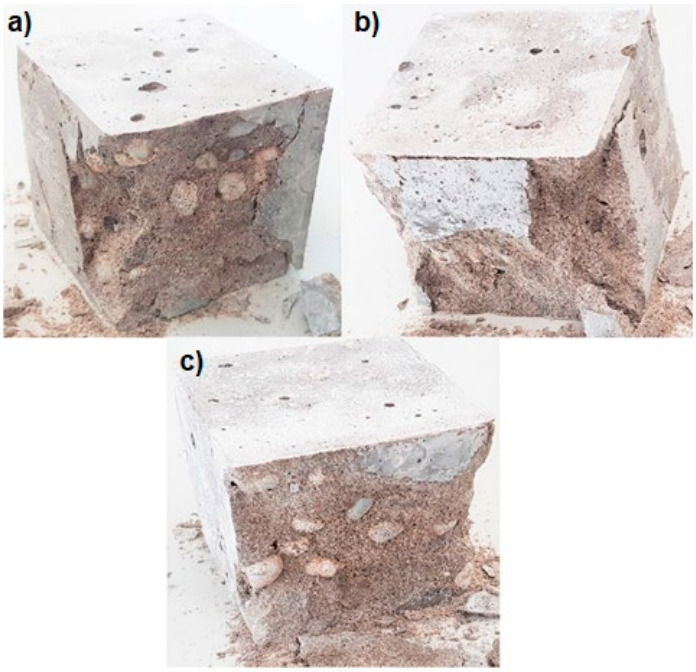


Figure 12. Destruction of concrete samples in series PR:
a) sample PR-1, b) sample PR-2, c) sample PR-3

Source: author's work.

After visual inspection of the destroyed cubes it must be noted that PET (PR) aggregate did not distribute evenly throughout the sample's cross-section. The bottom part contained plastic aggregate only in negligible amounts as a significant amount was present in the middle and top parts. This is a result of the low density of the aggregate.

Tests of tensile strength at splitting

The results of determinations of tensile strength at splitting according to EN 12390-6:2011 and the values of the splitting force for cylindrical samples with a diameter of 15 cm and a height of 30 cm are presented in table 6, whereas figures 13-15 show destruction of samples in the tested series.

When analysing the tested series "PR" sample, it can be noted that the crack only appeared at ¾ of the sample height, counting from its bottom part. The reason for such destruction is an uneven distribution of aggregate within the sample – a negligible part of coarse-grain aggregate was present in the bottom part, which resulted in the crack appearing precisely in that place. During densification, the aggregate moved upwards.

Table 6. Results of tests of tensile strength at the splitting of polymer-based, recycled, and fly ash-based aggregate samples

Series	Force	Tensile strength at splitting f_{ti}
	[kN]	[MPa]
PR	111.60	1.58
R	219.50	3.10
P	195.43	2.76

Source: author's work.

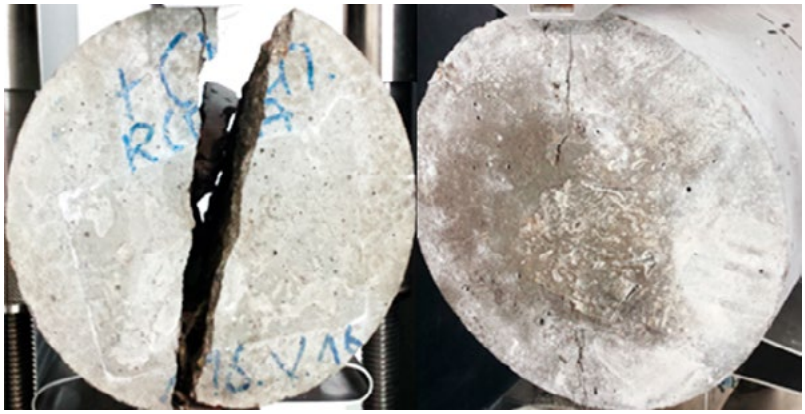


Figure 13. View of cylindrical samples in series R (left) and P (right) after the destruction

Source: author's work.

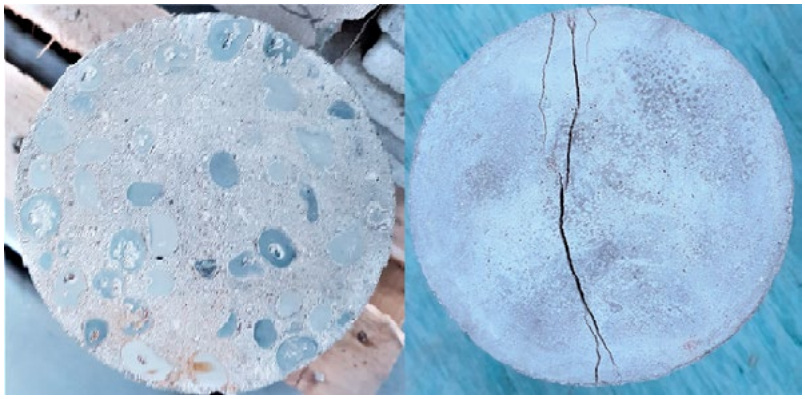


Figure 14. View of a series PR sample after destruction – top (left) and bottom (right) part of the cylinder

Source: author's work.

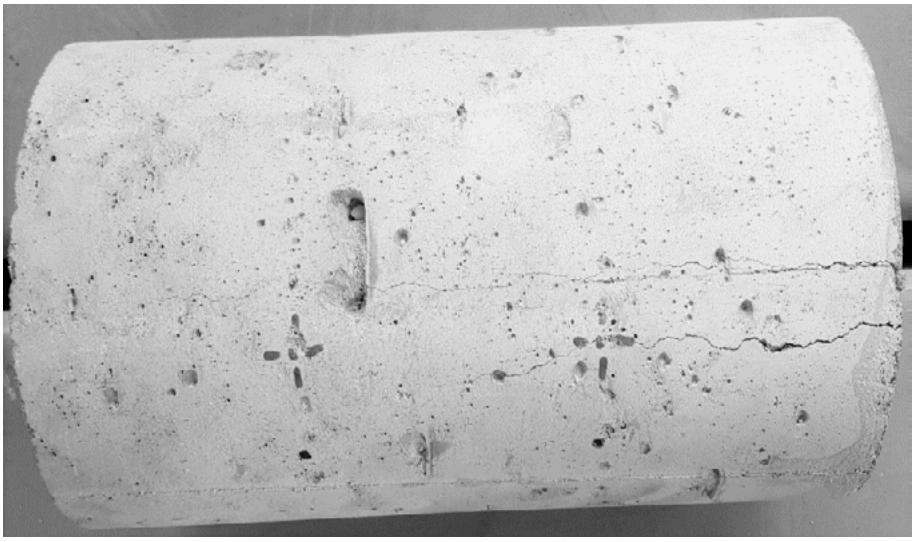


Figure 15. Side part of a PR series cylinder after the destruction
Source: author's work.

Tests of load-bearing capacity and deformability of reinforced concrete model beams

The load-bearing capacity and deformability tests were carried out after curing the concrete for 28 days. Below, the measured values of deflection, together with the calculated average values at given loads for beams with degrees of reinforcement $\rho = 0.67\%$ and $\rho = 1.21\%$, series "PR", are presented in the form of tables and graphs. In both cases, beams made with recycled aggregate are characterised with higher deflection compared to reinforced concrete beams made with fly ash based aggregate. Steel-reinforced beam PR-1 is characterised with a considerably lower deflection than basalt-reinforced beam PR-2. The graphs in figure 16 illustrate the relationship between deflection and the applied load.

When analysing the deflection values for the tested model beams contained in table 7, it should be noted that series "P" beams made with fly ash based aggregate are characterised with lower deflections. At a loading force of 16 kN, the greatest difference occurs in the case of samples PR-1 and PR-2 and equals 4.47 mm, i.e. 64% less than the beam made with the use of basalt reinforcement.

Table 7. Deflection of series "P", "R" and "PR" beams

Applied load	Deflection [mm]										
[kN]	PR-1	PR-2	Average	P-1	P-4	R-1	Average	P-2	P-3	R-2	Average
0	0	0	0	0	0	0	0	0	0	0	0
2	0.03	0.42	0.42	0.28	0.26	0.40	0.40	0.33	0.36	0.40	0.36
4	0.54	0.92	0.92	0.75	0.47	1.08	0.77	0.52	0.66	0.65	0.61
6	0.83	1.85	1.34	1.36	0.96	1.81	1.38	0.71	0.86	1.01	0.86
8	1.13	2.81	1.97	2.13	1.58	2.49	2.07	1.03	1.24	1.35	1.21
10	1.46	3.73	2.60	2.58	2.21	3.12	2.64	1.36	1.67	1.69	1.57
12	1.80	4.74	3.27	3.17	2.89	3.71	3.26	1.72	2.09	2.00	1.94
14	2.15	5.72	3.94	3.77	3.47	4.33	3.86	2.08	2.47	2.34	2.30
16	2.52	6.99	4.76	4.42	4.10	4.95	4.49	2.43	2.87	2.66	2.65
18	2.87	7.73	5.30	5.18	4.94	5.88	5.33	2.81	3.28	3.03	3.04
20	3.25	8.72	5.99	9.56	8.28	9.60	9.15	3.18	3.70	3.42	3.43
22	3.66	9.77	6.72	12.94	12.53	13.29	12.92	3.57	4.21	3.83	3.87
24	4.07	10.93	7.50					3.98	4.68	4.25	4.30
26	4.50	11.99	8.25					4.42	5.20	4.70	4.77
28	4.94	13.05	9.00					4.89	5.68	5.23	5.27
30	5.44							5.56	6.23	5.64	5.81
32	5.99							6.24	7.14	6.28	6.55
34	6.75							7.18	10.38	7.08	8.21
36	8.06							10.25		10.21	10.23
38	9.87										
40	11.24										
42											
Critical load [kN]	40.21	28.10		20.86	21.32	21.24		35.30	32.85	35.84	

Source: author's work.

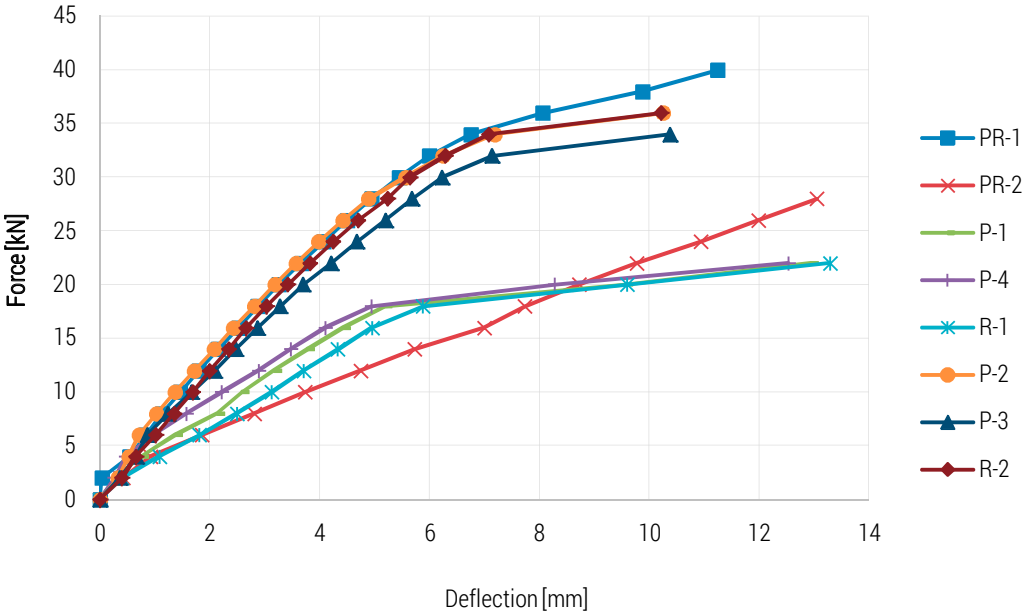


Figure 16. Load-deflection ratio plot – deflection for series "R", "P", and "PR"
Source: author's work.

The results of tests of the load-bearing capacity of reinforced concrete beams are summarised in figure 17 in the form of a bar chart. The breaking moment values for the particular beams were calculated according to the following formula:

$$M_{breaking} = \frac{P}{2} \cdot \frac{L}{3} = \frac{P \cdot L}{6},$$

where:
P – force [kN],
L – length of beam [m].

When analysing the presented results of flexural strength tests of model beams, series "R" is characterised with a slightly higher load-bearing capacity; however, the results are comparable with series "P", made with fly ash-based aggregate. Nonetheless, the highest load-bearing capacity occurred in the case of beam PR-1 made with PET plastic aggregate. The highest difference exists between beams P-3 and R-2, with the value for beam P-3 being lower by 8% compared to R-2. When comparing two types of reinforcement, it should be noted that sample PR-2 is characterised with a lower load-bearing capacity; this is, however, caused by the occurrence of shearing.

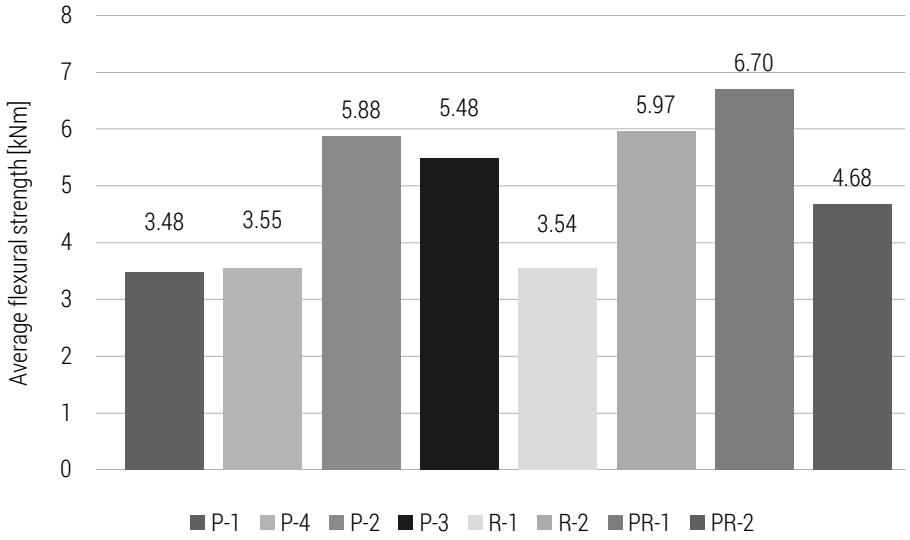


Figure 17. Average flexural strength of each of model beams [kNm]

Source: author's work.

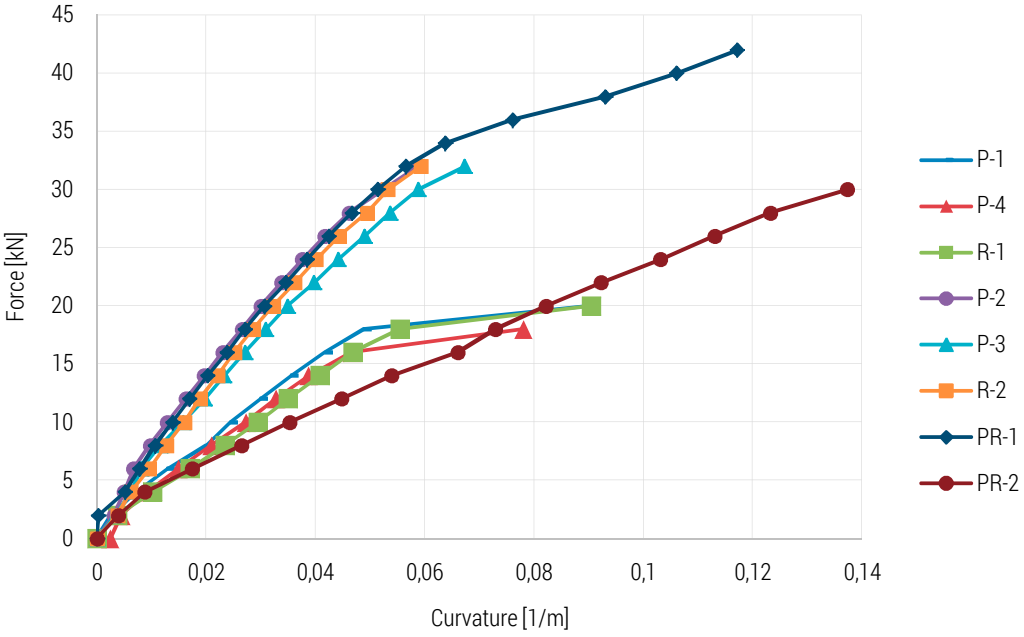


Figure18. Graph showing force P – curve X ratio for all beam series

Source: author's work.

Below, the values of stiffness B for all the tested reinforced concrete beams are summarised, while figure 18 shows a comparative plot showing the following ratio: force P – experimental curve X of the tested beams.

When analysing the tabular results presented above, as well as the graph showing experimental curves X and stiffness B of the tested reinforced concrete beams, it should be noted that although beam P-2, made with fly ash based aggregate, is characterised with the highest stiffness B compared to all the samples, series PR-1 beam is characterised with only marginally lower values of stiffness B than sample P-2, as the difference is only about 5%. At the same time, beams made with CERTYD and PET aggregates are characterised with lower values of experimental curves X for a given force, compared to reference beam REC, by 23% and 16%, respectively.

Conclusions

The tests of reinforced concrete model beams showed beneficial effects of using fly ash based aggregates for concrete. However, a comparative analysis of the measured values of deflections of model beams with degrees of reinforcement of ρ = 0.67% and ρ = 1.21% at bending enables to conclude that deflections of series "P" beams are characterised with lower values, from 9 to 17%, compared to series "R", made with recycled aggregate. When comparing the values of deflections of beams PR-1 and PR-2, on the other hand, using reinforcement of various types, i.e. steel and basalt, it should be noted that beams with composite reinforcement are characterised with values of deflections higher by as much as 177%.

Using fly ash based aggregates in the innovative LSA (Lightweight Sintered Aggregate) technology made it possible to reduce deflections of model reinforced concrete beams, while at the same time, load-bearing capacity remained at a level comparable to series "R" beams. When comparing the load-bearing capacity results for different beams, it can be noted that those in series "R" are characterised with values higher by as little as 1.5 to 8.2%. At the same time, they are characterised with higher deflection values, from 9.5 to 12%, at a particular force, compared to beams made with fly ash based aggregate. The highest value of load-bearing capacity was achieved in the case of beam PR-1 with aggregate produced from waste, i.e. plastic PET bottles, which equalled 6.70 kNm. The reason for the low strength of beam PR-2 made with composite reinforcement was the presence of shearing during sample loading.

When analysing the values of stiffness B for all the tested samples of reinforced concrete beams, it has been concluded that the highest values of stiffness B were achieved in the case of sample P-2 made with from fly ash aggre-

gate; however, a virtually identical result was obtained for beam PR-2, as the difference was as little as about 5% in favour of P-2.

A very small bulk density characterises PET aggregate. In the case of non-foamed grain, its bulk density is similar to that of Certyd aggregate, which is a porous aggregate. On the other hand, when comparing both porous aggregates, PET aggregate, with a bulk density of 460 kg/m^3, has a significant advantage, producing a result lower by 26% compared to Certyd. An additional advantage of the innovative aggregate is its low absorbability, at a level of 4.5 % (PET plastic has low absorbability at a level of about 0.2%).

When analysing the properties of the innovative aggregate produced from processed, used polyethylene terephthalate bottles, it can be concluded that it is characterised with above-average parameters compared to the lightweight aggregates already available on the market. This leads to the willingness to conduct further research using the aggregate in question in concrete to reduce the amounts of waste deposited in landfills and protect the environment.

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The contribution of the authors

Robert Grygo: conception – 50%, literature review – 40%, experimental research – 50%, analysis and interpretation of data –40%.

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Kevin Bujnarowski: conception – 20%, literature review – 40%, experimental research – 50%, analysis and interpretation of data – 30%.

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AGRICULTURE AND SCIENCE COLLABORATION: THE CASE OF ŁÓDŹ VOIVODESHIP (POLAND)

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ABSTRACT: The article aims to evaluate the cooperation of Polish farmers from ŁódźVoivodeship with science and other farmers in the field of implementing innovation in farms. Paper and Pencil Interview (PAPI) method was used. The analysis covers150 Polish farms located in the Łódź Voivodeship. The farms for the study were selected from the Polish FADN (Farm Accountancy Data Network) sample. The study was made in 2018. The conducted research has proved that interest in scientific achievements depends on the innovativeness of farms. The cooperation between Polish farmers from Łódź Voivodeship in the field of innovation activity does not differ in terms of their farming type. A consequence of the farms' selection is the lack of the ability to generalise the results to the entire population of farms in the Łódź Voivodeship. The added value of the analysis is the presentation of the results in terms of farm innovation.

KEYWORDS: agricultural innovation, farms, farms and science collaboration

Introduction

A much higher risk of failure characterises the innovation activities undertaken by the farmer than in other sectors of the economy. Farms can implement several types of innovations, including product and process. The innovative process is extremely complicated and time-consuming. Implementing innovations for most farmers relies on their knowledge and experience of other holdings, which may prove to be insufficient innovation activity and condemned to failure.

For this reason, supporting farmers in this area seems essential and necessary. Furthermore, foreign studies show that farms cannot just be passive participants while implementing innovations but must stimulate the activity of research and development related to innovation activities. In this dimension, agricultural innovation systems are already in operation, aiming to connect a number of factors related to the implementation of innovation, such as farmers, R&D institutions, universities, agricultural advisory services, non-governmental organisations, and the financial system. Proper cooperation of these entities and the active participation of innovative farmers in the processes can significantly affect a higher degree of commercialisation through/by using the obtained research results.

The article aims to evaluate the cooperation of Polish farmers from Łódź Voivodeship with science and other farmers in the field of implementing innovation in farms.

The analyses were prepared based on questionnaire interviews (PAPI method) conducted in 2018 in the Łódź Voivodeship in Poland. The farms for the study were selected from the Polish FADN sample. These entities voluntarily keep accounting and provide this information to the FADN.

An overview of the literature

Innovation is extremely popular and applies to every economic sector, including agriculture. Thematic popularity also translates into scientific publications. However, researching the field of innovation in agriculture is additionally hindered. The specificity of the activity and the lack of a universal tool for measuring the innovativeness of farms results in the lack of published data that could be used to assess it. The possible reason for this is the lack of a clear definition that would indicate what could be classified as agricultural innovation (Läpple et al., 2015, p. 2) and the fact that innovation, in general, is a phenomenon difficult to measure due to its complexity (OECD, 2010, p. 30).

The factors determining the implementation of innovations by farmers that appear in the literature were divided into two groups of variables: structural (related to the farm and innovation activity) and behavioural (features directly related to the farm manager). Economic size is one of the most frequently mentioned structural variables conditioning the implementation of innovation in agriculture. The authors emphasise that farmers with larger farms are more likely to innovate (Diederen et al., 2002; Deuninck et al., 2008; van der Meulen et al., 2016). Besides, farms with crop production implement innovations more often than other types of agricultural entities (van der Meulen et al., 2016). There is some doubt about farm debt as some authors state that households with higher indebtedness can implement innovations earlier using the incurred debt (von Pischke, 1978; Diederen et al., 2002). However, some studies have not positively verified this hypothesis (Lipton, 1976; Blank & Weber, 1994). In addition to these essential factors, the implementation of innovation is also conditioned by such variables as solvency (Diederen et al., 2002; Läpple et al., 2015), the number of people on the farm (Läpple et al., 2015), market position (Diederen et al., 2002), net value-added, family farm income, operating subsidies, assets, cash flow (van der Meulen et al., 2016).

In the group of behavioural variables, the farmer's age should be highlighted, which most often appears in models of farm innovation. The authors state that a senior farmer is less willing to implement innovation (Diederen et al., 2002). It is related to lower education and, thus, a lack of skills to assess innovation possibilities. Older farmers may also have a shorter time horizon and be less willing to invest in new technologies. Also, the implementation of innovations is conditioned by behavioural variables such as off-farm work, marriage, agricultural education (Läpple et al., 2015).

Unfortunately, most of the works mentioned above omit an essential factor that condition the implementation of innovation, namely the cooperation of farmers with science. The successful diffusion of innovation is not possible without cooperation. Current researches on innovation collaboration between sectors focus mainly on the manufacturing industry (Liu et al., 2019; Lalic et al., 2016; Broekel & Boschma, 2012) and the high-tech industry (Mikhaylov et al., 2018, Hong et al., 2014, Liefner & Hennemann,2011; Li et al., 2011). However, agriculture is ignored in these studies.

The lack of research on cooperation in agriculture does not mean that it is absent or there is no need for it. Cooperation in climate change and the growing trend towards organic food has helped farmers realise their vision of agriculture. This applies to, among others sharing know-how in organic farming methods, promoting a seed bank, encouraging farm education systems, or reducing fossil energy consumption (Lutz et al., 2017, pp. 934-935).

Cooperation allows for better results to be achieved than through an individual project. The strengths of one group can compensate for the limitations of the other (Hoffmann et al., 2007, p. 355). Countries such as Sweden and Denmark have accumulated experience in this field since the 19th century (Moraru, 2018; Böök & Johansson, 1988; Lantbrucarnas Riksförbund and Swedish Cooperative Centre, 1980). In Poland, the Agricultural Advisory Center started operating only in 2005, and one of its priorities is building a knowledge transfer network for innovation.

Cooperation in agriculture can have a diverse nature. However, in this work, the author would like to draw attention to its two basic types: farmers with science and farmers with farmers. Each has its advantages, and their combination can guarantee success in implementing innovation and sustainable development of a farm.

Farmers' cooperation with science requires a full understanding of each group's knowledge, skills, and limitations. Research projects are often implemented with limited contact between scientists and farmers, which can result in misunderstandings. As a result, communication and interaction between the two groups remain superficial (Hoffmann et al., 2007, p. 356). Despite many adversities, there are many examples of successful cooperation between scientists and farmers. One such example is a pioneering initiative to regenerate cultivated biodiversity as a result of cooperation between French farmers, facilitators, and scientists (Berthet et al., 2020).

Another example is the Indian selection of the most appropriate crop and plant density based on climate forecasts (Meinke et al., 2013). Regarding forecasts, mention should be made of SARRA-h, a crop monitoring system that uses rainfall forecasts to assess the probable sorghum yield in Burkina Faso (Mishra et al., 2008). Understanding farmers is extremely important in the cooperation of farmers and scientists. The speed of establishing cooperation can greatly reduce the effects of climate change. The method of establishing contact is significant in this respect. A Colombian team of researchers explored a way of establishing a dialogue between scientists and farmers that would give farmers opportunities in the face of short- and long-term climate change. They used for its Local Technical Agro-Climatic Committees (LTACs) in two Colombian regions (Loboguerrero et al., 2018). Searching for dialogue methods is important because farmers consider it riskier to introduce innovations from socially distant external entities than those developed by farmers (Hoffmann et al., 2007, p. 359).

Studies have shown that cooperation with other farms is very important for farmers. According to them, cooperation means reducing costs and labour and increasing the value of know-how (Lutz et al., 2017). Farmers prefer cooperation between farms rather than science because they have the same

problems as a social group. Conducting the same activity, they understand its specificity. Thanks to this, they can share their solutions and ideas. Informal cooperation has been and will be important among farmers, especially for small farms (Lutz et al., 2017, p. 926). This applies not only to shared machine parks and know-how but also to mutual assistance in fieldwork, especially during the harvest season (Cialdella et al., 2009, p.133). However, nowadays, formal cooperation groups between farmers are increasingly important. One of the most frequently mentioned countries in the field of cooperative agricultural relations in the Netherlands. Environmental Cooperatives have been in operation there since the 1990s – EC (Riley et al., 2018). Their main advantage is strengthening the voice of farmers when implementing new projects. Similar formalised farmers' cooperation groups operate, among others in Germany (Prager & Vanclay, 2010) and in Great Britain (Franks et al., 2007).

Many studies indicate that cooperation between farmers brings measurable benefits, especially in the context of environmental protection (Siebert et al., 2006, Soini & Aakkula, 2007). However, this cooperation will not always be possible. The degree of development of entities is a big limitation. For example, organic and conventional farmers will not agree on the common meaning of 'good farming' about agricultural production and environmental protection (Slovenc, 2019, p. 125). Besides, in their work, Riley et al. (2018) showed that the relationships between farmers are not universal and differ depending on the type of business. Farmers also often have conflicts with their neighbours, including personal misunderstandings that have been identified as barriers to participation in formal groups (Franks et al., 2016).

In Poland, formal operational groups began to operate only as part of the EU funding perspective for 2014-2020. They operate based on The Agricultural European Innovation Partnership (EIP-AGRI). The Network for Innovation in Agriculture and Rural Areas (SIR) helps build these groups. In addition to farmers, advisors, entrepreneurs, innovation brokers, and NGOs, the network also includes the Ministry of Agriculture and Rural Development, state research institutes, and universities, as well as local governments (SIR,2020). The diversity of network participants ensures the correct interaction within operational groups, resulting in the development of innovative projects that can be implemented in practice.

When implementing innovations, collaboration is important at every stage of this process. Undoubtedly, in times of climate change, the importance of cooperation increases. Therefore, all agricultural stakeholders must cooperate in implementing climate-smart agriculture practices (Kilungu & Meadu, 2014).

Research methods

Concerning the work purpose, as well as to the arguments collected based on reading the cited research papers, the following hypotheses were formulated:

H1: *Interest in learning achievements depends on the innovativeness of farms from Łódź Voivodeship.*

H2: *The cooperation of farmers and farmers from Łódź Voivodeship varies depending on the type of business.*

Empirical research was conducted on a sample of farms sharing their accounting data as part of the Farm Accountancy Data Network (FADN). Polish FADN is the only institution that collects sensitive farm data. The set of agricultural entities keeping accounts under the Polish FADN in 2018 included 12,032 farms of natural persons and 188 farms of legal persons. The total number of 12,220 entities is a statistically representative sample in terms of agricultural type and economic size class, as well as the FADN region for the Polish FADN observation field numbering 730,883 commercial farms in Poland (Floriańczyk et al., 2019, p. 44). Participation in FADN is voluntary, and therefore farms may opt-out of accounting after only one year. Failure to continue recording income and costs makes it difficult to compare and analyse results. Unfortunately, FADN is the only institution that regularly collects farm financial data. The thematic scope of the database does not apply to both innovation and R&D activities. However, the Polish FADN helps conduct individual surveys on a sample of accounting farms.

Questionnaire interviews were conducted at the end of 2017 and 2018 using the PAPI method. The analysed farms operate in the Łódź Voivodeship. The selection of objects for the study was purposeful within the economic size of the farms. The entities were selected for examination by the Institute of Agricultural and Food Economics – National Research Institute. In 2018, 880 farms participated in the FADN agricultural accounting system in the Łódź Voivodeship, of which 390 are the smallest entities with an economical size below 25,000 euros, and 490 – farms with a size exceeding 25,000 euros (Polski FADN, 2020). Research works covered farms with a crop, livestock, and mixed production profile. Farms with an economic size of fewer than 25,000 euros were rejected. This is because they are generally social entities that show low levels of investment and debt. Thus, the final sample selected for the study included 490 farms.

Questionnaire interviews using PAPI method were possible thanks to the support of the advisory service of the Łódź Agricultural Advisory Centre in Bratoszewice. This assistance was necessary due to legal restrictions on access to data and information security.

In order to carry out the study, an interview questionnaire was used, containing mainly closed questions (31) and a small number of open questions (5). The questionnaire was divided into three substantive parts:

- Part I – Characteristics of a farm;
- Part II – Innovative potential of a farm;
- Part III – Financing the innovative activity of a farm.

After the interviews, 150 correctly completed questionnaires were received, covering 30.6% of selected entities.

In developing the study results, appropriate computer programs were used, including PS Imago 5.1, as well as Microsoft Office (with particular emphasis on Word and Excel).The implementation of the goal and the verification of hypotheses was possible thanks to the use of the following statistical measures: structure indices, mean, median, standard deviation, coefficient of variation and V-Cramer's coefficient.

Due to the term research design (2016-2017), all concepts related to innovation were taken from the Oslo Manual 2005. Thus, innovation is understood as "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD, 2005). The author is aware of the current version of the manual (OECD, 2018). However, when the concept of the study was developed and conducted, it had not yet been published. Therefore it is justified to cite the Oslo Manual 2005 methodology (mainly in terms of defining innovation).

Results of the research

Entities conducting mixed activity predominate among the surveyed individual farms (46.3%). This is the most popular type of activity among entities with an economic size of no more than 100,000 euros (medium-small and medium-large).

Table 1. Type of individual farms by economic size class (in %)

Type of individual farms	Economic size class of individual farms			Total
	medium-small	medium-large	large and larger	
crop	17.2	20.0	33.3	20.8
livestock	24.1	38.6	38.1	32.9
mixed	58.6	41.4	28.6	46.3
Total	100.0	100.0	100.0	100.0

Source: own study based on the interviews conducted.

In contrast, the greatest part of large and larger farms (with an economical size exceeding 100,000 euros) conducts livestock production (table 1).

57.3% of analysed farms introduced at least one innovation in 2016-2018 (table 2). It should be noted that medium-sized entities are characterised by the highest activity in this area (50 000 < euros < 100 000). The smallest farms happened to be the least innovative.

Table 2. Innovativeness of individual farms by economic size class (in %)

Innovativeness of farms	Economic size class of individual farms			Total
	medium-small	medium-large	large and larger	
farms that have not implemented innovation	60.3	31.4	31.8	42.7
innovative farms	39.7	68.6	68.2	57.3
Total	100.0	100.0	100.0	100.0

Source: own study based on the interviews conducted.

Farmers most often implemented process innovations at the farm level. 88.4% of innovative farms conducted this kind of activity. 21.2% of product innovations were implemented at the local market level (in the Łódź Voivodeship). However, only 3% of product innovations are new in the country (table 3).

Table 3. Range of implemented product and process innovations (in %)

Range of innovations	Type of innovation		Total
	product	process	
at farm level	75.8	88.4	84.3
at local market level	21.2	11.6	14.7
at domestic market level	3.0	0.0	0.0
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

When analysing innovation, the expenditure on this type of activity should not be forgotten. In this work, the ratio of expenditure to income from a farm (FADN data from 2016) is understood as an innovation degree. Table 4 presents the basic parameters of the indicator for all economic values of the analysed entities. On average, 24.2% of income are spent by large and larger farms annually on implementing innovation. However, this group is characterised by a huge diversity, indicated by the high standard deviation and

a coefficient of 80.2%. The smaller the entities, the smaller the expenditure on innovation activities.

Table 4. Degree of innovativeness of individual farms by economic size class (in %)

Parameters	Economic size class of individual farms			Total
	medium-small	medium-large	large and larger	
	19.3	22.8	24.2	22.1
Me	15.0	20.0	19.5	20.0
S(x)	15.2	12.5	19.4	14.5
VS(x)	78.8	54.8	80.2	65.6

– mean, Me – median, S(x) – standard deviation, VS(x) – coefficient of variation.
Source: own study based on the interviews conducted.

A high degree of innovation makes it possible to analyse the cooperation of farmers with scientists and with other farmers. Respondents were asked if they were interested in the learning achievements in the field of conducting an activity that could contribute to the development of the farm. The vast majority (82.0%) answered in the affirmative. Interestingly, farms that have already implemented innovations show the greatest interest (table 5). The V-Cramer coefficient has confirmed the relationship between innovation and interest in science. This relationship is weak but statistically significant (V = 0.272; p = 0.002).

Table 5. Interest in learning achievements by the innovativeness of individual farms (in %)

Are you interested in learning achievements in the field of your business that could contribute to the development of the farm?	Innovativeness of individual farms		Total
	farms that have not implemented innovation	innovative farms	
Yes	70.3	90.7	82.0
No	3.1	2.3	2.7
I have no opinion	26.6	7.0	15.3
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

84.9% of innovative farms also believe that there is a need for cooperation between farmers and scientists. Over 4.7% of entities that have not implemented innovation do not see such a need (table 6).

Table 6. The need for farmers to cooperate with scientists by the innovativeness of individual farms (in %)

Do you think there is a need for farmers to cooperate with scientists from universities and research institutes?	Innovativeness of individual farms		Total
	farms that have not implemented innovation	innovative farms	
Yes	73.4	84.9	80.0
No	4.7	2.3	3.3
I have no opinion	21.9	12.8	16.7
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

The literature review has already noted that farmers' cooperation with science can bring several benefits. According to respondents, the most important is "the possibility of solving specific problems on the farm". 40.0% of non-innovative farms and 31.3% of innovative entities gave such an answer. As a second benefit, respondents describe "the possibility of reducing costs". However, this benefit is more important for innovative farms (26.6%).

Table 7. Benefits in cooperation between farmers and scientists by the innovativeness of individual farms (in %)

What benefits do you see in the possible cooperation between farmers and scientists?	Innovativeness of individual farms		Total
	farms that have not implemented innovation	innovative farms	
The possibility of solving specific problems on the farm	40.0	31.3	35.1
The possibility of reducing costs	18.0	26.6	22.8
Increase of farm competitiveness	16.0	9.4	12.3
Increased financial support in the field of implemented innovations	8.0	10.9	9.6
Access to the latest knowledge	10.0	9.4	9.6
Opportunity to develop	4.0	12.5	8.8
A sense of prestige	4.0	0.0	1.8
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

Less significant is the "increase in farm competitiveness" and "increased financial support in the field of implemented innovations". 20.2% of all respondents see "access to the latest knowledge" (9.6%), "opportunity to develop" (8.8%) and "a sense of prestige" (1.8%) in cooperation with science (table 7).

Farmers were also asked if there was a need to cooperate with other farmers as part of their innovation activities. More than 70% of respondents answered in the affirmative, of which 72.1% of innovative farms (table 8). Interestingly, this kind of cooperation is less desirable than cooperation with science.

Table 8. The need for farmers to cooperate with farmers by the innovativeness of individual farms (in %)

Do you think there is a need for farmers to cooperate with farmers as part of their innovation activities?	Innovativeness of individual farms		Total
	farms that have not implemented innovation	innovative farms	
Yes	69.8	72.1	71.1
No	9.5	3.5	6.0
I have no opinion	20.6	24.4	22.8
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

It is known that farmers constantly undertake all kinds of cooperation. Almost 48% of farms that have not implemented innovations assess the current cooperation as "good". A similar assessment was given by almost 50% of innovative entities (table 9).

Table 9. Assessment of cooperation with other farmers by the innovativeness of individual farms (in %)

How do you assess the current cooperation with other farmers in the region?	Innovativeness of individual farms		Total
	farms that have not implemented innovation	innovative farms	
good	47.6	49.4	48.6
sufficient	42.9	42.4	42.6
irrelevant / no cooperation	9.5	8.2	8.8
Total	100.0	100.0	100.0

Source: own study based on the interviews conducted.

It was decided to also present the obtained results in a cross-section of the type of conducted activity. However, no significant differences between the analysed groups were noticed. The current cooperation is assessed most favourably by 58.1% of crop entities. 10.4% of livestock farms and almost 12% of mixed entities estimate cooperation as "irrelevant" or even "no cooperation". No crop farmer gave such an answer (table 10). Also, the relationship between the assessment of cooperation with other farmers and the type of business activity, measured by the V-Cramer coefficient, is very weak and statistically insignificant (V = 0.124; p = 0.345).

Table 10. Assessment of cooperation with other farmers by type of individual farms (in %)

How do you assess the current cooperation with other farmers in the region?	Type of individual farms			Total
	crop	livestock	mixed	
good	58.1	43.8	47.1	48.3
sufficient	41.9	45.8	41.2	42.9
irrelevant / no cooperation	0.0	10.4	11.8	8.8
Total	100.0	100.0	100.0	100.0

Source: own study based on the interviews conducted.

The performed statistical analysis allows for the verification of the formulated hypotheses. Therefore, there is no reason to reject the H1 hypothesis. Based on the analysis of the V-Cramer coefficient, it should be stated that in the researched group of farmers, the interest in scientific achievements depends on the innovativeness of farms. Thus, entities that have already implemented innovations express a greater willingness to learn about new developments in the field of science. Such a strong need for farmers to cooperate with science may result from its deficit in reality. Thus, it may be that Polish farmers from Łódź Voivodeship are not afraid of contact with scientists, as claimed by Hoffman et al. in their work (Hoffmann et al., 2007, p. 359). On the contrary, Polish farmers expect support in solving specific farm problems or reducing costs.

The H2 hypothesis concerns cooperation between farmers from Łódź Voivodeship. However, as it was rejected, it cannot be concluded that the relations between farmers differ depending on the activities conducted. The results of the analyses undertaken, therefore, contradict Riley's et al. (2018) statements. Additionally, it should be noted that the relations between Polish farmers are not as negative as described by Franks et al. (2016). Most respondents assessed the current cooperation with other farmers as "good" or "sufficient". Only less than 9% of respondents do not cooperate or think it is

"irrelevant". It can, therefore, be concluded, like Lutz et al. (2017), that cooperation with other farmers is important for the respondents and helps (although still slightly) in implementing innovative activities.

The conducted analyses introduced some novelty to the discussion on cooperation in the agricultural sector. Presenting the results in the cross-section of innovation allows for the estimation of the impact of cooperation on the implementation of innovation in agriculture. The author realises that the differences are not spectacular, but it can be noticed that innovative farms are characterised by a greater need for cooperation with science and farmers. They also see other benefits in cooperation. There is no doubt that this is due to the experience gained. However, based on the results obtained, it can already be seen that cooperation certainly positively affects the development of innovation in farms.

Conclusions

The development of innovation in farms is an unquestionable necessity these days. It allows for more efficient and effective production methods while respecting the principles of environmental protection. There is no doubt that the introduction of advanced technologies requires cooperation in the entire complex innovation process. The article deals with the problem of cooperation between Polish farmers and science and other farmers. It allows the assessment of its current state and the formulation of preliminary recommendations. Data on the state of innovation also increases the work's value in agricultural entities due to the lack of such information by entities collecting statistical data. The conducted research allows us to conclude that Polish farmers need cooperation with science because it will allow them to develop specific benefits. Undoubtedly, cooperation between agriculture and science in Poland is still in its infancy. The operational groups are a very good introduction to its development. Institutional solid support at a local level is needed, with significant support from agricultural advisory services. The Ministry of Agriculture and Rural Development should intensify marketing related to the creation of operational groups. European funds under the measure "Cooperation" give farmers several benefits, but they are not always sufficiently informed.

The empirical research conducted in this paper allowed for the formulation of a number of useful conclusions, which are, however, limited. A consequence of the selection of farms from the Polish FADN sample is the lack of the ability to generalise the results to the entire population of farms in the Łódź Voivodeship. Moreover, in this analysis, only the largest farms were used to increase the probability of a majority share of innovative entities in

the group of respondents. Therefore, the actual distribution of innovative farms in all economic size classes is unknown. Moreover, it should be remembered that the study selected only agricultural entities that keep accounts. This procedure was dictated by the possibility of conducting questionnaire interviews and the access to quantitative data.

Bearing in mind further research, the analysed group of farms should be expanded to include the smallest entities, the economic size of which does not reach 25,000 euros. However, most of all, further research should focus on a detailed analysis of the impact of cooperation between farmers and science on the level of innovation. Not only structural but also behavioural factors must be taken into account.

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THE REASONS FOR CHOOSING A LEISURE DESTINATION IN THE RURAL AREAS OF THE BUG RIVER VALLEY IN TOURISTS` OPINION

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ABSTRACT: The aim of the study was to identify factors that may determine the choice of leisure destination as a form of tourism in the rural areas of the Bug River Valley. The analysis of these factors also considered the nationality of the people surveyed. A total of 148 people took part in the study: 73 of Polish nationality (45 women and 18 men) and 75 foreigners, mainly Belarusians (51 women and 24 men). It was found that Polish tourists most often chose to spend leisure time in guesthouses/hotels or the houses of friends and family, while international tourists rest mainly in the houses of friends and family. Regardless of their nationality, the majority of tourists were satisfied with their stay in selected facilities, highly rating the communication, accommodation, catering and cycling routes and trails. The factors determining the choice of their place of stay, irrespective of nationality, were peace and quiet, attractive surroundings and convenient location. Respondents rested most frequently with family or friends. Polish tourists preferably used catering from the owners of holiday facilities, while foreigners cooked their own meals.

KEYWORDS: Bug River Valley, tourism, choice of location

Introduction

According to the authors of the Development Strategy of the County of Biała Podlaska for 2018-2026 (Szot-Gabryś, 2018), the Bug River Valley is one of the most valuable natural resources of the county. The valley is rich not only in places of high natural value but also there are numerous architectural and construction monuments, historical and military objects connected with the Brest stronghold, remains of former manors, manor houses, churches, places of former settlements and old folk customs and crafts. This makes the area very attractive to tourists. Apart from the values mentioned above of the natural and cultural environment, the advantages of the Bug Valley include its favorable geographic location and well-developed logistics and transport infrastructure as well as high quality of human resources. Despite this, it is believed that the tourist potential is insufficiently promoted and exploited (Baker 2007).

The area of the Bug River Valley is characterized by forests, mountains or water reservoirs (Sokół, Boruch, 2011). According to many authors (Obidziński, 2010; Sokół, Boruch, 2011; Czarnecka, 2016), the present-day vegetation of the Bug River Valley is a result of centuries of plant migration, from the early glacial period to the present day. As a result, almost 1300 species of vascular plants have been found in the Bug River Valley, not counting 64 minor species of the dandelion genus (14 species are now considered extinct). Almost all of them are permanent flora components, and only 6 of them occur ephemerally or temporarily.

Due to the diversity and richness of species and habitats, a number of protected areas have been created in the rural areas of the Bug River Valley. As part of the Natura 2000 system, 26 special habitat protection areas and 19 special bird protection areas have been created in the Bug River basin. In 2012 the West Polesie Transboundary Biosphere Reserve was created. It integrates three national biosphere reserves: Polesie Zachodnie (Poland), Szatskyi Biosphere Reserve (Ukraine) and Pribuzskoye Polesie (Belarus). In addition, four landscape parks are connected with the Bug River Valley: Strzelecki Landscape Park, Sobiborski Landscape Park, Podlasie Bug River Gorge Landscape Park and Nadbużański Landscape Park (Iwaniuk, 2005).

Lifestyle is the most general form of activity of a given social group, including physical activity, which consists, among others, of tourist and recreational activities (WHO, 2002). The manner, environment and period of rest are also significant. Resting is of great significance for physical, mental and social wellbeing (Steiner 1999) as people cannot function without resting for a longer time. Relaxation is necessary, even indispensable, for both older and younger people and their lives, just like air, water, and food. That is

why a survey among domestic and foreign tourists was conducted on this subject.

The research report on the domestic tourism market commissioned by the Polish Tourism Organisation shows that Poles prefer moderately active forms of spending leisure time during tourist trips. The form of activity most frequently indicated by respondents is visiting places of natural and cultural interest, followed by less active rest and recreation, entertainment and social contacts. Only one in five tourists primarily undertake sports activities during their holidays. The least popular forms of activity among respondents include shopping, health and beauty care, and participation in religious practices. In the group of so-called "explorers" (sightseeing), historic towns or sites are particularly preferred. Active recreationists spend their time mainly in the mountains, at the seaside or on a lake. They often go cycling, swimming or trekking. In turn, the so-called "all-inclusive tourists" much more often than the others spend time shopping or participating in religious practices (Polish Tourism Organisation, 2014). Numerous studies have shown that agritourism is gaining popularity among many forms of leisure activities (Flanigan, Blastock, Hunter, 2014). It is addressed mainly to individual customers, families and small tourist groups. The advantage of this form is the possibility to use existing housing resources of farms, as well as unused livestock facilities and recreational space within the farm (Sokół, 2012). The authors point out that a significant percentage of tourists are those interested only in good, authentic, traditional and regional cuisine. The authors argue that food and catering services occupy a significant place in any form of tourism and that unique, original, and above all tasty "Podlasie cuisine" can significantly increase the recognition of Podlasie and contribute to the development of tourism in the area (Sokół, 2015). For example, W. Alejziak (2015) presented the research results on the role and importance of active tourism in the health-promoting lifestyle of university students from Kraków. The author analyzed the preferences of science students and tourism and recreation students and found that most science students chose mass tourism rather than active tourism. In contrast, tourism and recreation students chose the opposite. Despite these differences, the preferences of "engineers" and tourism students were very similar. In both studied groups, the largest number of young people participated in mountain and lowland hiking and cycling tourism.

Moreover, tourism students practised skiing and snowboarding in winter and canoeing in summer. A much smaller group of respondents pursued other forms of active tourism from both engineering and tourism studies. It mainly concerned climbing, sailing, horse riding and survival tourism.

The research aim was to determine the decisive factors regarding choosing a leisure destination in the rural areas of the Bug River Valley. The analysis of these factors also reflected the nationality of the respondents. On the Polish side of the Bug River, the research concerned Polish tourists and foreigners, mainly Belarusians, on the other side of the river.

Research shows that the respondents (especially foreigners) paid the least attention to the healing values of the environment as a very important motivating factor when going on holiday.

Material and methods

The study used one of the qualitative research methods, i.e. a diagnostic survey (Andersen, Hepbum, 2015). The research technique applied was a questionnaire, and the research tool was the original questionnaire sheet.

The research was conducted in 2020, with 148 participants, including 73 Poles (45 women and 18 men) and 75 Belarusians (51 women and 24 men). In the group of tourists from Poland, every third person lived in a city with 50,000 to 100,000 inhabitants, and every fourth person came from cities with more than 100,000 inhabitants. In the case of tourists from outside Poland, the vast majority were residents of cities with a population over 100,000 (65.3%).

The largest percentage of Polish tourists was 26-40 years old and 41-60 years old (34.2% each). The others were aged 18-25 (23.3%) or over 60 (8.2%). In the group of foreigners, most tourists were aged 18-25 (80%).

The largest percentage among Polish tourists were those with higher education (76.7%). In the case of foreigners, this percentage was 45.3%. 54.7% of Polish and 21.9% of foreign respondents graduated from secondary school.

More than half of respondents from both groups revealed that their material status was average (Polish tourists – 58.9%, foreigners – 54.7%). On the other hand, high status was held by 20.5 and 45.3% of tourists, respectively.

The majority of Polish tourists chose to relax on the Polish side of the Bug River (87.7%). On the other hand, foreigners preferably rested on the Belarusian side (66.7%).

Results

The study has shown that many reasons prompted the respondents to visit the Bug River Valley region. According to the survey, the main reasons to relax in this region, both for Polish and foreign tourists, included natural values (68.5% and 64% respectively) and natural landscape (50.7% and 53.3%

respectively), and, to a much lesser extent, transport accessibility (25.3% and 9.6%), regional cuisine (13.3% and 23.3%), cultural values (25.3% and 21.9%) or a multitude of tourist and recreational attractions (29.3% and 19.2%) –figure 1.

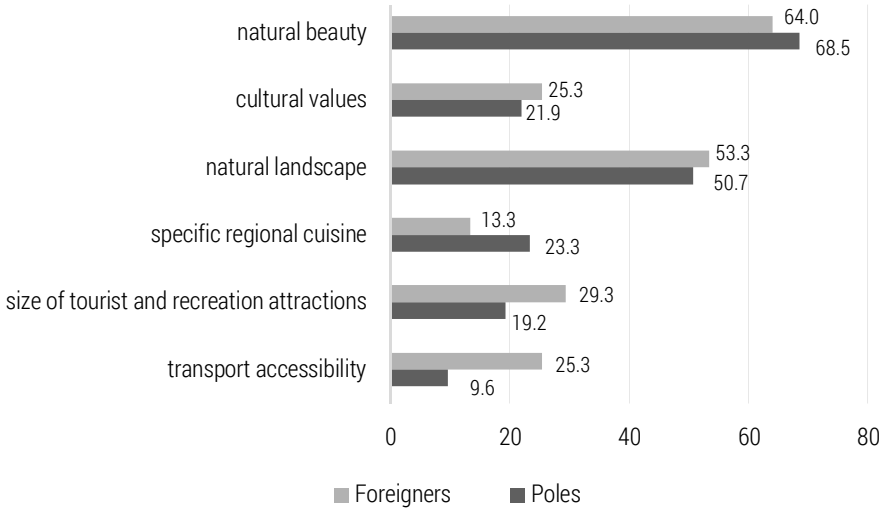

Figure 1. Reasons for visiting the region (in %); (the respondents could choose more than one answer)

Source: author's work.

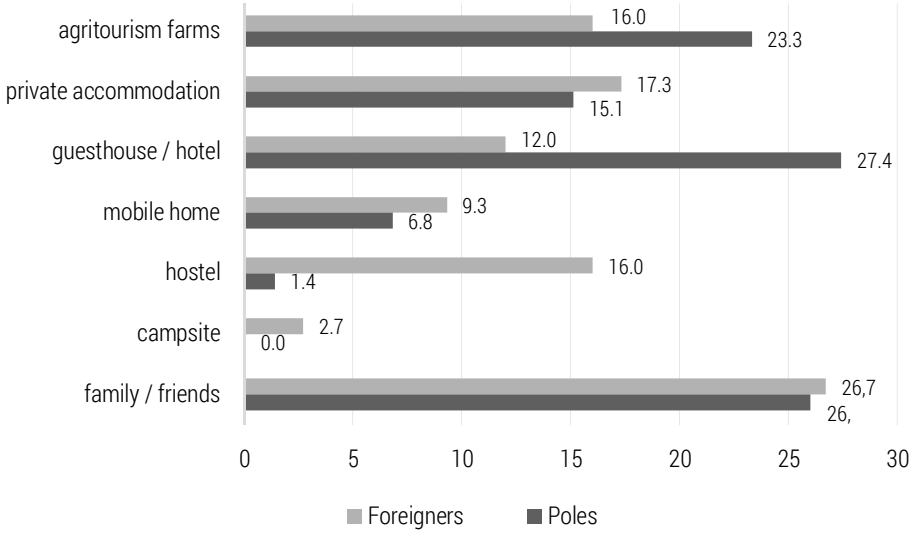

Figure 2. Rural tourism facilities most frequently selected by tourists (in %); (respondents could choose more than one answer)

Source: author's work.

As opposed to foreign tourists, domestic tourists preferably stayed in guesthouses/hotels (27.4% and 12% respectively) – figure 2. Both groups of tourists willingly and equally enjoyed staying with their friends' families (26 and 26.7% respectively). Besides, Poles often used accommodation in agritourism farms (23.3%), whereas foreigners in private accommodation (17.3%). Both groups equally used accommodation in agritourism farms (16%) and hostels (16%). It should be noted that tourists from Poland rarely stayed at hostels (1.4%).

In the opinion of both Polish and foreign tourists, the most important assets contributing to tourism development in the region include landscape values (4.1 and 4 points respectively) and clean water (4 and 4.1 points respectively) – figure 3. The least important factor for both groups was the low population in the region (3.3 and 3.1 points, respectively).

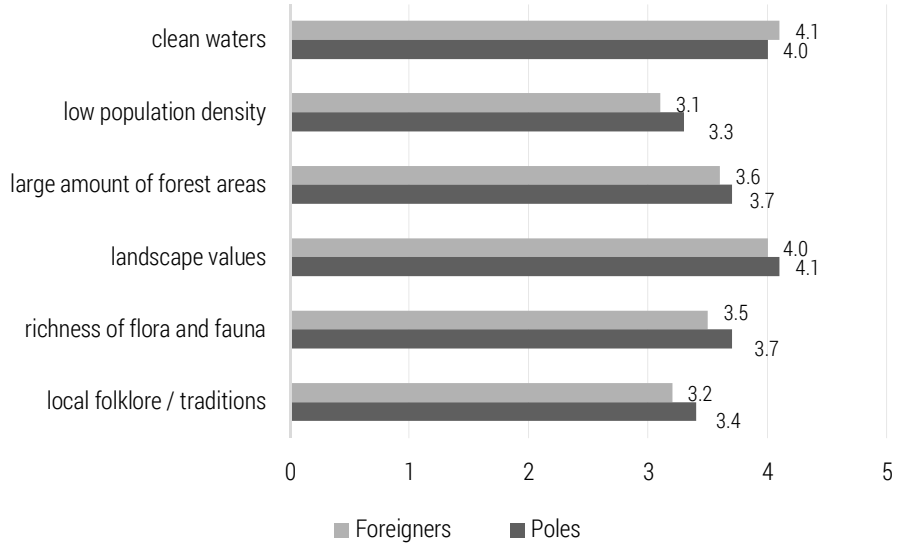

Figure 3. Main tourist values important for the development of tourism in the region in the opinion of the respondents (in points); scale – 0 points (unimportant) to 5 points (very important).

Source: author's work.

In most cases, in the group of Polish tourists, the respondents rated the stay at the selected facility as very good or good (49.3 and 42.5%, respectively). In the case of foreigners, the largest group were those who rated their satisfaction as good (58.7%) – figure 4.

When choosing a place to stay (figure 5), Polish tourists primarily took into account peace and quiet (46.6%) and a convenient location (38.4%).

In the group of foreigners, it was mainly the pleasant environment (57.3%), followed by a convenient location (46.7%) and peace and quiet (44%).

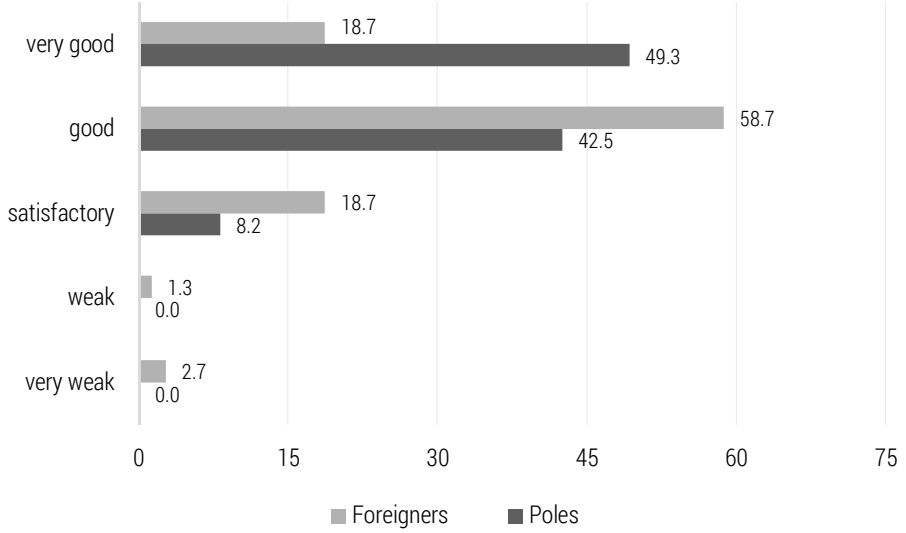

Figure 4. Degree of respondents' satisfaction with their stay in the selected facility (in %)

Source: author's work.

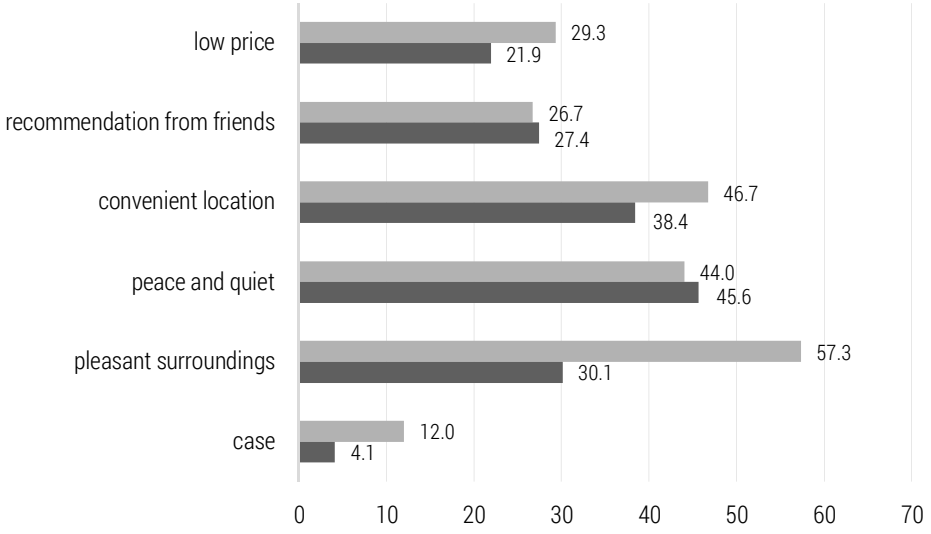

Figure 5. Factors influencing the choice of accommodation facilities by respondents (in %); (respondents could choose more than one answer)

Source: author's work.

Polish tourists most often used self-catering (45.2%), while foreign tourists ate meals prepared by themselves (44%) or used the offer of small catering establishments (29.3%) – figure 6.

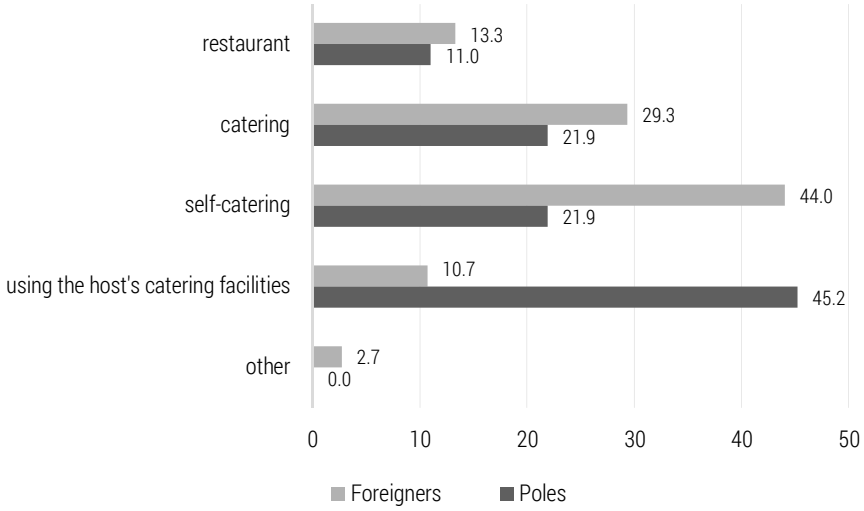

Figure 6. Types of catering facilities most frequently used by respondents during trips related to rural tourism in the Bug River Valley (in %)

Source: author's work.

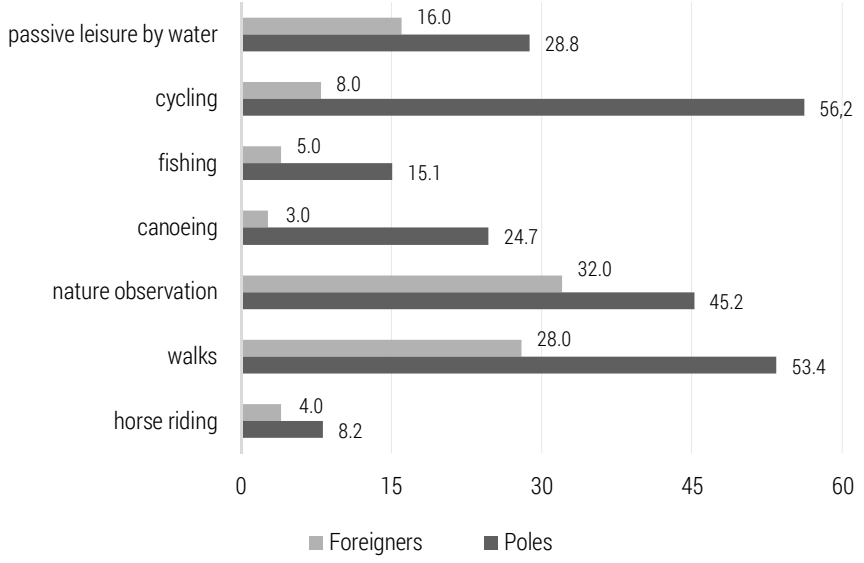

Figure 7. Forms of tourist activity preferred by respondents during their holidays (in %); (the respondents could choose more than one answer)

Source: author's work.

The highest percentage of Polish tourists declared that during their holidays in the Bug River Valley they went cycling (56.2%), walking (53.4%) and observed nature (45.2%). Foreigners, on the other hand, most often observed nature (32%), went walking (28%) and resting by the water (16%) – figure 7.

Polish tourists engaging in rural tourism in the area of the Bug River Valley gave the highest ratings to the accommodation and catering facilities (3.3 points each) as well as cycling routes (3.2 points). A similar infrastructure assessment was given by outside Poland tourists (figure 8). In their opinion, the best-developed facilities are transport (3.8 points), catering and accommodation (3.6 points each) and bicycle trails and routes (3.2 points). The lowest ratings were given by tourists for tourist equipment rentals (Poles – 2.4 points, foreigners – 2.6 points) and sports facilities (Poles – 2.4 points, foreigners – 2.8 points).

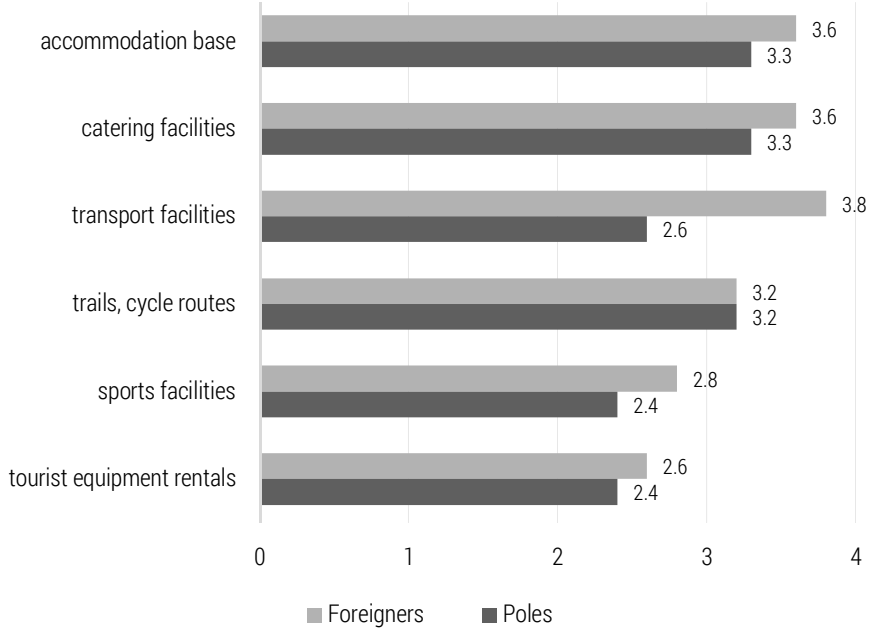

Figure 8. Condition of tourist infrastructure in the region in respondents' opinion (in points); scale – 0 points (unimportant) to 5 points (very important).

Source: author's work.

The majority of Polish tourists, as well as foreign ones, stated that they would come to the Bug River Valley again for tourist purposes (94.5 and 65.3% respectively) – figure 9.

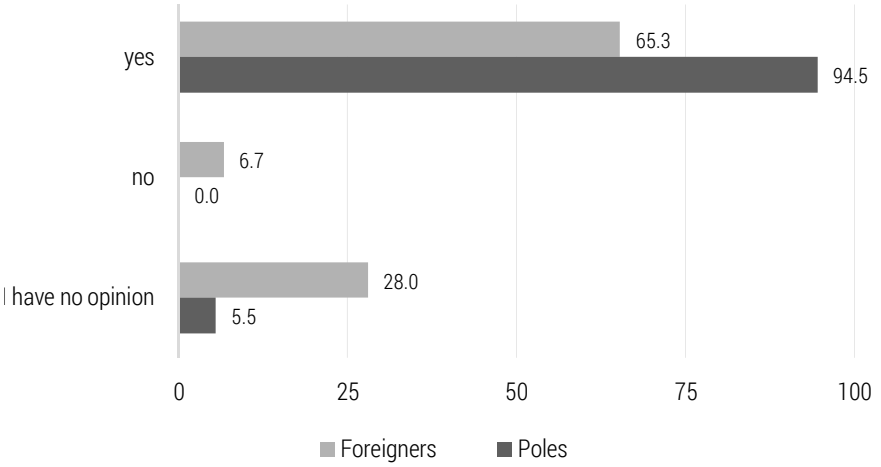

Figure 9. Respondents who declared the willingness to visit the Bug River Valley again (in %)
Source: author's work.

A vast majority of tourists from Poland and abroad would recommend the Bug River Valley as a holiday destination (72.6 and 45.3% respectively) – figure 10.

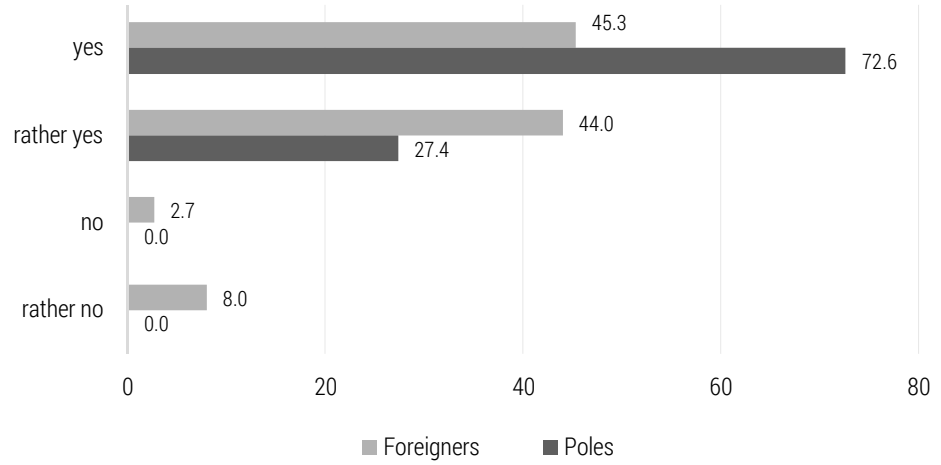

Figure 10. Respondents who would recommend other people to spend their holiday in the Bug River Valley (in %)
Source: author's work.

Discussion

Tourism plays an important role in the development of the economy and society. In the era of globalization and the development of civilization, it is not accidental to pay attention to the tourist attractiveness of rural areas. Rural tourism is frequently mentioned as a development direction in Poland's strategic plans prepared by local governments at various levels. One of the types of non-agricultural activity in rural areas is rural tourism, including agritourism. As J. Bański (2006) writes, the increased interest in rural areas and this form of recreation as a whole took place in the 1960s, and its popularity is not falling. As the research of numerous authors has shown, not only domestic but also foreign tourists rest in rural areas. A question may be asked, what were the tourists from Belarus guided by when choosing a place to rest in rural areas? Research has shown that in the case of tourists from the east, the decisive factor was the amount of fees for services, despite the fact that they came from relatively well-off families, but also the possibility of preparing meals on their own, as a result of which they saved by not paying for the full service.

On the other hand, as they claim, they saw what they were preparing and consuming. Another aspect worth emphasizing is that the respondents were a less demanding group of tourists and most often assessed their stay with satisfaction during their stay in various places. One of the main reasons for choosing a vacation spot was also the realization of their own intentions and hobbies of vacationers. The valley of the Bug River (especially in the border section) is also a unique cultural value resulting from the meeting of three cultures in this area: Polish, Ruthenian and Jewish, which are very visible in the landscape (Mączka 2008). Many authors (Sikorska-Wolak 2006; Cichowska 2011; Ciepiela 2014, Balińska 2014 and others) emphasize that the dynamics of agritourism development is strongly correlated with the natural and cultural attractiveness of the Bug valley. It is also one of the last great river valleys located in the centre of Europe, which so far has retained a very significant degree of naturalness. Hence there is interest in this area, as well as many scientific studies on this subject.

Conclusions

The topics concerning the motives for choosing a place for rest in the rural areas of the Bug river valley have not been presented in scientific journals so far. Of course, there were studies, but they concerned mainly the tourist and landscape values as well as the general characteristics of the rural areas of the said area. Hence, there was a gap in this subject, which we decided to fill.

Research has shown that the Bug River Valley area is very popular among domestic and foreign tourists. It is mainly determined by the tourism potential, which includes the environment and its surroundings. Conclusion and it can be said that not only coastal and mountainous areas attract tourists, but the area of Podlasie does not differ from the ones mentioned above.

According to the survey, tourists from Poland preferably rested in guesthouses/hotels and at houses friends' and agritourism farms. At the same time, foreigners mainly stayed at friends', and to a lesser extent in private accommodation, agritourism farms or hostels.

In most cases, both Polish and foreign tourists were satisfied with their stay in rural areas of the Bug River Valley. They spoke highly of the transport, accommodation and catering facilities, as well as of the cycling routes and trails. Tourists from Poland preferred self-catering facilities, while foreigners cooked their own meals.

The deciding factors for choosing a place to stay, regardless of nationality, were peace and quiet, pleasant surroundings and a convenient location. Surprisingly, no importance was attached by the respondents, especially foreigners, to the healing qualities.

The contribution of the authors

Dominik Dąbrowski – 30% (conception, literature review, data analysis, interpretation, conclusions, language correction).

Mikołaj Jalinik – 30% (conception, literature review, data analysis, interpretation, conclusions, language correction).

Janusz Leszek Sokół – 15% (conception, literature review, data analysis, interpretation, conclusions, language correction).

Katarzyna Radwańska – 15% (literature review, data collection, language correction).

Jakub Szwedo – 10% (literature review, data collection)

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GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

PROBLEMATYKA OGÓLNOEKOLOGICZNA I SPOŁECZNA

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ASSESSMENT OF TOURIST TRAFFIC IN TATRA NATIONAL PARK IN 2018-2020

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ABSTRACT: The aim of the article is to analyse the qualitative and quantitative research conducted between 2018 and 2020 in the field of tourist traffic in the Tatra National Park. The data presented in the article focuses on the situation of limitations to spatial mobility. To show the impact of changes in terms of implementation and meeting the needs of tourist trips, the period leading up to the outbreak of the SARS-CoV-2 virus pandemic was thoroughly studied, with a period marked by severe mobility restrictions. The obtained data made it possible to present the relationship between the restrictions and satisfying mentioned needs, which is visible in the example of the number of tourists visiting the Tatra National Park in the sections of 2020, which were characterised by a different scope of restrictions on social mobility.

KEYWORDS: Tatra National Park Poland, Tourist Traffic, Net Fear Score, Net Promoter Score, the pandemic of SARS-CoV-2

Introduction

The aim of the article was to show the possibility of using quantitative and qualitative research on tourism in the Małopolska province to create its characteristics (quantitative and qualitative) in a smaller territorial unit of the studied province, which is precisely delimited to the area of the Tatra National Park and to verify the thesis initially "that the more human needs are impossible to satisfy during the normal daily rhythm of life, the faster appears the need to leave the environment in which he is subject to restrictions (probably the most burdensome for a human being are social restrictions), and go to a place far enough from the place of permanent residence to become a socially anonymous individual, and thus to be able to realise and satisfy the needs that he could not or was not allowed to satisfy in the daily environment" in terms of extreme conditions caused by SARS-CoV-2.

In the years 2018-2020, the Małopolska Tourist Organisation conducted a study of tourist traffic in Małopolska, which is one of the Polish voivodeships where tourism plays an important role in the social and economic sector, as part of its statutory tasks, which include "taking measures to increase the number of tourists visiting the Małopolska Voivodeship." Data (2018 n = 594, 2019 n = 631, 2020 n = 663) on the volume and quality of tourist traffic in the Tatra National Park were extracted from a database derived from survey research conducted among the tourists in the Małopolska province in 2018-2020 with an annual representative sample of a minimum of n = 5,400 (2018 n = 7,200, 2019 n = 7,019, 2020 n = 5,400).

The second group of tools (desk research methods) was based on publicly available data. These were mainly quantitative data collected from the management of the Tatra National Park, as well as from the Regional Data Bank and communiqués, bulletins, electronic publications (including archival data) published by the General Office of Statistics.

The study of the stream of tourist traffic in the Tatra National Park area over two years (2018-2019) preceding the year 2020 marked by severe limitations of social mobility caused by the WHO-announced SARS-CoV-2 virus pandemic showed the quantitative and qualitative picture of the stream of tourist traffic in the analysed period and at the same time gave the possibility to confirm that indeed the dependence of the "escape" from urbanised spaces into non-degraded spaces of the Tatra National Park occurs. The "escape" of the inhabitants of big cities into the open and non-degraded space of the trails in the Tatra National Park in 2020 was clearly marked.

This change in 2020 relative to the 2018-19 average was 15.35 p.p. in TNP. The results introduce a new point of view in the discussion on the management of visitors' stays in the Tatra National Park, through an annual or

even biannual (winter season/summer season) comparative analysis of the presented visitors' segmentations with the preferred travel types and/or purchased services accompanying their stay taking into account the means of transport used in the trip. In the international context, we emphasise the importance of the Małopolska Tourist Organization's technology for studying tourist phenomena, which has been proven as a valuable tool in profiling tourists since 2004, and we highlight the issue of the need to monitor their subjective feelings and opinions when visiting special places in protected areas as part of mass tourism.

Literature review

The research was conducted by experts from the Intercollegiate Scientific Team of the Małopolska Tourist Organisation, based on an original method that enables comparative analysis of the volume and structure of tourism (Borkowski et al., 2021). Thanks to the integration of quantitative and qualitative data and the continuity of observation of the phenomenon, the research results are the excellent starting material for undertaking activities stimulating sustainable tourism development in specific areas of the Małopolska Voivodeship. Based on the conducted research, material on the stay of tourists in the Tatra National Park in 2018-2020 were extracted.

This research allows "understanding the motivations and behaviours of visitors to protected areas which is crucial for the effective management of vulnerable areas (Taczanowska et al., 2019). They signal that it is the analysis and understanding of tourism phenomena that need reliable techniques to support the management of tourism destinations. Segmentation is a widespread approach to reducing the complexity of visitor characteristics and behaviour. In many cases, the services generated by natural protected areas in general and National Parks, in particular, are "invisible" to the market, as they lack an assigned price (Sotelo Navalpotro et al., 2012). Tourist Traffic is used to put a monetary value which settles the value to heritage and encourages the public and private sectors for its conservation. This has been reflected in the new national and international regulations, which recognises tourist use among its main management objectives. At the same time, from an environmental perspective, the development of tourism gives rise to a series of negative externalities that may affect the conservation of these areas if the "load capacity" of these is not taken into consideration.

Research by the Małopolska Tourist Organization comes to the aid of administrators of specific tourist destinations. The problem was diagnosed in 2010 by the TNP director, writing that "during the fifty years of the Tatra National Park, there has been a tremendous increase in tourist traffic. Since

1993, when the sale of entrance tickets to the park was introduced, we have reliable data on the volume of entrance traffic. They allow us to assess the volume of traffic in spatial (based on information from seventeen ticket sales points) and temporal (weekly, monthly and yearly) variation" (Skawiński, 2010). However, there has been a lack of separate, systematic and based on a representative sample, qualitative studies of park visitors in this area until now.

Methodology of studying tourist traffic in the Małopolska region, including tourist stays in the Tatra National Park

The data collection system adopted in the research was based on two main methods: face-to-face interviews conducted by interviewers using a paper questionnaire (PEPI – Paper and Pencil Interviewing) and desk research. Those methods allowed the Tatra National Park to conduct extensive quantitative and qualitative research on tourist traffic in 2018-2020. In addition, the triangulation of research methods used increases the quality of the research and significantly reduces measurement error.

The survey included visitors to the Tatra National Park who were classified as tourists (staying at least one night) and one-day visitors by the United Nations World Tourism Organization (UNWTO) for cognitive, recreational, professional, religious, family, health, and other reasons.

Domestic and foreign visitors, who declared a stay exceeding 90 days, were omitted from the study. Also, the leisure activity of Małopolska residents permanently working or studying in the Małopolska region and foreigners residing in Poland was considered. People from these categories constitute an important part of the tourist traffic stream and are not only direct tourist service staff but are also active tourists using the region's leisure offer.

The minimum sample size and sampling frame were based on 2017 Central Statistical Office (CSO) data on the use of collective accommodation facilities.

It was determined that a sample size of a minimum of n = 5,400 people guarantees an estimation accuracy of 1.5%. The size of the sample taken and verified for further analysis in the Małopolska province was in 2018 n = 7,200, in 2019 n = 7,019, in 2020 n = 5,400 from which data were extracted for TNP from 2018 n = 594, from 2019 n = 631 and from 2020 n = 663 which gave a total of 1,888 questionnaires on the size and quality of tourist traffic in the Tatra National Park. A stratified sampling scheme was adopted for the general sample, where the stratum was the county and the type of facility in each county (hotels, motels, guesthouses, tourist homes, youth hostels, holi-

day resorts, guest rooms, camping sites, campgrounds, holiday camps, other facilities) in proportion to the number of overnight visitors. Additionally, places of concentration of travellers such as railroad and bus stations, airports and tourist attractions were indicated for sampling. Experts determined the list of these places based on information obtained from employees of the tourism sector, guides, operators of tourist attractions, organisers of tourist traffic, customs service, and the Balice International Airport. The following rules were adopted for sampling: all persons interviewed were 16 years of age or older; in the case of family surveys, only one family member was interviewed; in the case of organised groups, at most two adults from the group were interviewed.

Surveys were conducted from January to November 2018 and 2019, and in 2020 (with a break in survey collection from March to May) according to the accepted sampling sites distribution for each month. In the last measurement year (2020), due to the SARS-CoV-2 virus pandemic, survey collection and sampling site selection were variable and dynamic. It largely depended on the collection of questionnaires from both foreign and domestic tourists staying in open spaces. More than 20 thousand respondents were surveyed during the entire research period, and 19619 questionnaires were qualified to the database after substantive verification. Each record (questionnaire saved in the database) contained a maximum of 293 elements (variants of answers to 42 questions contained in the questionnaire) plus 19 metric questions (a total of 333 elements). The smallest number of questionnaires (over 5450) was collected in 2020, of which 5400 records were analysed after verification. The work of interviewers in 2020 under severe pandemic conditions was efficient, resulting in a large number of correctly retrieved surveys. Questionnaires were entered into the database through a form on an html page and using script coded in scripting programming language PHP.

The second group of tools (desk research) was based on commonly available data. First of all, it was quantitative data coming directly from Tatra National Park management, as well as from Regional Data Bank and communiqués, bulletins, electronic publications (including archival data) provided by Central Statistical Office.

Profile of tourists visiting the Tatra National Park surveyed in 2018-2020

There was a significant change in the structure of visitors to TNP in 2020 in favour of permanent residents. According to the data in table 1, there was a 13.5 percent change in the mentioned structure in 2020 compared to the 2018-19 average. This was undoubtedly influenced by the Polish state bor-

ders being closed to foreigners from 13.03.2020 as a consequence of the decision of March 11 2020, when the World Health Organisation (WHO) declared a series of cases of respiratory infectious disease caused by the SARS-CoV-2 virus infection, as a pandemic.

Table 1. Percentage structure of tourists visiting the Tatra National Park surveyed in 2018-2020 in terms of their declared country of permanent residence (Country – Foreign)

TNP	% vertical	% vertical	% vertical	Average 18-19	Change in 2020 relationship to averages 18-19
Year	2018	2019	2020		
Country	90.2	78.8	98.0	84.5	13.5 p.p.
Abroad	9.8	21.2	2.0	15.5	-13.5 p.p.
Total	100.0	100.0	100.0	100.0	0.0 p.p.

Source: own study.

In 2020, there was a clear "flight" of big-city residents into the Tatra National Park's open non-degraded trail space. According to the table below, the change in 2020 compared to the 2018-19 average was 15.35 p.p.

Table 2. Percentage structure of tourists visiting the Tatra National Park surveyed in 2018-2020 by the size of their declared place of permanent residence

TNP	% vertical	% vertical	% vertical	Average 18-19	Change in 2020 relationship to averages 18-19
Year	2018	2019	2020		
Big city	26.5	16.0	36.6	21.25	15.35 p.p.
Town	28.1	37.8	35.7	32.95	2.75 p.p.
Big town	30.6	26.8	23.6	28.71	-5.11 p.p.
Big village	9.0	15.5	3.4	12.25	-8.85 p.p.
Small village	5.8	3.9	0.7	4.85	-4.15 p.p.
Total	100.0	100.0	100.0	100.0	0.0 p.p.

Source: own study.

Spatial mobility is a natural human trait, subject to many constraints over the course of human life. The longer these constraints operate, the more force it reveals once the sets of limiting factors weaken or disappear (Borkowski, 2019). There is a clear relationship between the degree of possibility of realisation and satisfaction of needs felt daily and the speed of appearance in a human of the need for a tourist trip (temporary change of the permanent

living and working environment – permanent place of residence). The more needs of the human being are impossible to be satisfied during the normal daily rhythm of life, the faster the need to leave the environment in which he/she is subject to limitations (the most burdensome of which are probably social limitations) and go to a place distant enough from the place of permanent residence to become a socially anonymous individual and thus realise and satisfy the needs that he or she could not or was not allowed to stay. Probably these, not always fully conscious, and unsatisfied needs imply the need to leave the place of permanent residence, including a tourist trip (Borkowski, Borkowska, 2005).

Analysing the data, declared by the tourists visiting Tatra National Park in 2018-2020 (table 3), about the places of their permanent residence as the country where they stay on a daily basis, it can be shown that the basic list of countries starts with two equal emission markets, that is, the United Kingdom and Germany. In 2020, a clear advantage was gained by tourists from Germany, who could also reach Małopolska by means of transport other than air travel. In this group, the change in 2020 in relation to the average of 18-19 amounted to 15.7 p.p., while visitors from the United Kingdom showed a decrease of almost 10 p.p. in 2020 in relation to the average of 18-19 (-9.6 p.p.). In 2020 there was a kind of compensation in the groups described above in relation to the average in 18-19, the result of which reached 6.1 p.p. The third place is invariably occupied ex aequo by tourists from Italy and Spain with an average result for three years ≈ 13% share in the stream of foreign inbound tourism to the Tatra National Park. Despite the pandemic situation in 2020, the % structure of the tourist stream for the top four countries proved to be stable, remaining at a similar level as in previous years consuming in 2020 (table 3) more than 70% shares. A clear change in arrivals from France in relation to the 18-19 average of over 19 p.p. was noted in 2020. However, it should be remembered that the annual calculation of the size of the tourist stream visiting the Tatra National Park was strongly influenced by the sensational first quarter of 2020 (winter season), which was better than the first quarter and the record-breaking one for the Małopolska tourism industry in 2019.

More than half (53.4%) of domestic tourists who visited the Tatra National Park in 2020 were residents of Małopolska (table 4) who decided to "Be a tourist at home – in their province". This is related, among others, today trips without an overnight stay, which was difficult, risky or even impossible. This is exemplified by the high all-day turnout recorded in Q4 2020 during the 20/21 winter season on the ski slopes of Małopolska. People who arrived late had a serious problem parking their cars.

Table 3. Percentage structure of foreign tourists visiting the Tatra National Park surveyed in 2018-2020 in terms of their declared country of permanent residence

Country	2018	2019	2020	average 18-19	Change in 2020 relationship to averages 18-19
The United Kingdom	28.9	21.0	15.4	24.9	-9.6 p.p.
Germany	13.3	16.8	30.8	15.1	15.7 p.p.
∑ – 1 – intermediate	42.20	37.80	46.20	40.00	6.10 p.p.
Italy	17.8	11.8	15.4	14.8	0.6 p.p.
Spain	15.6	10.1	15.4	12.8	2.6 p.p.
∑ – 2 – intermediate	33.40	21.90	30.80	27.60	3.20 p.p.
Slovakia	4.4	9.2	0.0	6.8	-6.8 p.p.
Irleland	6.7	5.9	0.0	6.3	-6.3 p.p.
Hungary	4.4	5.0	0.0	4.7	-4.7 p.p.
Belgium	4.4	4.2	0.0	4.3	-4.3 p.p.
France	4.4	3.4	23.1	3.9	19.2 p.p.
The Czech Republic	0.0	7.6	0.0	3.8	-3.8 p.p.
Switzerland	0.0	5.0	0.0	2.5	-2.5 p.p.
Final total	100.0	100.0	100.0	100.0	0.0 p.p.

Source: own study.

However, under the prevailing pandemic threat conditions, they proved to be an excellent means of safe transportation, a place to consume victuals from their own picnic basket or purchased at the drive-through windows. It was noticed that in 2020, there would be a significant increase in tourist arrivals from the Silesian region, with a share of nearly 19%. As presented in table 4, Silesians represent a very strong segment of the stream of tourist traffic to the Tatra National Park, which reached an average of ≈15% (14.77%) for the next three years of observation. In third place, ex aequo were tourists from Podkarpacie and Mazowsze regions obtaining an average for the three analysed years of ≈9%, ≈7% share, respectively. However, even though in 2020 tourists from Podkarpacie (9.1%) overtook tourists from Mazovia by almost 2.5%, there was a decrease in arrivals to the TNP from both Podkarpacie and Mazovia, which can be explained by the increased tourist travels of Mazovia residents within their own province as well as towards Warmia and Mazury region, and the travels of the Małopolska residents largely included the areas of the Bieszczady National Park.

Table 4. Percentage structure of domestic tourists visiting the Tatra National Park surveyed in 2018-2020 in terms of their declared province of permanent residence

Voivodeship	2018	2019	2020	Average 18-19	Change in 2020 in relation to 18-19 average
Małopolskie	40.2	42.3	53.4	41.26	12.12 p.p.
Śląskie	11.8	13.7	18.8	12.74	6.03 p.p.
Podkarpackie	10.3	11.7	5.2	10.99	-5.76 p.p.
Mazowieckie	8.4	6.5	4.9	7.43	-2.51 p.p.
Wielkopolskie	5.8	5.4	2.9	5.62	-2.70 p.p.
Pomorskie	5.2	3.2	1.2	4.23	-3.00 p.p.
Łódzkie	5.6	2.8	2.6	4.22	-1.60 p.p.
Świętokrzyskie	3.4	3.2	3.5	3.30	0.24 p.p.
Dolnośląskie	2.8	2.2	2.3	2.51	-0.20 p.p.
Kujawsko-pomorskie	3.6	1.4	0.5	2.48	-2.02 p.p.
Opolskie	1.1	1.4	1.8	1.27	0.58 p.p.
Zachodniopomorskie	0.7	1.6	0.9	1.18	-0.26 p.p.
Lubelskie	0.4	1.8	1.1	1.09	-0.02 p.p.
Podlaskie	0.7	1.2	0.0	0.98	-0.98 p.p.
Lubuskie	0.0	1.2	0.5	0.60	-0.14 p.p.
Warmińsko-mazurskie	0.0	0.2	0.3	0.10	0.21 p.p.
Total	100.0	100.0	100.0	100.00	0.00 p.p.

Source: own study.

Subjective components of Client Relations Management and loyalty decision of visitors to Małopolska

Evaluation of safety level before coming to Małopolska – Net Fear Score index of visitors of Tatra National Park

The Net Fear Score (NFS) is an index of fear, anxiety, and fear of arriving at a destination. Borkowski K. developed NFS index in 2016 based on previous studies of Tourist Traffic in Krakow. It was implemented as a pilot during the study of Participants of World Youth Day 2016 in Krakow done by the Extended Intercollegiate Team of Experts of the Małopolska Tourist Organization (Borkowski et al., 2017).

In its broadest sense, safety is very important for the development of tourism in the region. Thus, the surveyed visitors to Małopolska were asked to determine on an 11-point numerical scale the subjective level of their own fear and anxiety about coming to Małopolska, where: "0" meant that: *I was not afraid at all*, while 10 meant that *I was full of fears*. When the total results for the years 2018-2020 are examined, it can be seen that the largest group of TNP visitors declared a total of "0" level (mean of 18-19 years = ≈70%; and in 2020 with pandemic risk ≈ 46%), that is, there was a serious change of mental attitude before coming to TNP by more than -25 p.p. in relation to the mean of 18-19 years. In the typical conditions, travellers consciously agree to increase the *risk of life* in favour of pursuing current goals for a limited time. In this way, a potential (natural?) human psychological barrier of fear of the unknown is broken down (neophobia). Then the person leaves the safe place of permanent residence, setting off into the unknown (Herzig, 1998).

Table 5. Subjective evaluation of the level of safety in the destination before deciding to travel to Małopolska by visitors to the Tatra National Park

Concerns about coming to Małopolska/TNP	2018	2019	2020	Average 18-19	Change in 2020 in relation to 18-19
0	65.6	76.1	45.5	70.88	-25.37 p.p.
1	8.2	18.1	23.1	13.18	9.89 p.p.
2	6.0	3.6	20.7	4.80	15.95 p.p.
3	3.7	0.2	8.0	1.96	6.09 p.p.
4	4.1	0.2	0.8	2.16	-1.39 p.p.
5	1.9	0.0	0.6	0.93	-0.31 p.p.
6	1.2	0.2	0.3	0.72	-0.41 p.p.
7	2.5	0.0	0.5	1.23	-0.77 p.p.
8	2.3	0.0	0.2	1.13	-0.98 p.p.
9	1.2	0.4	0.2	0.83	-0.68 p.p.
10	3.3	1.1	0.2	2.18	-2.02 p.p.
Final total	100.0	100.0	100.0	100.00	0.00 p.p.
NFS Index	61.5	92.5	66.7	77.0	-10.3 p.p.

Source: own study.

The indicated levels of fear have been aggregated. Travellers' fears and anxieties were indicated by the sum of the indications from the values "5" to "10". Those who marked states "4" – "3"-"2" on the numerical scale were con-

sidered neutral, as people going on a trip try to protect themselves by preparing for the trip, and this means analysing possible threats occurring outside the place of permanent residence. The numerical scale values "0" and "1" represent the state of complete absence of fear and anxiety before arrival. They reflect the subjective feelings of people who are fully convinced that their trip to the Tatra National Park was at no time accompanied by a feeling of anxiety, fear or worry about their property, health and life.

Despite a spectacular decrease of more than 25 p.p. (table 5) in the feeling of the state of total safety when travelling to the Tatra National Park in 2020, the NFS index for visitors to the TNP remained very high. It remained for the three analysed years at an average level of 73.6%. An NFS index score above 50% is considered a success for the destination.

Evaluation of the level of satisfaction from a stay in Małopolska – Net Promoter Score of visitors of the Tatra National Park

The destination visitor satisfaction and loyalty index – Net Promoter Score, also known as the advocacy index – was used as the second contingency dimension. Net Promoter Score (NPS) is an indicator created by Reichheld F. It is used to measure consumer loyalty and the quality of relationships built with them. The essence of the indicator comes down to the study of the customer's propensity to recommend the product or service of a given brand. Regular monitoring of NPS level allows evaluating the quality of conducted activities and provides necessary information that facilitates planning strategies to build customer satisfaction. Optimally used it can be a tool to increase company's profits. (Gajewska, Szewczyk, 2012)

During surveying, respondents were asked: "how likely are they to recommend Małopolska to their friends". Responses were also given by visitors to the Tatra National Park using an 11-point scale, from 0 to 10, where "0" meant no willingness to recommend, and "10" meant full loyalty and complete satisfaction with their stay in the destination.

It is assumed that a positive NPS index already indicates good standards, and with a score higher than 50%, one can speak of success. In the analysed case, the NPS index for 2020 was 80%, and the average of 2018-2019 = 74% (table 6). The change in 2020 in relation to the 18-19 average reached the level of 6 p.p. in plus which for the reception of tourists in the conditions of the epidemic condition is a very optimistic result of the level of satisfaction with the offer obtained tourists during their stay in TNP.

Table 6. Subjective evaluation of the level of satisfaction from the stay in the destination by visitors to the Tatra National Park

Declaration of the TNP recommendation	2018	2019	2020	average 18-19	Change in 2020 in relation to 18-19 average
0	0.4	1.4	0.0	0.90	-0.90 p.p.
1	0.6	0.4	0.2	0.49	-0.33 p.p.
2	0.0	0.2	0.0	0.10	-0.10 p.p.
3	0.6	0.0	0.3	0.29	0.02 p.p.
4	0.4	0.0	0.2	0.19	-0.04 p.p.
5	1.5	0.0	0.3	0.76	-0.45 p.p.
6	2.7	0.2	0.5	1.44	-0.97 p.p.
7	7.1	1.4	5.1	4.25	0.88 p.p.
8	20.1	6.7	12.0	13.40	-1.42 p.p.
9	10.5	34.4	41.8	22.47	19.37 p.p.
10	56.2	55.2	39.7	55.70	-16.05 p.p.
NPS	60.50	87.40	80.00	74.00	6.09 p.p.

Source: own study.

Declaration of revisiting the Tatra National Park by visitors to TNP

Analysing the respondents' answers on their declaration to come to the Tatra National Park again (table 7), in 2020, the vast majority of respondents answered affirmatively: "rather yes" (54.4%), "definitely yes" (35.5%), which is ≈90% (89.9%) of the surveyed people. The group of undecided people who answered "don't know" in 2020 reached almost 10% of the shares of the tourist stream (9.9%), achieving a result of a change in relation to the average of 2018-2019 by almost 5 p.p. (4.99 p.p.). People who declared that they would not travel to the Tatra National Park again in 2020 were virtually non-existent: "definitely not" (0.0%) and "rather not" (0,2%).

Table 7. Declaration of return of visitors to the Tatra National Park in percent

Declaration of revisiting	2018	2019	2020	average 18-19	Change in 2020 in relation to 18-19 average
definitely yes	68.6	57.3	35.5	62.93	-27.41 p.p.
rather yes	25.8	36.8	54.4	31.26	23.14 p.p.
don't know	4.9	4.9	9.9	4.93	4.99 p.p.
rather not	0.0	1.0	0.2	0.51	-0.35 p.p.
definitely no	0.8	0.0	0.0	0.38	-0.38 p.p.
final total	100.0	100.0	100.0	100.00	0.00 p.p.

Source: own study.

Attendance on Tatra National Park trails in 2020

It is visible in figure 1 how the administrative decisions of the state in connection with the epidemic regulations influenced the size of the stream of tourist traffic in the Tatra National Park. For example, when the lockdown was announced from March 13 to mid-May 2020, practically only two entrances to TNP were accessible (Dolina Białego and Dolina Strążyska). Also, the last months of 2020 (November and December) were at almost zero level compared to the summer season.

This data confirms the MOT study presented in table 8, showing the phenomenon of compensating tourist flow during June, July, August, and proving at the same time the power of "accumulated deferred needs" that are revealed in society immediately when the restrictions block them are lifted.

The survey of tourists done by the MOT expert method within the Tatra National Park was conducted on a total sample of 1888 respondents in 2018 (594 people), 2019 (631 people), 2020 (663 people). TNP statistics from this period show that between 2018 and 2020, a total of 10,628,459 people were admitted to the park with tickets of which in 2018 – 3,782,610 people, in 2019 – 3,782,610 people and in 2020 – 3,301,895 people. The annual average of admissions to the TNP for 2018-19 is 3 782 610 people who, in relation to the number of admissions to the Tatra National Park from the year 2020 (with the total blockade of admission to the park in April and May) gives only less than half a million (480 715) people less.

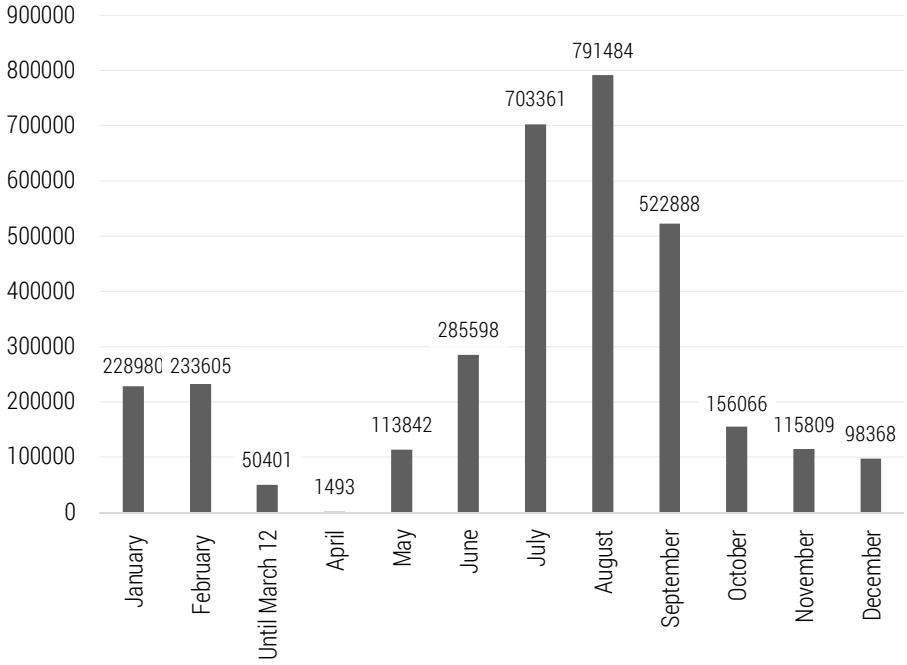

Figure 1. TNP admissions statistics in 2020 by month – sold tickets

Source: Own elaboration based on: Tatra National Park Directorate https://tpn.pl/zwiedzaj/turystyka/statystyka.

Table 8. Monthly structure of tourist attendance in percent in the Tatra National Park in 2020

Month	2020	Average 18-19	Change in 2020 in relation to 18-19 average
1	5.0	3.98	1.00 p.p.
2	11.5	9.55	1.91 p.p.
3	3.8	3.71	0.06 p.p.
4	0.0	1.48	-1.48 p.p.
5	0.0	7.28	-7.28 p.p.
6	21.1	4.35	16.77 p.p.
7	19.5	9.69	9.77 p.p.
8	25.6	17.72	7.92 p.p.
9	11.3	11.84	-0.52 p.p.
10	2.3	10.11	-7.85 p.p.

Month	2020	Average 18-19	Change in 2020 in relation to 18-19 average
11	0.0	15.85	-15.85 p.p.
12	0.0	4.45	-4.45 p.p.
Final total	100.0	100.00	0.00 p.p.

Source: own study.

Discussion

Delekta et al. (Delekta et al., 2020) write that "increasing human impact in mountain areas may constitute a challenge to national park authorities," implying the importance of monitoring the most valuable areas, including but not limited to national parks, particularly the Tatra National Park. Therefore, interdisciplinary research is important in order to address the various aspects of the functioning of protected areas.

Similarly, notes (Klimek, 2017), writing that "since the second half of the 19th century, mountain tourism has contributed to the development of international tourism and, according to estimates, annually generates about 15-20% of revenues generated from tourism worldwide (UNEP, 2007). Despite the great diversity of offerings, since the mid-1960s, there has been a noticeable stagnation of summer tourism in many mountain regions, in contrast to well-developed winter tourism." She signals, however, that "research on the development of summer tourism in mountain regions is rarely presented in scientific studies in Poland and abroad". In her article, she showed the role of local and regional tourism organisations (DMOs) in stimulating summer mountain tourism through diversified product strategies. The systematic quantitative and qualitative research on tourism phenomena, conducted since 2003 by the Małopolska Tourist Organization, the regional Destination Management Organizations (DMOs), fits in with this way of looking at the problem.

In terms of sample size and thematic scope of questions included in the survey, the data presented in this article are unique in the country. The data were extracted specifically to present the problem and demonstrate how they could be used to help manage a well-defined tourist reception area.

Mountain tourism, which began in the nineteenth century, has a very strong capital attraction for international tourist flow and represents approximately 15-20% of annual global tourism income (UNEP, 2007). Although a huge variety of activities has been offered in numerous mountain destinations since the mid-1960s, summer tourism stagnates, unlike winter tourism

(France Montagne, 2014; Nydegger, 2014). Nevertheless, signals that studies concerned with summer tourism development in mountain regions are rare. The paper presents the result of a comparative study conducted between 2013, 2014 and 2015 in 183 local and regional Destination Management Organisations (DMOs) operating in selected European and North American mountain areas to understand their role in the stimulation of summer tourism through various product commercialisation strategies.

Systematic quantitative and qualitative studies of tourism phenomena carried out since 2003 by the Małopolska Tourist Organization as regional Destination Management Organizations (DMOs) fit in with this way of looking at the problem.

Apart from obtaining detailed data on the flow of tourist traffic, a very important element resulting from the research carried out is the analysis of its social aspects (NFS and NPS indicators). The presented data confirm that the needs of tourist trips accumulated in the period characterised by the lack of mobility are satisfied as soon as possible. The data on tourist traffic confirm this in individual months of 2020 presented in figure 1. This phenomenon is particularly visible during the summer season when restrictions on social mobility have been partially limited or lifted. A very important aspect related to the course of changes in the field of movement in space are also issues related to environmental protection.

The SARS-CoV-2 virus pandemic, on the one hand, had a large, negative impact on society and the comfort of its functioning; on the other hand, positive effects on the natural environment characterised it. In the case of the Tatra National Park, the most important thing to mention is the ecological renovation of tourist destinations (Hrytsai, 2021). The drastically reduced number of tourists using the trails located in the Tatra National Park in particular periods of 2020 provided the possibility of ecological regeneration of this area. The comparative data on the number of tourists visiting the protected area in individual months in 2018-2020 clearly shows that the period in which tourist traffic is low significantly extended in 2020, and thus the period was extended in which tourists do not directly influence of the natural environment.

Conclusions

The space of the Tatra National Park with its tourist function proved in the pandemic year 2020 resistant to the most restrictive limitations of social mobility. Active tourism, requiring individual skills to practice it, selected the stream of tourist participants reaching the territory of TNP. Therefore, this destination was particularly frequented by residents of very large cities,

followed by residents of large cities. This part of the population felt most the lack of access to natural or nature-like geographical space, which is extremely difficult to find in cities, especially very large ones. Feelings of fear for one's health and life kept most people with sufficient daily contact with the natural environment (inhabitants of villages and small towns) in their permanent residence, as well as people with a low sense of security who most often used the commercial offer of holidays or travel agencies. At the same time, people who could prepare their own trips for themselves and their families used their skills in partner trips with a strong emphasis on qualified tourism. An excellent area for such trips is the Tatra National Park.

Despite the fact that the index of fear of NFS departure dropped strongly in 2020 to the level of less than 67%, it turns out that the same respondents, already being on the spot and using the offer that TNP, together with other managers of the Tatra Mountains tourist base and attractions, prepared for them, gave a very high rating to the Tatra National Park, because the MPS index, which is measurable proof of individual satisfaction with the stay on the trails of TNP in 2020 was 80%. Also, the declaration of coming to the Tatra National Park again reached 90% of indications for YES, with 10% of hesitant people. After the removal of administrative restrictions in the summer season (June, July, August), there was a cumulative realisation of the "needs set aside" by the public during the recommended and sometimes forced "quarantine" in the place of permanent residence, which was clearly manifested in the intensity of the stream of tourist traffic in the Tatras, including the area of the TNP. This proves that once the possibility of SARS-CoV-2 infection is controlled and eliminated, tourism in the Małopolska region, especially in areas least degraded by civilisation, such as the Tatra National Park, will develop very dynamically.

The unique results of quantitative and qualitative research in the Tatra National Park, presented in this paper, are only a signal margin of the possibilities offered by the tourism database collected by the Małopolska Tourist Organization concerning the phenomena accompanying the penetration of the province by participants in both domestic and foreign tourism. Applying the method developed by the Intercollegiate Team of Experts of the Małopolska Tourist Organization to other regions (voivodeships) would allow comparative analyses of other destinations in similar periods according to the same parameters and indicators. As a result, it would be possible to obtain a complete picture of Poland as a Tourism Reception Area (Żemła, 2010; Seweryn, 2012), i.e. a destination for domestic and foreign tourists. The authors suggest that the described quantitative and qualitative research method on tourism participants be applied not only in other regions of Poland but also in other countries of the world (Borkowski, Grabińska, Seweryn, 2016).

The contribution of the authors

Individual contribution of the authors:

Conceptualization – Borkowski Krzysztof – 100%

Methodology – Borkowski Krzysztof – 100%

Software – Kubasiak Marcin – 70%, Borkowski Krzysztof – 30%

Validation – Kubasiak Marcin – 60%, Durmała Marek – 40%

Formal analysis – Borkowski Krzysztof – 50%, Kubasiak Marcin – 25%, Durmała Marek – 25%

The Investigation – Durmała Marek – 50%, Chowaniec Elżbieta – 50%

Resources – Borkowski Krzysztof – 70%, Durmała Marek – 30%

Data protection – Kubasiak Marcin -70%, Chowaniec Elżbieta – 30%

Writing – original draft – Borkowski Krzysztof – 40%, Durmała Marek – 20%, Kubasiak Marcin – 20%, Chowaniec Elżbieta – 20%

Writing – review and editing – Borkowski Krzysztof – 50%, Durmała Marek – 20%, Chowaniec Elżbieta – 30%

Visualization – Kubasiak Marcin – 80%, Chowaniec Elżbieta – 20%

Supervision –Chowaniec Elżbieta – 40%, Borkowski Krzysztof – 60%

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ORGANIZATION OF NATURE PROTECTION SYSTEM AND THE QUALITY OF MANAGEMENT IN NATIONAL PARKS - CONTRIBUTION TO THE DISCUSSION

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ABSTRACT: The aim of the article is to compare the legal and administrative foundations of the functioning of national parks as factors determining the quality of management. National parks in Poland and Ukraine, representing different nature protection systems, were selected for the comparative analysis and evaluation. The data was obtained from published sources. The most important were legislations that create the legal basis of the nature protection systems in both countries. The available data were used for analysis using the Desk Research method. There are numerous differences between the Polish and Ukrainian systems of protected areas, mostly based upon the position in the government structure (what is the way of creating the national park and which ministry is responsible for it). Despite those differences, general conclusions can be drawn. Due to the separate legal entity of individual units, as well as subordination to various ministries, there is no clear link between the institutions. This hinders the flow of information and reporting and complicates the decision-making process both at individual units and between national parks.

KEYWORDS: national park, nature protection system, organisational structure, quality of management, decision-making process

Introduction

Nature is a value in itself. Even though this maxim appears to be self-evident, the modern man appears to forget it all too often. The accelerating pace of life, still clearly visible consumption attitudes, conviction of eternal right ascribed to man to use goods – all this results in the growing expectation of satisfying human needs at the expense of environmental values. Fortunately, the tendency to make unhindered use of natural resources without paying attention to the imbalance of the environment is contrasted by the tendency to acknowledge the value of nature as a common good that should be respected, protected and cared for. It is by no means a new concept – this type of conviction has been with mankind basically since the beginning of time. For centuries, the protection of natural resources has been based on purely pragmatic reasons – from the human point of view, of course. We are talking here about reasons of religious origin (natural phenomena were treated as supernatural elements, sacred symbols of gods or places of worship), social (the most valuable and rich in game forest complexes or the most dignified animals were treated as the exclusive domain of kings or magnates) or military (such as protection of yew, which was the basic raw material for the production of bows). It took another century to recognise that nature deserves to be protected for its own sake and not because of its usefulness to man. The efforts of many generations of naturalists were crowned with success in 1872, when the world's first national park was established – Yellowstone National Park in the United States. Not much water flowed in the Vistula or the Dnieper, and the idea of creating protected areas was firmly established also in Central Europe.

In 1885, the idea of protecting the Tatra Mountains as the property of the whole nation emerged. Unfortunately, there was still a long way to go from the idea to its realisation. The first national parks were established in Poland in 1932 – these were the Pieniny National Park and Bialowieza National Park. The Tatra Mountains, which had been called for protection since the 1880s, had to wait for their national park until after the Second World War, more precisely until 1954. The oldest national park in Ukraine is the Carpathian National Park, which was established in 1980, but this does not mean that the protection of nature on the Dnieper River is only in the last 40 years. Much earlier, in 1898, Baron F. Falz-Fein announced the creation of the private park Askania-Nova, which was proclaimed a national park in 1919. This site is the first nature reserve in Ukraine.

The issue of national parks is a broad topic and may be the subject of extremely interesting research. This is due to the specific dualism of the

national park: on the one hand, it is a form of nature protection (in this matter, natural aspects prevail); on the other hand, it is an institution and an employer that is bound by certain management standards. The specific place of national parks in the legal and administrative system (especially in terms of supervision over them, sources of financing and structural connections between individual parks) generates clear effects on the effectiveness of the management. It is not so visible if one looks only from one country's perspective, and thus one system of nature protection. It is much easier to see the advantages and disadvantages of a given system when compared with the systems in force in other countries. Analyses should begin with an assessment of the current state; in other words, it is necessary to answer the question of what the current situation of national parks looks like on both sides of the Polish-Ukrainian border. This comparison seems to be of great importance not only in theoretical but also in practical terms. It should be noted that in both countries, the structure of territorial forms of nature protection, especially administrative location and functioning of national parks, is different. It seems to be legitimated to assume that the Polish system, where responsibility lies on a single ministry, is clearer, despite its obvious drawbacks. The most important disadvantage, which needs to be corrected, is the lack of formal relationships between national parks within both systems. It is also important that, in contrast to Poland, in Ukraine, the dynamics of creating national parks are still noticeable. The question is if this situation results from differences in the system of protected areas, different management or just political decisions.

The analysis of the present situation of national parks in Ukraine and Poland should begin with a synthetic summary of the most important data concerning protected areas in both countries. Currently, there are 23 national parks on the territory of Poland, covering a total area of approx. 3,168 sq. km, which means that Poland's highest form of nature protection covers approx. 1% of the country's area. The smallest of the Polish national parks is the Ojców National Park, located in the Małopolskie Province, with 21.46 km^2, while the largest is the Biebrza National Park, protecting 592.23 km^2 in the Podlaskie Province.

Ukraine, in turn, currently has 53 areas designated as National Nature Parks. Their total area is just over 13276 km^2, which is about 2.2% of the country's area. The largest national park is Podil Tovtry National Nature Park, with an area of 2316.16 km^2 located in Khmelnytskyi Oblast, while the smallest is Derman-Ostroh National Nature Park, with an area of 16.48 km^2, located in Rivne Oblast.

The process of creating new national parks in Ukraine is underway. In 2019, 4 new national parks were created in Ukraine, and in 2020, 1 national park, while in Poland, the last national park was created in 2001.

Materials and methods

In order to obtain a broad perspective enabling the comparison of the functioning systems of national parks in Poland and Ukraine, research was carried out using the Desk Research analysis method. The data was obtained from available published sources, with the fundamental contribution made by analysing legal acts relating to nature protection, which function in the legal system in Poland and Ukraine. The international composition of the research team guaranteed access to currently updated sources of existing data, which were then verified and processed to obtain a unified form of data from both countries, which allowed for their comparison. This allowed for a complete diagnosis of the current state of national parks, with the indication of differences in both compared systems. The image obtained in this way was analysed to evaluate both systems' potential. The main focus was on the basic problems that emerged during the analysis, thus assessing the effectiveness of both countries' formal and legal solutions.

Although it would seem that comparing the ways in which national parks function on both sides of the border should not pose any significant problems, the truth is somewhat more complicated. An attempt to analyse the nature protection systems in both countries leads to an unavoidable conclusion that the discrepancy concerns the very definition of a national park and its location in the system of area forms of nature protection. While in Poland, the national park is the highest form of nature protection, in Ukraine, there are two more categories of protected areas above the national nature parks (called National Nature Parks), namely the preserves and the preserves of the biosphere. These forms do not function in Polish legislation (equivalents of biosphere predictors in Poland are biosphere reserves, which, however, are not in any way embedded in the Act on Nature Protection). The difference between the different categories of Ukrainian protected areas is important for further considerations.

Nature Preserves protect areas with the highest natural values, which are important from the point of view of nature protection on the national scale. They are created not only to preserve in their natural state unique ecosystems in Ukraine but also to protect typical habitats characteristic of a particular type of landscape. These areas are under strict nature protection and are completely excluded from any commercial use. The main purpose of the existence of the preserves is to protect all the natural resources in their area,

as well as to conduct scientific research and monitoring. The data collected in the preserves (which are a kind of "reference areas" for the rest of the protected areas) is the basis for forming recommendations for nature protection on a national scale. If the land is transferred to the Ministry of Environmental Protection or the National Academy of Sciences of Ukraine, such areas are referred to as nature preserves.

Another category is natural national parks, which constitute the third category in the territorial forms of nature protection system in Ukraine. They also include naturally valuable areas, and, similarly to the preserves, they are excluded from commercial use. However, their goals include – apart from nature protection and conducting scientific research – protection of cultural and historical resources, making the protected areas accessible for tourism and recreation and conducting activities in the field of ecological education. Protected areas in the form of national nature parks may include areas that are not only owned by the state but also by other owners.

The above comparison clearly indicates that in terms of the goals of their existence, tasks, and ownership structure, the natural national parks of Ukraine are the equivalents of Polish national parks, and this analysis will focus on those areas. However, one should not forget that despite the fact that there are no nature preserves in Poland, many areas under strict protection in Polish national parks show equally high natural value.

Results

The basic legal Act regulating the issues of nature protection in Poland is the Act of April 16, 2004, on Nature Protection (Journal of Laws of 2020, item 1378). It defines what nature protection really is, understanding it as the preservation, sustainable use and renewal of resources, formations and components of nature (Article 2 of the Act of April 16, 2004, on Nature Conservation). The presented Act sets broad objectives for nature protection, which include maintaining ecological processes and the stability of ecosystems, maintaining biological diversity, preserving geological and paleontological heritage, ensuring continuous existence of plant, animal and fungi species, together with their habitats, by maintaining or restoring them to the proper state of protection, protecting landscape values, greenery in towns and villages and afforestation, maintaining or restoring natural habitats to the proper state of protection, as well as other resources, formations and components of nature, and also shaping proper human attitudes towards nature through education, information and promotion in the field of nature protection (Ibid.).

Table 1. Comparison of national parks in Poland and Ukraine

No.	Criteria for comparison	Polish national parks	Ukrainian national parks
1.	Number of units	23	53
2.	Total area	3168 km^2 (1% of the area of the country)	13 276 km^2 (2,2% of the area of the country))
3.	The area of the smallest park	21,46 km^2	2316,16 km^2
4.	The area of the largest park	592,23 km^2	16,48 km^2
5.	The year in which the oldest park was established	1932	1980
6.	The year in which the youngest park was established	2001	2020
7.	Creating institution	Council of Ministers (borders and statute introduced by the minister responsible for the environment)	President of Ukraine (the regulations must be approved by the Council of Ministers)
8.	Supervising / managing institution	Ministry of the Climate and Environment	Ministry of Environmental Protection and Natural Resources of Ukraine (for most of parks) State Agency for Forest Resources of Ukraine (eight national parks) State Administration (one national park)
9.	Sources of funding	Subsidy from the state budget (33%), the park's own revenues (36%), national and international special purpose funds (31%)	Subsidy from the state budget (80-100%), the park's own revenues (do 20%), special purpose funds (for nature protection), support from the business and private sector, international technical assistance
10.	Dedicated service inside the park staff	National park service – designated positions on the basis of the Nature protection act and the ordinance of the Minister of the Environment on qualification requirements in Nps	The State Protection Service provided by the Resolution of the Council of Ministers of Ukraine of July 14, 2000 "About the State Protection Service of the Nature Reserve Fund of Ukraine"
11.	NGOs associating national parks / acting for the benefit of national parks	Association of the Employers of Polish National Parks	Association of Protected Areas of Ukraine
12.	The influence of the state forests	Financial support (Forest fund)	Influence on the creation and functioning of national parks (many national parks are created in the areas of state forests)
13.	Strategic plan	National Park Protection Plan – valid for 20 years	Project of Organization of the Territory – park development strategy (10 years), main activities of the national park (5 years)

Source: author's work.

The Act on Nature Protection also formulates a catalogue of forms of nature protection, which under Polish legislation are: national parks, nature reserves, landscape parks, areas of protected landscape, Natura 2000 areas, natural monuments, documentary sites, ecological grounds, natural and landscape complexes and species protection of plants, animals and fungi (Article 6 of the Act of April 16, 2004, on Nature Conservation). The position of national parks on the aforementioned statutory list is not accidental – they constitute the highest form of nature protection in the light of Polish legislation, so it is not surprising that a significant part of the whole Act on Nature Protection is devoted to them. It should also be noted that the level of complexity of the functioning of national parks in Poland makes them regulated not only by the Act on Nature Protection. Currently, entries directly related to the activities of national parks can be found in nearly 120 legal acts in the rank of an act and in almost four thousand executive acts in the rank of a regulation. Such a strong dispersion of legislation concerning national parks does not facilitate their functioning, hence the recurring idea of creating a separate legal act, which would be the Act on National Parks, gathering the majority of regulations concerning the highest form of nature protection (Pasierbek, 2020).

The existing legal conditions, issues of financing sources and the location in the spectrum of responsibilities of individual ministries and other institutions generate specific problems in the functioning of national parks in Poland and Ukraine (table 1).

National parks in Polish law

The Act mentioned above of April 16, 2004, on nature protection recognises as a national park an area distinguished by a special natural, scientific, social, cultural and educational values. The law also limits the size of the national park by defining its minimum area at 1000 ha. In this area, the whole nature and landscape values are subject to protection (Article 8 of the Act of April 16, 2004, on Nature Conservation). The Act on Nature Protection also indicates a catalogue of prohibitions that apply in the area of each national park, the purpose of which is to preserve the natural values protected there (Article 15 of the Act of April 16, 2004, on Nature Conservation).

The purpose of the national park's existence is not only to preserve biodiversity, resources, formations and components of inanimate nature, and landscape values, but also to restore the proper condition of nature's resources and components, as well as to reconstruct deformed natural habitats, plant habitats, animal habitats, or fungi habitats (Article 8 of the Act of April 16, 2004, on Nature Conservation). In practice, it means that areas

where man has transformed nature, but there is a real chance to restore a high level of wildness in this area, can be included in the national park. This definition justifies also performing active protection activities in national parks, aiming to achieve statutory goals of the highest form of nature protection in Poland.

The objectives defined in this way are reflected in the legislator's tasks set before the national parks. These include:

- carrying out protection activities in the ecosystems of the national park, aiming at realising the above mentioned statutory goals of the existence of national parks,
- making the area of a national park available in accordance with the principles specified in the protection plan or protection tasks and the resolutions of the director of the national park,
- carrying out activities related to nature education (Article 8b of the Act of April 16, 2004, on Nature Conservation).

The issue of making the national park accessible, included in the second task, is further specified in the content of the Act on Nature Protection, specifically in part concerning the National Park Service. It states that the tasks of the National Park Service include making the area of the park available for scientific, educational, recreational and sporting purposes. It is also worth noting that the above mentioned three tasks set by the national parks are not a closed catalogue, which is evidenced by the fact that the list mentioned above is preceded by the phrase "in particular". However, it should be remembered that the tasks set for national parks, especially making the area of the park available to the public, cannot stand in opposition to the fundamental purpose of this form of nature protection, which is to preserve the values of living and inanimate nature (Article 12 of the Act of April 16, 2004, on Nature Conservation).

From the administrative point of view, a national park is a state legal entity in the understanding of article 9, point 14 of the Act of August 27, 2009, on public finances (Article 8a of the Act of April 16, 2004, on Nature Conservation). It means that it belongs to the public finance sector; it is established by the Act, based on the Act or in the execution of the Act by the government administration body to realise public tasks (Article 3 of the Law of December 16, 2016, on the principles of state property management).

The role of supervision over 23 independent entities, which Polish national parks are, is assigned by the Nature Protection Act to the minister in charge of the environment (currently, from October 6, 2020, it is the Minister of Climate and Environment). This supervision includes, in particular, the approval of annual material tasks resulting from the protection plan or protective tasks, the control of the functioning of national parks, the control of

the performance of economic activities by national parks, the control of the implementation of national parks' tasks, the control of the implementation of national parks' financial plans and the control of the activities of the national park director undertaken as a nature protection authority (Article 9 of the Act of April 16, 2004, on Nature Conservation). The minister in charge of the environment also grants the national park a statute defining, among others, the internal organisation of the national park in order to ensure efficient functioning of the national park and proper execution of its tasks (Article 8f of the Act of April 16, 2004, on Nature Conservation).

The individual status of a state legal person gives each of the Polish national parks considerable independence and freedom. It is clearly visible in organisational matters and in managing the institution. Each of the parks takes decisions independently, without the need for consultation or agreement with other parks, which means that in similar cases, the decisions of individual parks may be divergent. The organisational structures of national parks are also difficult to compare – although the positions in the National Park Service are defined in the Act, and the qualification requirements for their occupation are specified in the appropriate regulation (Regulation of the Minister of the Environment on positions and qualification requirements to be met by employees working on particular positions in the National Park Service of April 28 2005) the internal division of the park into organisational units is established separately in each national park. The director of each Polish national park independently represents the park externally and takes decisions regarding commitments made by the given national park. This refers not only to obligations in the form of employment contracts, civil-law contracts or contracting goods and services, but also to undertaking cooperation, including international ones (many Polish national parks have signed appropriate agreements with parks, institutions or non-governmental organisations dealing with nature protection from different countries). There are also different management standards, particularly national parks, which do not have to be unified.

Although the specification of each of the Polish national parks is different, what undoubtedly links them is the enormous natural value of those areas. Therefore, to further strengthen the protection of national parks against the negative impact of human activity, a buffer zone, called the buffer zone of the park, is delimited on the areas bordering the national park (Article 11 of the Act of April 16, 2004, on Nature Conservation).

The basic strategic document regulating the functioning of a national park in Poland is the protection plan. It is assumed that it should be created within 5 years from the date of establishing the national park (Article 18 of

the Act of April 16, 2004, on Nature Conservation); however, currently, the majority of national parks are still at the stage of creating the protection plan.

A project of a protection plan is prepared by the director of a national park, ensuring the possibility of public participation in its creation. It also requires an opinion of local boards of communes. Such a prepared project is submitted to the minister in charge of the environment, who establishes the protection plan for the national park by decree or refuses to establish it if the draft plan contradicts the objectives of nature protection (Article 19 of the Act of April 16, 2004, on Nature Conservation).

Sources of National Park funding in Poland

The separate legal personality of each national park also means that each of them runs its own financial management. Legislators have made it possible for national parks to perform the economic activity, restricting that this activity cannot conflict with the Act's regulations on nature protection (Article 8b of the Act of April 16, 2004, on Nature Conservation). In other words, national parks have the right to generate their own revenue, but this activity must not conflict with the primary goal of environmental protection.

Carrying out independent financial management, Polish National Parks cover, from their funds and revenues, the expenses connected with realisation of tasks defined in the Act, including National Park Service tasks, as well as other activity costs. This is done based on an annual financial plan that is the basis of park financial management, including, among others, income from conducted activities, subsidies (including those from the state budget), costs and funds for property expenses (Article 8g of the Act of April 16, 2004, on Nature Conservation).

The legislator has also identified potential sources of income for national parks, which can be summarised into three basic categories:

1. Subsidies from external sources, including the state budget, domestic and foreign purpose funds (EU and others);
2. Earnings from the statutory activities of the park, including income from the sale of products obtained through the implementation of tasks resulting from the protection plan or protective tasks, income from fees collected in connection with park educational activities and from the sale of educational, scientific and information materials, income from entrance fees to the park, as well as income from the rental of premises;
3. Other sources of park income not covered above, such as donations, inheritances, or generated by conservation projects (Pawlusiński, 2019).

It should be mentioned that revenues from certain sources can only be used to perform the first of the park's statutory tasks, i.e. to carry out protec-

tive work in national park ecosystems (Article 8h of the Act of April 16, 2004, on Nature Conservation).

Analysing the current financial situation of Polish national parks, it should be noted that, although the income structure in particular national parks may significantly differ from one another, it is possible to make some generalisations pointing to the main regularity in the financing of national parks. Although included in the public finance sector, Polish national parks cover on average about 1/3 of their costs from subsidies from the state budget (Raj, 2019). Another 36% is the park's own income, which, depending on the specifics, can be income from fees for access to the park, income from leasing land or from the sale of products derived from protective operations (e.g. timber from sanitary cuts). About 30% of parks' revenues are grants from purpose funds, both national (NFEP&WM, VEPF, Forest Fund) and international (EU, EEA, GEF and others), (Babczuk and Kachniarz, 2015). The share of grants has been increasing in recent years, especially due to the support given to national parks by the Forest Fund and the implementation of numerous infrastructure projects financed by the European Union.

A rarely used but allowed by the Act, national parks financing are also loans and credits that parks can take for their activities. The Act strictly defines such activity – it requires the approval of the minister in charge of the environment in agreement with the minister in charge of finance, and the amount of incurred liabilities cannot exceed 60% of the amounts included in the financial plan of income or 60% of costs (Art. 8h (3) of the Act of April 16, 2004, on Nature Conservation).

The complicated financial structure of Polish national parks does not facilitate the management of these units. This is particularly visible from the level of cooperation between national parks – financial flows between parks are practically impossible, which, in principle, does not allow parks in a more difficult financial situation or facing large investments to be supported by parks that have significant revenues. This makes the division into richer and poorer parks more critical, while it is worth noting that, for example, the tourist attractiveness, and therefore the potential to generate income in individual parks, can be very different. The lack of a common financial policy makes it extremely difficult to coordinate the tasks performed by national parks, as well as strategic planning of activities in national parks at the national level.

Organisation of national parks in Ukraine

Considering the national importance of national nature parks, their activities are regulated by national laws and other regulations, mainly the Ukrainian law "On Nature Reserves". In particular, the problems of the functioning of national nature parks are revealed in Chapter 3. This chapter explains the status, tasks and functional zoning of national parks but does not reveal the features of their functioning that caused the need for another lower level legislation. There is no separate law on the operation of national nature parks to date.

Among other laws related to the development of environmental protection is the Law of Ukraine "On the Ecological Network of Ukraine". National nature parks are defined as elements of the national ecological network in Ukraine.

Certain directions of the functioning of national parks are determined by various resolutions of the Cabinet of Ministers of Ukraine. In particular, the issue of compliance with the ecological regime is regulated by the Resolution of the Cabinet of Ministers of Ukraine "On approval of the fee for calculation of the amount of damage caused by violation of the regulations on nature reserves" (№ 541 z 24.07. 2013).

The park activities are described in detail in the regulations approved by the competent ministry. The most strategic regulations for the activities of the national nature park are the "Regulations on the project of organisation of the national nature park, protection, reproduction and recreational use of its natural complexes and objects", enacted in 2005 national park. The issue of individual national park territories is regulated by various regulations, including: "Regulations on scientific and scientific-technical activities of nature and biosphere reserves and national parks" (approved by the Order of the Ministry of Ecology and Natural Resources of Ukraine № 414 of 29.10. 2015); "Regulations on ecological education of nature reserves" (approved by the Order of the Ministry of Ecology and Natural Resources of Ukraine № 399 of 26.10.2015); "Regulations on recreational activities on the territories and fund objects of nature reserve of Ukraine" (approved by the Order of the Ministry of Environmental Protection of Ukraine № 333 of 22.06.2009). There are also many guidelines for issuing permits and setting restrictions for special use of natural resources in protected areas.

It should be noted that the creation of national parks is carried out by publishing a decree of the President of Ukraine "On the creation of a national nature park". Then, the Cabinet of Ministers of Ukraine must approve the newly created national park regulations.

The Ministry of Environmental Protection and Natural Resources of Ukraine is responsible for most of Ukraine's national parks. Eight national parks (Kreminski Lisy, Male Polesya) are under the jurisdiction of the State Agency for Forest Resources of Ukraine – the central executive body of Ukraine for breeding forest, hunting and game dogs. Azov-Sivaska National Nature Park is legally subordinated to the State Administration – a special state body for logistic, social and other support of the President of Ukraine, the Verkhovna Rada, the Council of Ministers, the National Security and Defense Council and others government agencies, all international diplomatic missions in the country.

Each national nature park maintains accounting, operational accounting, compiles periodic, annual, financial and statistical reports and submits them in the prescribed manner. The director and the chief accountant of the park are personally responsible for the organisation and maintenance of accounting and operational accounting, its accuracy, maintenance of periodic, annual, financial, statistical and other reporting, as well as for the preservation of relevant documentation. The park reports on its activities, in particular, to the Ministry of Environmental Protection and Natural Resources of Ukraine and the relevant state executive authorities in the manner and within the time limits specified by the law.

The Chronicle of Nature is one of the main forms of reporting in national nature parks. The major form of generalisation of the results of scientific research in reserves and national nature parks is the Chronicle of Nature which is conducted in accordance with approved manuals, instructions, and recommendations. The Chronicle of Nature provides basic data on nature's calendar, physical and geographical conditions, flora and fauna, anthropogenic impact on nature reserves. A separate section also describes research on other topics. The Chronicle of Nature also provides appendices. Chronicle of Nature – is a research project, which is constantly conducted, and its results are published annually in separate volumes. In addition to the natural history record, national parks annually prepare "Information on the results of the scientific research activities of the park".

The structural connection between the national nature parks of Ukraine is provided by the Resolution of the Cabinet of Ministers of Ukraine of July 14, 2000, "About the State Protection Service of the Nature Reserve Fund of Ukraine". The State Protection Service of the Nature Reserve Fund of Ukraine provides protection and preservation of nature reserves, biosphere reserves, national nature parks, botanical gardens, dendrological parks, zoological parks, parks-monuments of landscape art and regional landscape parks.

The State Protection Service in accordance with the tasks assigned to it:

- protects natural complexes of nature reserves, biosphere reserves, national nature parks, botanical gardens, dendrological parks, zoological parks, parks-monuments of landscape art and regional landscape parks;
- protects wildlife and their habitats on the lands and facilities of the wildlife sanctuary fund;
- ensures the use of natural resources;
- provides compliance with the requirements for visiting the lands and facilities of the nature reserve fund;
- prevents damage to forest plantations due to illegal logging;
- takes measures to prevent the occurrence, spread and fight fires and other emergencies;
- informs relevant state authorities of emergencies;
- ensures the implementation of measures to prevent and protect natural complexes from pests and diseases on reserve fund lands and facilities;
- maintains borders and security signs, information signs, quarter and field poles, as well as fire-fighting structures in good condition;
- ensures compliance with the regime of the territories and facilities of the reserve fund, including compliance with the requirements of the projects of organisation of the territories and facilities or the projects of maintenance and restoration of the facilities of the reserve fund throughout its territory;
- explains the need to preserve particularly valuable natural complexes and facilities.

It should be noted that the representatives of the State Protection Service are the direct employees of separate national parks. Within the park, the Service includes the director, chief naturalist and employees of the department of state protection of the nature reserve fund.

Among the national NGOs that directly specialise in the management of protected areas is the Association of Protected Areas of Ukraine – an all-Ukrainian public organisation created to support the protected areas of Ukraine, unifying them into one system, improving the management of protected areas of Ukraine nature reserves and environmental education. The association was established with the support of a collaborative project of the United Nations Development Program in Ukraine and the Global Environment Facility: "Strengthening the management and financial sustainability of the national system of protected areas in Ukraine". The activities of the association cover the entire territory of Ukraine. In particular, the collective members of the association are the national nature parks: Halytsky, Ichnyanskyi, Sviati Hory, Velykyi Luh, Hutsulshchyna, Skolivsky Beskydy and others.

When it comes to the internal structure of national nature parks, it is mostly consistent for all national nature parks. It comprises different departments – state nature reserve protection, economic, scientific, recreational and tourism.

Besides the relevant ministry, the State Forest Resources Agency of Ukraine influences the functioning and creation of national nature parks. Finally, mainly nature reserves are created on its territories. In particular, 16.6% of forests under the management of the State Forest Resources Agency of Ukraine are protected. Almost in all regions, forest reserves are higher than national ones. The forest plots belonging to the Forest Fund of Ukraine are 10.4 million hectares, including 9.6 million hectares covered with forest vegetation. Of this, 7.6 million hectares (73%) are under the management of the State Forest Resources Agency of Ukraine. The reserve forests of the State Forest Resources Agency of Ukraine occupy one third (33%) of the state reserve fund, and the forest coverage of the territory of Ukraine – 15.9%. In Ukraine, logging in the main use is already prohibited in 46.9% of forested areas.

In the forests of the State Forest Resources Agency of Ukraine, more than 3,300 nature reserve fund sites and facilities with a total area of 1.3 million ha have been created. In addition, the State Agency for Forest Resources of Ukraine in recent years approved proposed decrees of the President of Ukraine on the establishment, among others by the forests of the State Agency for Forest Resources of Ukraine, of national nature parks – Kamyanskaya Sich, Nobelskiy, Bojkovshchyna, Kreminskiy Lisy with a total area of 32.4 thousand ha, as well as proposals of decrees of the President of Ukraine on the change of borders (expansion) of national nature parks – Oleshkivski Pisky, Dniester Canyon, Uzhansky National Nature Park, etc. Today, forest areas are the main source of increasing the state reserve fund. In 2020, two national parks were created in the forests of the State Forest Resources Agency of Ukraine: Kuyalnytsky and Pushcha Radzivila.

According to the legislation of Ukraine, the sources of financing of national nature parks can be general funds of the state budget, environmental protection funds (environmental funds), private funds of business entities, international technical assistance. The main part of the financing of national nature parks falls on state subsidies (state budget fund, environmental fund). Its share varies from 80 to 100%, depending on the park's activities and the specifics of its location. Income from economic activity varies from 0 to 20%. The smallest part is international technical assistance, which is intermittent and fragmentary in nature. The analysis of financial indicators of the Shatsky Landscape Park (as one of the oldest and recreationally developed parks in Ukraine) indicates the following structure of income: 82% – income from the

state fund; 17.9% – income from provided services and economic activity; 0.1% – donations. In national parks it is necessary to pay more attention to the possibilities of obtaining international financial assistance, as well as to increase the possibility of obtaining additional funds through the providing of paid services.

According to Chapters 47 and 48 of the Ukrainian Law "On the Nature Reserve Fund", national nature parks may receive income from their statutory activities and create special ecological funds, which are supplemented by fees for violations of environmental regulations.

Providing paid services by national natural parks is regulated by the Resolution of the Cabinet of Ministers of Ukraine "About the approval of the list of paid services that may be provided by budgetary institutions of the nature reserve fund" (No. 1913 of 28.12. 2000). According to this regulation, national nature parks may carry out 19 different types of economic activities: leisure and tourist services; photography and video services; accommodation, food and transportation of tourists; veterinary services; sale of livestock and plant products; organisation of ceremonial events; location of commercial sites; sale of timber and wood products, etc. Within the list provided, park administrators may organise various business enterprises.

According to the "Regulations on the Project of Organization of National Nature Park, Protection, Reproduction and Recreational Use of its Natural Assemblages and Objects", each national nature park must have a Project of Organization of the Territory formulated and approved. It predicts the strategic plan of territory development for 10 years and main activities for five years. The project is prepared on the basis of regulations on dedicated parks approved by the Cabinet of Ministers of Ukraine.

The main tasks of the Territorial Organization Project are:

- to define the park development strategy for 10 years;
- to carry out a scientifically justified functional zoning of the park area and to establish a territorially differentiated regime of protection;
- to determine in accordance with the strategy and then implement by it concrete efficient actions for the development of the park, conservation, reproduction and leisure use of its natural complexes and facilities for five years.

In general, the project includes the following main components: park description, identifying priorities and problems, a ten-year strategy for park development, a five-year action plan, measures and resources, applications (cartographic materials, documents, functional zones).

The functioning of national nature parks in Ukraine does not contradict the development of communities. The borders of national parks include the settlements and facilities operating there. Therefore, conflicts between park

management are not excluded, which is connected with different visions of land development, but such conflicts are isolated. They are mostly related to illegal activities in the park: fishing, hunting, logging, etc. It should be noted that, in general, the public recognises the significance of a high-ranking environmental site's operation, and the escalation of environmental problems encourages the emergence of environmental awareness among the population.

Conclusions

Analysing the quality of management in national parks, one can clearly see the influence of the organisation of the nature conservation system itself, both in Poland and in Ukraine. The basic problem, which is already drawn at a cursory glance, is the lack of clear organisational links between protected areas. Individual national parks in Ukraine are under the supervision of different ministries or state forests, which definitely does not facilitate the coordination of activities undertaken in these areas. In Poland, all national parks are supervised by the minister responsible for the environment. However, it does not mean that we can talk about common management of protected areas in this case. The separate legal entity of each of the national parks makes them managed in a completely independent way. Internal organisational structure, resulting from the statute given by the minister, can be even similar, but its reflection in the functionality belongs to the specifics of each national park. Each park adjusts the structure individually to its needs, which makes, even at this level, any comparison between parks extremely difficult.

A similar situation occurs in the case of financial management. Considerable autonomy in decision-making in this respect causes particular national parks to differ not only in the structure of income and costs but also in the plan of accounts or in the financial and accounting programs used. This makes it almost impossible to summarise all parks' economic activities, hindering collective reports covering the units supervised by a particular minister. The individual approach to each national park also leads to discrepancies in tax issues. Although it would seem that taxes should affect every public institution in the country in the same way, it happens that in detailed issues, tax regulations are subject to the interpretation of regional branches of National Tax Information. These interpretations are binding in a given case and apply only to the requesting institution. This means that such a fundamental issue as the possibility to deduct tax on goods and services in different national parks may be different because they are subject to different locally competent tax authorities.

Conducting economically stable activities is one of the key conditions for realising the idea of nature protection. The fragmentation of the sources of income, and especially the insufficient level of subsidies from the state budget, are another problem influencing the management and decision-making processes. National parks are units, by definition, intended to protect natural resources, and this activity should be their priority. Meanwhile, the lack of financing from the state budget for the basic needs of the parks, such as conducting protection activities or the costs of employing staff with appropriate competencies, makes the administration of protected areas look for additional sources of funding. It is not a problem if additional sources of income are national or international purpose funds dedicated to nature protection, but it is definitely not enough in many cases. It is then necessary to work out the income on their own, without which the functioning of the national park will be questioned. The Act states that conducting profit-making activity by the park cannot contradict the primary goal of its existence, which is nature protection. However, it is to be feared that the need to find funds for remuneration of employees or other liabilities due may lead to bending, if not an outright violation of this principle. It may result, for example, in exceeding the tourist capacity of the area or making the national park into an object that does not differ much from a commercial forest.

Making independent decisions by particular National Park directors also concerns the issues related to nature protection and making the national park area accessible. Lack of necessity to agree on a common position in matters referring, for example, to tourist or leisure activities in the area of national parks causes those decisions made by particular directors may not only be divergent but often even mutually exclusive. This greatly weakens the message of nature protection – tourists visiting national parks may do things in some parks that are forbidden in others. This immediately raises questions about the substantive justification of rules in national parks and the arbitrary nature of decisions made by those who manage them. This usually concerns issues with strong social connotations, resulting from clearly defined expectations of visitors to national parks, such as the problem of bringing dogs into the area of a national park, moving around the park after dark, or – in the case of mountain parks – the use of ski-touring equipment.

Furthermore, the quality of management in national parks is affected by the previously described interdisciplinary nature of national park activities, resulting in a huge dispersion of normative acts regarding the functioning of this category of protected areas. It is not difficult to guess that it does not increase the quality of management in protected areas – the necessity to translate hundreds of legal acts in the rank of acts and regulations into management and administrative practice is time-consuming and requires expert

knowledge of the law. There is also an increased risk of making a mistake resulting from misinterpretation of some regulations. It is even greater because each national park in Poland does it independently – in many cases, there are no top-down guidelines even on basic issues.

Another issue affecting the quality of management of protected areas is weakening representation at the central level. Because there is no single organisational unit representing the interests of all national parks, whose voice would be much more distinct than the voices of individual national parks, the needs of national parks are perceived as local, unimportant from a national perspective, and thus marginalised. It may also lead to "fratricidal" competition between national parks – the richer, more popular and widely known parks will have much more influence on decisions concerning the whole nature protection system than their "smaller siblings".

However, the independence of national parks, resulting from the organisation of the nature protection system, also has its undeniable good sides, which improve the quality of the management process of these areas. The possibility of individual decision-making contributes to a significant acceleration of the decision process, which takes place bypassing central institutions. It also reflects more fully the specificity of a given national park, to which the central bodies may not pay due to attention. The separate legal personality of each protected area also contributes to establishing the national park in the region, building an appropriate social environment necessary for the proper functioning of nature protection. It allows for direct contact between the local community representatives, and especially of the local self-government at various levels, with the decision-makers in national parks, which, with significant centralisation of the nature protection system, could be impossible and certainly would be much more difficult.

It is extremely difficult to compare the organisation of the nature protection system in different countries. They function in different legal, administrative and economic conditions, in a different system of values and in a different social environment. However, it is certainly worth investigating various models of institutional nature protection, and especially their influence on the quality of the management process itself – both the area, understood as a form of nature protection, and the institution of the national park, considered as a workplace or a public administration body. The undeniable connection between the organisation of nature protection system and decision-making efficiency and effectiveness should be a subject of deeper research aiming at working out a way to increase the quality of protected areas administration.

Coordination of activities carried out by national parks, which could occur at the central level, seems to be a remedy for the problems presented

in this article. The potential creation of a new unit, whose decisions would be reflected in the functioning of national parks, or the voluntary agreement of park directors to transfer some of the competencies to an organisation that would coordinate some of the activities undertaken by all national parks, are only two of the possible ways of implementing this type of assumption. However, it requires extensive statutory changes that should lead to a single law that would normalise most national parks' functioning areas.

A mindset change at the administration level of the national parks themselves is also necessary in this regard. Ceding part of the powers to an external entity may give the impression of losing sovereignty, which never receives clear support. It is accompanied by the fear of excessive centralisation and, consequently, politicisation of the natural protection system. Building trust in such a structure certainly requires time and calm – nature protection should function stably, without unnecessary pressure, and decisions should be based on a strong factual foundation.

The above considerations lead to the conclusion that the present nature protection systems in relation to national parks in Poland and in Ukraine are waiting for changes that will improve the functioning of national parks and thus will raise the quality of the management process not only at the organisational level but also in terms of protection and management of natural components. Furthermore, reasonable modifications of statutory and organisational foundations of territorial nature protection will allow national parks to respond to present-day Central European nature challenges.

The contribution of the authors

Bezruchko Lyubomir – validation, investigation, writing – original draft preparation, writing – review and editing (20%)

Pasierbek Tomasz – conceptualisation, methodology, investigation, writing – original draft preparation, writing – review and editing, supervision (40%)

Juraj Rakos – validation, formal analysis, writing – review and editing, supervision (20%)

Zhuk Yuriy – validation, investigation, writing – original draft preparation (20%)

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ENVIRONMENTAL PERFORMANCE OF PIG MEAT PRODUCTS AND IMPROVEMENT OPPORTUNITIES. CASE STUDY FROM SPAIN

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ABSTRACT: The publication aims to assess the environmental performance of meat product and to point out the possibilities of improving the product quality in terms of its environmental impact. The research was performed within the CIRC4Life project on the example of ALIA company, Spain. The Life Cycle Assessment method and literature study were used for this purpose. The LCA was carried out for subsystems: feed production, pig housing, slaughtering, meat processing. Two scenarios: basic and improved were compared using the ReCiPe method. In the basic scenario, the highest impacts are attributed to agricultural land occupation 29%, climate change 34%, natural land transformation 11% and fossil depletion-11%. Animal feed production is the most critical phase. Comparative analysis of the scenarios showed that there is a potential for beneficial trade-offs between different impact categories by changing the processes and materials for feed production.

KEYWORDS: life cycle assessment, LCA of pork, environmental performance

Introduction

The existing studies show that the pig meat production systems contribute to increased water, soil, and air pollution. The pig meat production sector has to face many challenges related to transforming agriculture to be more friendly to the environment and the climate, which needs implementing sustainable production methods and circular business models in food processing and retail.

This publication aims to assess the environmental performance of pig meat product manufactured within the ALIA company and identify the opportunities for the improvement of its selected meat product quality in terms of its environmental impact. ALIA is an agricultural transformation society, located in La Hoya, in the centre of Guadalentin Valley, Lorca, in the Murcia region of Spain. The cooperative is currently comprised of over 900 members ranging from small family farms to large, industrial-sized agricultural enterprises. It covers, in the value chain of meat products, mainly the processes of fodder production, rearing of pigs, slaughterhouse, meat processing plant and its distribution. To some extent, it also encompasses crop production, but most of the raw materials for feed production come from the global market. The company is a part of a circular economy demonstrator, within the CIRC4Life project, focused on improving manufactured products' environmental and social performance and reducing wastes. The demonstration activities are aimed at shaping sustainable consumption patterns through the development of the environmental performance indicators of ALIA products as an integral part of the eco-labels put on these articles. For this purpose, the environmental assessment of selected pork products was performed, and some parts of this analysis are presented in this paper.

In this publication, the Life Cycle Assessment (LCA) was used. It covers the following phases of the value chain of the production of pig meat product:

- production of feed for pigs,
- farming of pigs,
- slaughterhouse activities,
- processing of meat and distribution of the products to the consumers.

The analysis was performed for two scenarios: the basic scenario which refers to the current ALIA practices and the improved scenario taking into account changes in the full life cycle of the production process aimed at improvement of the environmental performance.

An overview of the literature

Pig meat production is one of the major contributors to global environmental degradation. The pig sector is a complex system that involves fertilisers and pesticides for crop production, land transformation, transportation to and from farms, energy for processing and heat, water for animal feeding and farmyard washing, and waste management (McAuliffe et al., 2016). World livestock production has major impacts on the environment because of its emissions, which affect air, water and soil quality, and the use of limited or non-renewable resources. In this context, European Union pig production systems are facing major challenges. There is increasing public concern about the dominant intensive production systems mainly because of shortcomings in environmental and animal welfare. Due to economic constraints and globalisation, pig production systems are similar throughout the world (Dourmad J. Y. et al., 2014).

The environmental impact of pork production is the subject of many studies. These studies are carried out using a life cycle approach, particularly the life cycle analysis tool , which allows for identifying the most important impacts associated with individual phases of the manufacturing process. LCA is a useful tool for the analysis of the environmental assessment of meat products because it considers all the GHGs emitted from all stages of agricultural and food production. Apart from climate change in respect to global warming, other impacts include acidification, eutrophication, consumption of natural resources (mainly water and energy), and polluting the environment with various types of waste and wastewater discharge (Djekic I., 2015). LCA can assist in determining the overall material and energy efficiency of an agricultural system and can assist in the identification of 'hotspots' for polluting stages in production systems (Biswas et al., 2010).

The LCA analysis is focused on different phases of meat production. The main impact categories identified in the literature are: global warming potential related to emissions of methane, nitrous oxide and carbon dioxide; acidification and eutrophication potential as well as the use of natural resources, namely water and energy (Reckmann K., et al., 2012, Basset-Mens C et al., 2005, Dalgaard R. et al., Dalgaard R. et al., 2007b).

The production of feed for pigs is viewed as the main contributor to the environmental impacts of pork production in Europe causing the majority of emissions (Dalgaard, R., 2007b). According to the global LCA Study on the pig supply chain from the Food and Agriculture Organisation, feed production contributes around 60% of the emissions arising from global pig supply chains, and manure storage/processing 27%. The remaining 13% arises from a combination of post farm processing and transport of meat (6%),

direct and indirect energy use in livestock production (3%) and enteric fermentation (3%) (Djekic I. et al., 2015; MacLeod M, 2013). In order to reduce the emissions from the production of pork products to the environment, it is important to make some improvements at the stage of feeding. The literature data show that the substitution of soybean products in animal feed seems to have the greatest potential for minimising the environmental impact (Reckamann K. et al., 2016). A large share of greenhouse gas emissions from using soybean products is related to crop production, transport, and land-use change which refers to the conversion of land used. The cultivation of soybeans for livestock feed manufacturing has expanded rapidly in recent years. Therefore, improving feed production in the livestock supply chain has a great potential to minimise environmental impacts.

The LCA analysis in this paper was carried out for a selected meat product: cured pork sausage Longaniza Imperial de Lorca produced by ALIA company. It is a cradle to gate analysis including also the meat processing and its distribution. Identification of key determinants of the environmental impacts were used for the optimisation of the environmental performance of the value chain. The improvements were focused on feed for fatteners composition. Two scenarios for fodder composition were compared to validate the assumptions.

Research methods

In the study, the Life Cycle Assessment (LCA) was used to assess which of the production phases cause relatively high damage to the environment. This method was also used to optimise the environmental performance in the value chain. Especially, it was used to optimise the feed recipe for pigs in order to select the feed ingredients in such a way that, while ensuring adequate nutritional value, they have a relatively low impact on the environment, taking into account both their production method and source of origin.

The LCA method and tool

Life cycle assessment (LCA) is a tool for environmental evaluation that has attracted much attention in the last decade, as it allows the comparison of different products or activities, based on the quantification of their potential environmental impacts related to the emissions of pollutants to the soil, air and water as well as the consumption of resources throughout their life cycle (Guine´e J.B., 2002). Principles of carrying out research with LCA have been given by the International Committee for Standardization in the EN ISO 14040 and EN ISO 14044. The standard PN-EN ISO 14040, refers to a life cycle assessment and a life cycle inventory analysis. The rules described in

that standard should be used as the guidelines for decision making in LCA planning and running. In the standard PN-EN ISO 14044, the requirements and guidelines concerning a life cycle assessment have been given. The standard's resolutions refer to four main parts of the LCA study: defining its aim and scope, a life cycle inventory analysis, a life cycle impact assessment and an interpretation of results.

The result of an LCA study is an environmental profile of a product or activity in the form of a "score list" with environmental effects. The environmental profile shows the largest environmental problems caused by the production of a product, and at which stage(s), in the life cycle, these problems appear. The LCA process is iterative and involves revisiting previous steps when, for example, new data become available or a gap in required data is acknowledged.

In the case of agricultural systems, the LCA evaluation may be useful in practice for the decision making in the field of application of new technologies, improvement of existing products or services, marketing purposes, strategic planning and policymaking. Product designers can explore how their design choices affect the sustainability of the products.

For the purposes of the LCA of meat products, it was used the SimaPro tool, Release 8.5.2.0.

Goal and scope of analysis

The objective of this study is to assess the environmental performance of the cured pork sausage in its life cycle from the production of feed for pigs, the pig farm, via slaughterhouse to a meat processing plant in Murcia Region in Spain.

The study comprised the following steps:

- identification of relevance of life cycle phases,
- identification of the main environmental impacts of the most relevant life cycle phases,
- identification of main factors determining the impacts,
- assess the opportunities for improvement based on plans proposed by the producer.

The cured pork sausage was selected as a subject of environmental analysis because it is a very popular ALIA's meat product among consumers in Spain and is representative of a whole range of common food products.

The LCA covers the following phases of the value chain:

- production of food for pigs,
- farming of pigs,
- slaughterhouse activities,
- processing of meat and distribution of the products.

The analysis was performed in two steps which correspond to two scenarios:

- the basic scenario of ALIA current situation,
- the improved scenario in which changes have been made by the ALIA company to achieve the higher environmental performance of the assessed product.

The analysis was carried out with regard to the 18 impact categories (midpoint indicators, ReCIPe 2016 Endpoint method) and then the most important midpoint indicators have been identified using the endpoint analysis and then assessed for the main life cycle phases.

Functional unit

A comparison of life cycle environmental impacts should be based on a comparable function (or 'functional unit') to allow a fair comparison of the results. The functional unit adopted for the study is 1 kg of meat product: 1 kg of Longaniza Imperial de Lorca pork sausage - as a final product to the customer. Longaniza Imperial de Lorca is a raw Spanish sausage originating from Lorca in Murcia produced by selection and chopping of meat: lean pork, pork belly, salt, white pepper and nutmeg. This mixture is stuffed into natural, calf casings. Then the product is submitted to a controlled process of maturing and drying, which ensures good stability, as well as the characteristic colour, smell, taste and texture. Imperial de Lorca preserves the traditional and manual character of the LOS QUIJALES brand. The sausage is sold on the market in packages of about 250 g.

System boundary

The starting point for guiding LCA analysis is the exact definition of the product system by drawing the boundaries of the system, life cycle stages and the unit processes. For example, the production chains of pork cured sausage consist of different production steps: feed production, pig housing, slaughtering, meat processing. This study is a 'cradle to gate ' life cycle assessment. The consumption (storing at consumer) and post-consumption stage (waste generated after the product has been used by the consumer/waste from wasted products at consumer) are excluded from the analysis.

Within the feed production subsystem, all processes required for the production of animal fodder were considered. Feed is made from crop products, by-products, processed products and processed feeds. This sub-system includes the relevant agricultural processes: cultivation of crops, transport of crops from the place of cultivation to the processing plant, and its processing. The analysis was performed for three types of feed which differ in composi-

tion: feed for sows, feed for piglets from 6 kg to 20 kg and feed for fatteners from 20 kg to 100 kg.

Pig housing at the farm includes key activities which take place on the farm. In the farming of pigs, there is considered: feeding of sucking piglets, weaned piglets, fatteners, breeding gilts, boars and sows. The analysis covered three processes: rearing sows and sucking piglets, rearing piglets and feeding fatteners for slaughter. At this phase the direct use of manure as fertiliser was assumed as a preferable and standard method of waste disposal. In the case of dead animals disposal, the incineration method was considered. Waste management in all phases and production processes, including the dead animals from breeding, was included in the study.

Slaughtering subsystem includes key activities which take place in a slaughterhouse from reception of live pigs, covering livestock handling and animal welfare, slaughtering comprising stunning, bleeding, scalding and dehairing, evisceration, splitting the carcass, and chilling.

For the production of 1 kg of sausage, 1,35 kg of the animal must be raised and transported to the slaughtering house. As a result, only parts of the animal that are fit for human consumption are kept and the inedible parts are removed in the slaughtering process. The allocation factors for pigs' mass fractions in the slaughterhouse were used according to the Product Environmental Footprint Category Rules (PEFCRs) for pork modelling (European Commission, 2017). Waste management and the use of cleaning agents were included in this subsystem and used in the calculations.

Meat processing included all activities which take place in a processing plant, from the reception of carcasses, covering preparation activities, thermal processing, waste handling and storage of final products. The use of waste and cleaning agents were included in this subsystem and used in the calculations. Waste management and distribution of products were included in the study.

The system boundary of the LCA of meat products is presented in figure 1.

In life cycle assessment, different types of co-product allocation methods can be used. The Handbook on LCA (Guinee, 2002) advises using economic allocation as a baseline for most allocation situations in a detailed LCA. In the LCA of meat product, the economic allocation was used according to the Product Environmental Footprint Category Rules (PEFCRs) for pork modelling. This is also in line with most LCA's performed for the food sector. Economic allocation means that the shares of upstream impacts are divided between co-products based on their relative value fraction which is based on the sum of all revenues of all co-products produced in a specific production stage.

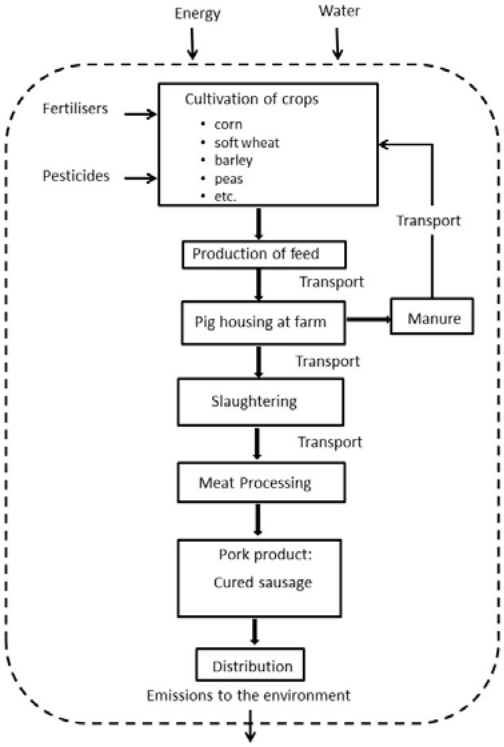


Figure 1.
The overview of the system boundary of the LCA of meat products

Source: author's work.

Allocation procedures

In order to describe how activity datasets are linked to form product systems in the ecoinvent database version3 the Allocation, ecoinvent default system model was predominantly used. It follows the attributional approach in which burdens are attributed proportionally to specific processes. Taking into account the goal of the analysis, the attributional modelling was used as this approach does not account for consequences in the surrounding market. Within this approach, all the environmental inputs and outputs are summed from raw material extraction (cradle) to the gate of the products.

Life cycle inventory analysis

Data requirements

In the first phase of the LCA, a product system is defined and in the second phase, it is filled with the inventory data. To perform an LCA all impacts of a product from cradle to gate were considered. As a rule, not only the main process chain – processes directly related to the functional unit – needed to be assessed, but also background processes like material production, energy

supply, waste disposal and the delivery of services like transportation, construction, maintenance.

The inventory data in the study covered two types of data:

- foreground data on the system of primary concern were obtained from ALIA company.
- background data includes energy and materials that are delivered to the foreground system as aggregated data sets in which individual plants and operations are not identified. Background data were derived from secondary sources, e.g., literature, background databases providing average datasets, including the European ecoinvent database.

Foreground data provided by the ALIA company are included in table 1. The inventory for the individual processes and the fuel and energy balance, as well as for the unit processes of background subsystem were obtained from the ecoinvent database version 3 and Agri-footprint. In addition, output data related to main emissions, sewage and waste were obtained from the literature as well as from this database.

Assumptions and limitations

For the calculations, the infrastructure was not included. The ALIA company provided in most cases indicators, not the actual measures of the key parameters to describe the subsystems. To some extent, it was necessary to adjust SimaPro ecoinvent database version 3 selected processes for the model of ALIA system of meat production. There was no available data on the ranges of parameters and variants for the key processes limiting the sensitivity analysis.

Inventory Analysis

In this step, information on the use of resource materials and energy that are used within the life cycle, as well as the emission of substances throughout the life cycle, was collected. ALIA provided inventory data and for some parameters, the values from the ecoinvent database version 3 as well as Agri-footprint – comprehensive SimaPro database, were adjusted based on the information provided and expert knowledge and literature. The inventory includes data collection for the two scenarios of meat processing:

- the basic scenario based on current practices of rearing pigs by ALIA and meat processing,
- the improved scenario where changes have been made to achieve a higher environmental performance of the meat products.

To strengthen the sustainability of the products, the new formula of the nutritional material for fatteners 20 kg to 100 kg has been developed. Compared to the basic scenario, the amount of some components (barley, sunflower cake) decreased and in the case of soft wheat the place of origin has changed from Brazil to Europe. Instead, new ingredient has been incorporated (flour cake and beet), and the amount of corn increased by 8% in comparison to the previous formula. To strengthen sustainability, it has also been declared that there are no dead animals at the animal breeding stage. In this scenario, the use of water for the preparation of feed for piglets is not required. The thermal energy is also zero because the consistency of the fodder is in 100% flour (not granulated) as it is – it is a more efficient way of the production of animal feed.

For raw materials and bioproducts, there were used ecoinvent database version 3. Impacts of the raw materials used were included in the assessment as it was taken into account in the background information from the ecoinvent database. For fodder additives and additives in the sausage production proxy data from the ecoinvent database or own modelling based on background data from the ecoinvent database was used. Emissions to water and air from pigs rearing including manure management were based on a modified ecoinvent database – adjusted to ALIA farm structure. Foreground data on farm structure, water, feeding material energy, manure disposed and dead animals were provided by the producer. The inventory data is presented in table 1.

Table 1. Inventory data for the production of meat processing products for the basic scenario and the improved scenario

Input/output category	Unit	Basic scenario	Improved scenario
Production of animal feeding			
Corn 13%	g	1376.170	1467.805
Barley	g	693.808	659.574
Soft wheat F10	g	533.219	613.374
Peas	g	565.088	604.697
Middlings	g	242.484	255.725
Beet / sugar cane	g	24.248	-
Byproducts	g	929258	1313271
Additives	g	193.202	247850
Electrical energy	MJ	1.480	0538

Input/output category	Unit	Basic scenario	Improved scenario
Biomass	MJ	0.954	0220
Fuels	MJ	0.129	0056
Water	t	0.269	0102
Kraft paper	g	7.541	7541
Pig housing at the farm			
Transport	tkm	0164	0206
Veterinary medicine	kg	0569	0006
Heat almond shells	MJ	3704	4125
Drinking water	l	45147	25528
methane biogenic from enteric fermentation	kg	0056	0057
nitrogen monoxide - indirect emissions	kg	0001	0001
Ammonia	kg	0041	0041
particulates < 10 um	g	0455	0444
Dead animals	kg	0231	0020
Manure liquid	t	0034	0018
Subsystem Slaughterhouse			
Drinking water	l	4172	
Transport van < 3,5	tkm	0068	
Electricity	kWh	0278	
Heat natural gas 100 kW	kWh	0356	
Sewage sludge	m3	0027	
Slaughterhouse waste	kg	0009	
Subsystem: Manufacturing of products			
Electricity	kWh	1670	
Waste	kg	0029	
Drinking water	kg	6354	
Transport truck 10-20 t	tkm	0060	
Additives	kg	0179	
PE	kg	0006	

Source: author's work based on ALIA company's data.

Life Cycle Impact Assessment

In this step, the inventory data – Life Cycle Inventory results – were assessed using the SimaPro tool. Life Cycle Impact Assessment translates emissions and resource extractions into a limited number of environmental impact scores by means of so-called characterisation factors. ReCiPe 2016 method was used to calculate the product total score endpoints and midpoints to measure the environmental impacts of products. ReCiPe calculates eighteen midpoint indicators and three endpoint indicators. Midpoint indicators concern single environmental problems. In this study, the most relevant midpoint indicators have been identified using the endpoint analysis and then assessed for the main life cycle phases.

Results of the research

Basic scenario assessment

The most important endpoint impacts of the life cycle of the cured sausage (measured as mPt ReCIPe 2016 Endpoint method) analysed for the basic scenario concern human health and ecosystems. The share is respectively for human health: 32% and ecosystem 57% of the total score (figure 2). The impact on resources is relatively low (11%).

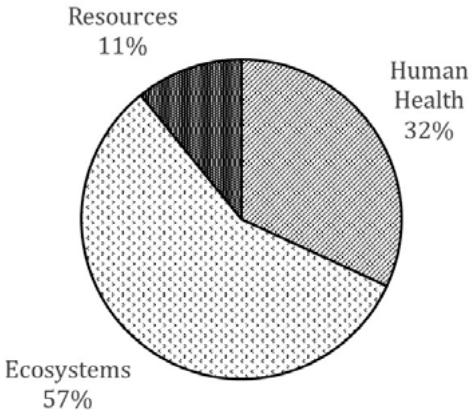


Figure 2.
Percentage share of endpoint indicators of environmental impact (expressed as single score) of the full life cycle of the cured pork sausage in the basic scenario (Recipe 2016 Endpoint method)

Source: author's work.

The main processes contributing to damage to human health are related to the feed production phase. Feed production is also the main phase contributing to damage to ecosystems. As regarding the damage to resources feed production and meat processing phases has the highest contribution.

Analysing the basic scenario with regard to the impact categories (midpoint indicators, ReCIPe 2016 Endpoint method), the most important are (figure 3):

- climate change human health,
- human toxicity,
- particulate matter formation,
- climate change ecosystems,
- agricultural land occupation,
- natural land transformation,
- fossil depletion.

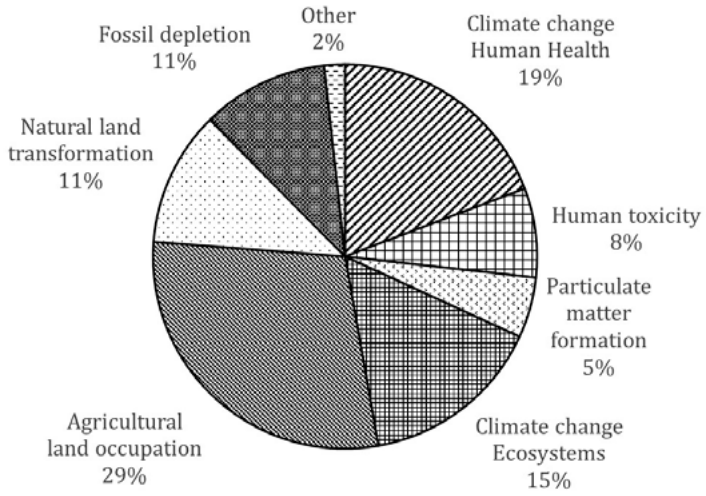


Figure 3. Percentage share of midpoint indicators of the total environmental impact (expressed as a single score – RECIPE 2016 Endpoint method) of the full life cycle of the cured pork sausage in the basic scenario

Source: author's work.

The identified impact categories constitute 98% of the total score expressed in mPt (Recipe 2016 method). The highest midpoint indicators are attributed to agricultural land occupation – 29%, climate change: 34% (ecosystems – 15% and human health – 19%), natural land transformation – 11% and fossil depletion – 11%.

The highest midpoint impacts, except for particulate matter are attributed to feeding production. It concerns especially agricultural land occupation and natural land transformation for which the feed production impact contribution is higher than 95% (figure 4e, figure 4f). The dominating role of feed production is due to extensive global networks of crops markets that are the basis for feed production (Mc Auliffe et al., 2016). It is also the case of

ALIA which production pattern is rather typical for Europe, where the feed production is based on global markets. In order to produce each individual ingredient, resources and energy are required and large-scale transportation networks are utilised. The dominating factors in this phase are processes of raw materials production. In the case of the Climate change (figure 4a) midpoint indicator, it is 32%, especially soybean production in Brazil (17% of the indicator). For the agricultural land occupation, 96 % of this indicator is shared by the cultivation of soybean, maise, pea, wheat grain and barley. In the basic scenario soybean, maise and wheat grain are in the biggest part produced outside of EU-27. Soybean cultivation in Brazil is responsible for 87% share of the Natural land transformation indicator. Transportation of the materials is also an important factor (11% of the total Climate change indicator) with the highest share is allocated to the feed production phase.

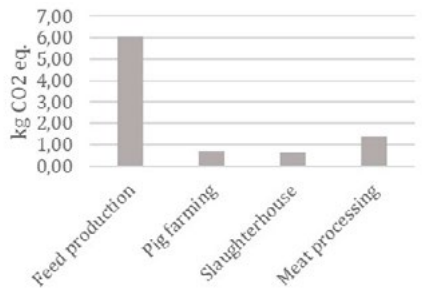
According to literature, the role of feed production is also viewed to be the largest contributor to environmental burdens in the pig supply chain (Mc Auliffe et al., 2016, Van der Werf H.M. et al., 2005).

The main factor of the environmental impact of the meat production phase is caused by demand for electricity use is responsible for the climate change indicator at the level of 21% with the highest share attributed to meat processing (57%).

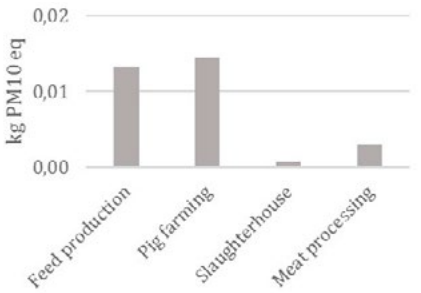
The human toxicity midpoint indicator (figure 4c) is attributed to agricultural production (feed production and farming) and to a lesser extent to the meat processing phase. Human toxicity is determined mostly by electricity use 30% share (where 66% is attributed to feed production) and also energy-related processes along with chemicals use especially during the production of raw materials with 77% share attributed to this phase. Fossil depletion midpoint indicator (figure 4d) is related mostly to electricity used in the meat processing and feed production phases. Particulate matter formation (figure 4b) is attributed to a variety of processes including energy-related processes and chemicals production.

Pig farming has a relatively high impact only in the case of particulate matter midpoint indicator. The process of pigs rearing is sensitive to manure management as well as emissions to the air from the farm. In the case of ALIA manure is used as fertiliser locally in the fields. Based on the specificity of the usage (type of soil, time of application and weather conditions) the total assessment can differ up to 10%. Benefits of applying manure as fertiliser are included in the assessment. The benefits depend also on the actual content of NPK elements in the manure used as fertiliser. As a result, negative impacts on human health are avoided. Important factors are also waste treatment transportation of the manure and management practices being the cause of air and water emissions. Considering other research results, the direct appli-

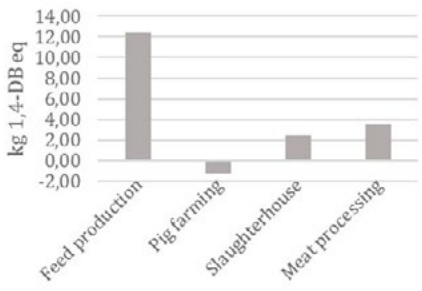
cation of pig manure as fertilizer is an environmentally friendly solution (Makara A., et al., 2019). According to other authors, this is of high importance shown in other studies using other interpretation tools (e.g. ILCD, CML Baseline method) (Reckamann K. et al., 2015). Slaughterhouse has the lowest values in all impact categories, and the impact is related mostly to energy and transportation.



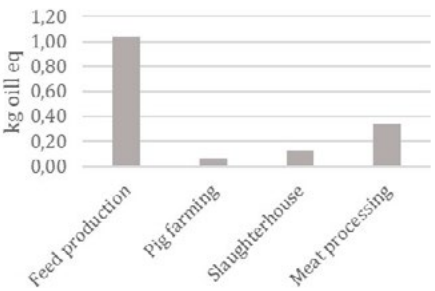
4a. Climate change



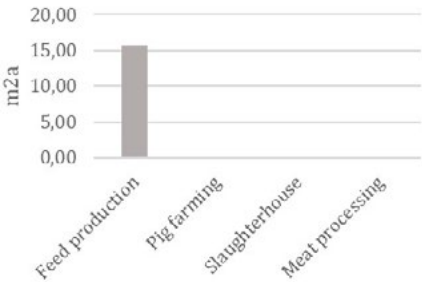
4b. Particulate matter



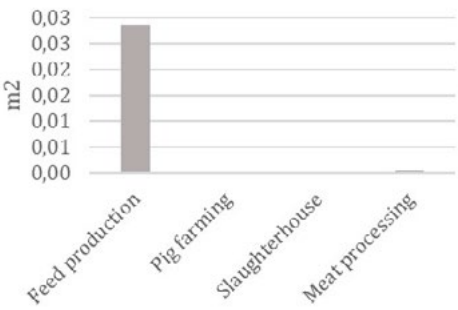
4c. Human toxicity



4d. Fossil depletion



4e. Agricultural land occupation



4f. Natural land transformation

Figure 4. Environmental impacts of the cured pork sausage per 17 categories of environmental damages – basic scenario (ReCiPe 2016 Midpoint)

Source: author's work.

The uncertainty of analysis is mainly related to the market information on crops. Assumptions had to be made as the producer provided general information about the origin of products (country). Data concerning pigs rearing, slaughterhouse and meat processing were of good quality based on company data.

It has to be noted that feed production is a more globalised burden while livestock production and waste management generate more localised burdens. Based on the results it was recommended in the first place to use waste materials from agricultural production for animal feed production and to pay attention to the origin of agricultural raw materials used for the production of feed with a preference for locally produced materials.

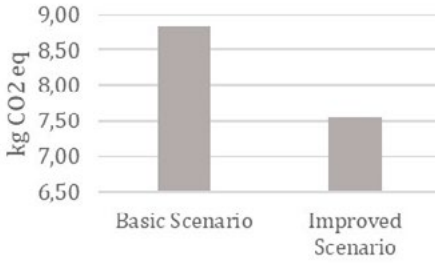
It has to be noted that the assessment is sensitive to the type of electricity mix. In the studied case electric grid mix for Spain was applied in the basic scenario. Depending on the local conditions and the company activities the potential impact might be essentially lower.

Comparison of the basic and improved scenarios

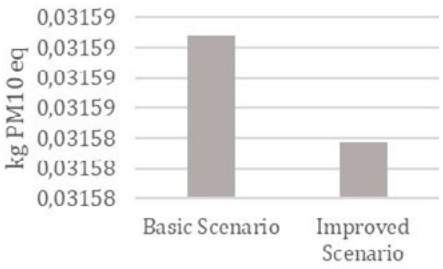
In the improved scenario, ALIA proposed the new formula of feed for rearing pigs. This scenario was compared with the basic scenario. The ReCiPe 2016 Midpoint method was used to compare the scenarios for the selected as the most relevant impact categories. Implementing the modified formula of fodder has predominantly consequences in raw materials value chains, feeding production process, and to some extent on pigs rearing.

The chart below presents a comparison of impacts midpoint indicators of the production of cured pork sausage per impact category for the two compared scenarios (figure 5). There is observed essential improvement in the impacts attributed to agricultural land cultivation including natural transformation and agricultural land occupation, and climate change.

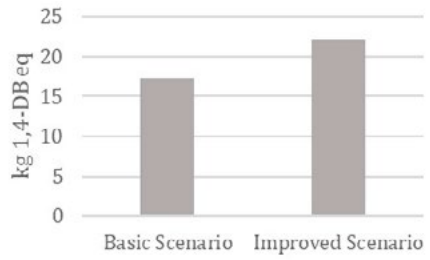
The improved scenario is slightly worse than the basic scenario for midpoint indicators: human toxicity, particulate matter and fossil depletion (table 2). It is attributed to by-products used in the modified fodder formula and higher use of feeding supplements (amino acids). The reason is that processing of raw materials and the production of feeding supplements is energy and in some cases chemicals and water-intensive. According to the producer some activities were undertaken to switch to renewable energy, and they were assumed in heat production in feed processing.



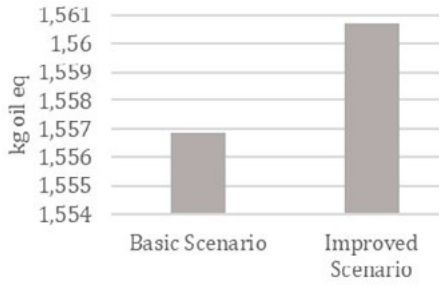
5a. Climate change



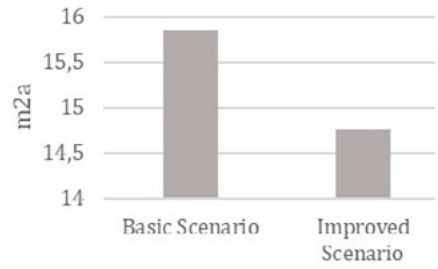
5b. Particulate matter



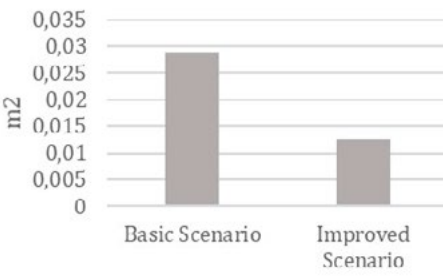
5c. Human toxicity



5d. Fossil depletion



5e. Agricultural land occupation



5f. Natural land transformation

Figure 5. Comparison of impacts of the production of cured pork sausage per impact category for the basic scenario and improved scenario (ReCiPe 2016 Midpoint)

Source: author's work.

Considering the results, it can be concluded that there is a potential for beneficial trade-offs between different impact categories by changing the processes and materials. The main trade-offs are between climate change, agricultural land and natural land transformation as mostly ecosystem related impacts versus human toxicity as human health-related impact.

Table 2. Relative change between basic scenario and the improved scenario

Impact category	Relative change
Climate change	-14.46
Human toxicity	+28.06
Particulate matter formation	-0.02
Agricultural land occupation	-6.92
Natural land transformation	-56.64
Fossil depletion	+0.25

Source: author's work.

Conclusions

The study provides insight into key factors of the environmental performance of pork meat products and the opportunities for improving environmental performance based on the example of Alia company, Spain. Meat production is an important food sector characterised by high environmental burdens. The most impactful are processes of production of agricultural raw materials use in the fodder production phase. In the studied case production of fodder in pig farming is based on global markets with a high share of inputs from Brazil, to a lesser extent from Ukraine and EU 27 countries. Changing of the fodder formula was proposed by the company to improve the environmental performance in the whole life cycle perspective of the meat product. It was based on the following assumptions:

- It is recommended to use by-products from agricultural production for animal feed production while ensuring the high quality of the feed.
- It is very important that high-quality feeds originate from food production processes based on locally available materials.
- It is crucial to pay attention to the origin of agricultural raw materials used for the production of feed. It is preferred to use locally produced materials whenever possible. Taking into account different conditions including the selected breeding technology.

From a nutritional point of view, the modified formula required adding to the fodder feeding supplements, including amino acids produced in chemical/biochemical processes. The comparative analysis showed that the new formula lowers the overall impact of meat products on ecosystems including climate change but raises slightly the impact in relation to human health indicators. It confirms that there are opportunities for improvement of the envi-

ronmental performance of pig meat products nevertheless the extent of the refinement is limited due to the complexity of value chains and availability of materials related to the manufacturing of these articles.

Meat production can be improved in the pig rearing phase, although the potential environmental impact reduction is on a smaller scale but it can be important for specific environmental aspects. Pig farming causes emissions of gases to the environment related to stable and manure management and for this reason, it is recommended to use air protection solutions.

Animal wastes should be managed in a sustainable way thanks to which it will be possible to obtain maximum benefits for the company with a minimum impact on the environment. Animal manures are valuable sources of nutrients and organic matter for use in the maintenance of soil fertility and crop production. It can be also used for energy production with consecutive production of residual material from fermentation that can be used as fertiliser. Keeping the level of mortality of the stock as low as possible considering the humanitarian aspect of husbandry and implementation of effective environmentally friendly methods of the utilisation of dead animals are crucial elements of waste management.

There are also the essential aspects of energy and transport. In the studied case renewable energy for heating purposes, based on biomass from local sources was used. It was also recommended in feed production, pig farming and meat processing to use renewable electricity. One of the options might be electrical energy from cogeneration based on local sources or renewable energy from the grid.

Transport plays an important role in all phases of meat production and processes. Increasing the effectiveness of transport will minimise its negative environmental effects.

Acknowledgements

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The contribution of the authors

Janusz Krupanek: conception 50%, literature review 80%, acquisition of data 10%, analysis and interpretation of data 80%, writing 50%.

Beata Michaliszyn: conception 50%, literature review 20%, acquisition of data 10%, analysis and interpretation of data 20%, writing 50%.

Manuel Moreno: acquisition of data 80%.

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SUMMARIES IN POLISH

STRESZCZENIA POLSKOJĘZYCZNE

Agnieszka CIECHELSKA

ODPADY KOMUNALNE JAKO DOBRO WSPÓLNE W KRAJOWYCH SYSTEMACH GOSPODARKI ODPADAMI

STRESZCZENIE: Współcześnie odpady są źródłem zasobów surowcowych i energetycznych, które mogą być odzyskane. Ta ekonomiczna wartość odpadów powoduje, że w krajach rozwijających się, tworzą się nieformalne grupy zbieraczy przywłaszczających odpady surowcowe. Tego rodzaju sytuacje są opisywane w literaturze. Stosując ramy analityczne SES Ostrom, autorzy wskazują, że odpady komunalne w krajach rozwijających się mogą być traktowane jak dobro wspólne (CPR).

Celem tego artykułu jest odpowiedź na pytanie czy również odpady komunalne w krajach rozwiniętych, mogą być tak traktowane, choć tutaj działania nieformalnych zbieraczy są marginalne. W analizie również zastosowano schemat analityczny SES Ostrom. Jednak ze względu na inną organizację systemu gospodarki odpadami w krajach rozwiniętych, inaczej niż w literaturze, określono poszczególne elementy schematu. Dzięki temu powstał inny schemat odpadów komunalnych jako dóbr wspólnych. Takie podejście pozwala na zastosowanie tego schematu zarówno w skali lokalnej, jak i szerszej oraz w odniesieniu do wszystkich rodzajów odpadów komunalnych, a nie tylko materiałowych.

SŁOWA KLUCZOWE: odpady komunalne, zasoby, recykling, dobra wspólne, CPR

Borys BURKYNSKYI, Natalya ANDRYEYEVA, Hanna TIUTIUNNYK

STRATEGICZNE ZARZĄDZANIE DZIAŁANIAMI INWESTYCYJNYMI I INNOWACJAMI W ZAKRESIE BEZPIECZNEGO EKOLOGICZNIE UŻYTKOWANIA GRUNTÓW

STRESZCZENIE: Celem artykułu jest wypracowanie metodologii strategicznego zarządzania działalnością inwestycyjną i innowacyjną w zakresie bezpiecznego ekologicznie użytkowania gruntów w oparciu o analizę doświadczeń światowych. Metodyczne podejście do badań opiera się na stopniowym przeprowadzaniu badań SMART, analizie ekonomiczno-ekologicznej, systematycznej ocenie działalności inwestycyjno-innowacyjnej, analizie PESTLE, analizie SWOT, definiowaniu strategii bezpiecznych ekologicznie. Badania opierają się na zintegrowanym podejściu do łączenia metodologii foresight w zakresie przyjaznego środowisku użytkowania gruntów. Proponowana koncepcja uwzględnia priorytety zrównoważonego rozwoju w kontekście współczesnych trendów Green Deal. Zaproponowane podejście metodologiczne będzie promować rozwój narzędzi systemów zarządzania strategicznego dla działalności inwestycyjnej i innowacyjnej w zakresie przyjaznego środowisku użytkowania gruntów.

Opracowana metodyka strategicznego zarządzania działalnością inwestycyjną i innowacyjną w zakresie bezpiecznego ekologicznie użytkowania gruntów, w przeciwieństwie do dotychczasowych podejść metodycznych, opiera się na kompleksowym połączeniu i wykorzystaniu narzędzi foresight.

SŁOWA KLUCZOWE: Foresight, SMART, Quintuple Helix (5 helis), PESTLE, zarządzanie strategiczne, przyjazne dla środowiska użytkowanie gruntów

Daniel TOKARSKI

UWARUNKOWANIA LOKALIZACJI MIEJSKICH CENTRÓW LOGISTYCZNYCH W KONCEPCJI ZRÓWNOWAŻONEGO ROZWOJU

STRESZCZENIE: Procesy podejmowania decyzji dla celów planowania infrastruktury kompatybilnej ze środowiskiem naturalnym są niezwykle złożone, podobnie jak same procesy logistyczne. Koncepcje lokalizacji miejskich centrów logistycznych zostały porównane ze strefami ekologicznego zagrożenia w Polsce. Wyodrębniono w ten sposób obszary o wysokim stopniu degradacji środowiska naturalnego szczególnie niekorzystne z punktu widzenia lokalizacji nowych centrów logistycznych. Decyzję o lokalizacji planowanego przedsięwzięcia należy podjąć na podstawie opracowanej wcześniej, specjalnej procedury dotyczącej oceny realizacji inwestycji i jej wpływu na środowisko naturalne. Celem opracowania jest wskazanie na infrastrukturę miejskich centrów logistycznych jako na jeden z niezbędnych i najbardziej efektywnych czynników determinujących zrównoważony rozwój. Z reguły infrastrukturę można tworzyć na dwa sposoby. Pierwszy nakazuje budować przedsiębiorstwo, a później jego infrastrukturę, drugi zaś zaleca podejście odwrotne.

Z punktu widzenia infrastruktury zrównoważonego rozwoju właściwe wydaje się podejście drugie, pozwalające na skuteczną realizację strategii zrównoważonego rozwoju. Pierwsze podejście może jedynie doprowadzić do spadku znaczenia pojęcia zrównoważonego rozwoju w mentalności i świadomości społecznej (Ratajczak, 2000). Różnorodność podejść w literaturze przedmiotu definiujących pojęcie infrastruktury zrównoważonego rozwoju obejmuje zarówno obszar ekonomii, społeczeństwa i środowiska. Istotnym z punktu widzenia przyszłych pokoleń wydaje się być aspekt środowiskowy dotyczący tworzenia miejskich centrów logistycznych w dobie zrównoważonego rozwoju. Jedną z zasadniczych właściwości środowiska naturalnego jest równowaga, która zachodzi, gdy odpływ i dopływ energii i materii w przyrodzie są zrównoważone. Środowisko naturalne znajduje się w ciągłej interakcji z człowiekiem, aby nie dopuścić do jego gradacji podejmowane są działania zmierzające do zapobiegania wyrządzeniu szkód fizycznemu otoczeniu lub zasobom naturalnym, prowadzone są także czynności zmierzające do zmniejszenia ryzyka wystąpienia strat, bądź zachęcające do efektywnego wykorzystywania zasobów naturalnych, w tym środki służące oszczędzaniu energii i stosowania odnawialnych źródeł energii (Tokarski, 2020).

SŁOWA KLUCZOWE: centra logistyczne, infrastruktura i środowisko, zrównoważony rozwój

Justyna TOMALA, Maria URBANIEC

EKOINNOWACYJNOŚĆ WYBRANYCH KRAJÓW EUROPEJSKICH I AZJATYCKICH: ANALIZA PORÓWNAWCZA

STRESZCZENIE: Na rozwój ekoinnowacji mają wpływ między innymi procesy globalizacyjne, postęp technologiczny i zmiany klimatyczne. Jest on również bezpośrednio związany z dążeniem do zrównoważonego rozwoju, a także z ograniczeniem negatywnego wpływu na środowisko i efektywnym wykorzystaniem zasobów naturalnych. Monitorowanie postępu w kierunku zrównoważonego rozwoju wymaga systematycznego pomiaru ekoinnowacji. Ważnym wyzwaniem teoretycznym i praktycznym jest opracowanie metod i wskaźników do pomiaru ekoinnowacji. Obecnie istnieją różne systemy pomiaru ekoinnowacji, co utrudnia międzynarodową analizę porównawczą. Celem artykułu jest analiza porównawcza rozwoju ekoinnowacji w wybranych krajach europejskich i azjatyckich. W opracowaniu wykorzystano krytyczny przegląd literatury oraz metodę analizy porównawczej i syntezy opartej na indeksie ekoinnowacji ASEM. Badanie dostarcza dowodów na istnienie szeregu różnic pod względem poziomu ekoinnowacyjności w krajach europejskich i azjatyckich. Pomiar ekoinnowacji jest szczególnie ważny przy planowaniu i wdrażaniu instrumentów stymulujących innowacje środowiskowe w poszczególnych krajach.

SŁOWA KLUCZOWE: ekoinnowacje, pomiar, wskaźniki, Indeks ekoinnowacji ASEM

Ewa OŁDAKOWSKA

ZUŻYTE OPONY SAMOCHODOWE W POLSKIM BUDOWNICTWIE DROGOWYM – EKOLOGIA, PRAWO, WYKORZYSTANIE I EKONOMIKA

STRESZCZENIE: Recykling zużytych opon wymuszany jest przede wszystkim przepisami prawa, ale motywacją są też względy ekologiczne i ekonomiczne. W Polsce odzysk materiałów gumowych pozwala na pozyskanie materiałów dobrej jakości i o bardzo szerokich zastosowaniach, np.: do poroelastycznej nawierzchni drogowej czy produkcji tak zwanego gumowego asfaltu, stosowanego do warstwy ścieralnej dróg, a także do innowacyjnych materiałów przeznaczonych na zasypki przyczółków mostów zintegrowanych. W artykule rozważono aspekt finansowy stosowania rozdrobnionych odpadów gumowych przeprowadzając analizę kosztów zastąpienia lepiszcza różną ilością miału gumowego (10%, 12%, 14%, 16%). Analiza, przy przyjętych założeniach, pozwoliła stwierdzić, że wraz ze wzrostem zawartości dodatku gumowego zmianie ulega koszt lepiszcza.

SŁOWA KLUCZOWE: recykling, budownictwo drogowe, guma, zrównoważony rozwój

Anetta ZIELIŃSKA

POZIOM WDRAŻANIA LOGISTYKI ZWROTNEJ W ASPEKCIE GOSPODAROWANIA ODPADAMI W WOJEWÓDZTWACH POLSKI WEDŁUG WIELOWYMIAROWEJ ANALIZY PORÓWNAWCZEJ

STRESZCZENIE: W praktyce logistyka zwrotna w Polsce, odnosi się do wąskiego podejścia poprzez zagadnienie gospodarowania odpadami. Województwa, zostały zobligowane do efektywniejszej realizacji procesów logistyki zwrotnej, jakim jest gospodarowanie odpadami. Celem artykułu jest zdiagnozowanie poziomu wdrażania procesów gospodarowania odpadami (część logistyki zwrotnej) w województwach Polski. W badaniach wykorzystano wielowymiarową analizę porównawczą, która porządkuje województwa według wskaźników gospodarowania odpadami.

SŁOWA KLUCZOWE: gospodarka odpadami, recykling, logistyka zwrotna, wielowymiarowa analiza porównawcza

Robert GRYGO, Jolanta Anna PRUSIEL and Kevin BUJNAROWSKI

ZASTOSOWANIE EKOLOGICZNYCH LEKKICH KRUSZYW W KONSTRUKCJACH ŻELBETOWYCH

STRESZCZENIE: W artykule omówiono możliwości utylizacji zarówno odpadów z elektrociepłowni, tj. popiołów lotnych, jak i odpadów tworzyw sztucznych PET (politereftalan etylenu), poprzez przetworzenie na lekkie kruszywo wykorzystywane do konstruowania żelbetowych elementów belkowych w celu ochrony środowiska naturalnego. Przedstawiono właściwości zastosowanych lekkich kruszyw sztucznych. Omówiono wybrane wyniki badań eksperymentalnych w zakresie nośności i odkształcalności belek żelbetowych wykonanych w skali modelowej. Analiza badań wykazała, że elementy belkowe wykonane z zastosowaniem kruszywa sztucznego, pomimo niższej wytrzymałości kruszywa na zgniatanie, nie różnią się pod względem nośności od belek żelbetowych wykonanych z kruszywa recyklingowego, w niektórych przypadkach mają wyższą wytrzymałość na zginanie.

SŁOWA KLUCZOWE: elementy zginane; kruszywa sztuczne; kruszywo PET; recykling; beton lekki

Marta BARANIAK

WSPÓŁPRACA ROLNICTWA Z NAUKĄ: PRZYKŁAD WOJEWÓDZTWA ŁÓDZKIEGO (POLSKA)

STRESZCZENIE: Celem artykułu jest ocena współpracy polskich rolników z województwa łódzkiego z nauką i innymi rolnikami w zakresie wdrażania innowacji w gospodarstwach rolnych. Wykorzystano metodę Paper and Pencil Interview (PAPI). Analiza obejmuje 150 polskich gospodarstw położonych w województwie łódzkim. Gospodarstwa do badań zostały wybrane z próby Polskiego FADN (Sieć Danych Rachunkowych Gospodarstw Rolnych). Badania wykonano w 2018 roku. Przeprowadzone badania wykazały, że zainteresowanie osiągnięciami naukowymi zależy od innowacyjności gospodarstw. Relacje polskich rolników z województwa łódzkiego w zakresie działalności innowacyjnej nie różnią się w zależności od prowadzonej działalności. Konsekwencją doboru podmiotów jest brak możliwości uogólnienia wyników na całą populację gospodarstw w województwie łódzkim. Wartością dodaną analizy jest prezentacja wyników w zakresie innowacyjności gospodarstw.

SŁOWA KLUCZOWE: innowacje rolnicze, gospodarstwa rolne, współpraca rolnictwa z nauką

Dominik DĄBROWSKI, Mikołaj JALINIK, Janusz Leszek SOKÓŁ,
Katarzyna RADWAŃSKA, Jakub SZWEDO

MOTYWY WYBORU MIEJSCA WYPOCZYNKU NA OBSZARACH WIEJSKICH DOLINY RZEKI BUG W OPINII TURYSTÓW

STRESZCZENIE: Celem pracy było określenie czynników, które mogą decydować o wyborze miejsca wypoczynku jako formy turystyki na obszarach wiejskich doliny rzeki Bug. Analiza tych czynników uwzględniała też narodowość badanych osób. W badaniach przeprowadzonych w 2020 roku wzięło udział 148 osób: w tym 73 narodowości polskiej (45 kobiet i 18 mężczyzn) i 75 obcokrajowców, głównie Białorusinów (51 kobiet i 24 mężczyzn). Stwierdzono, że turyści z Polski najchętniej wypoczywali w pensjonatach/hotelach, znajomych, w gronie rodziny, natomiast obcokrajowcy – głównie u znajomych i w gronie rodziny. Większość turystów, niezależnie od narodowości była zadowolona z pobytu w wybranych przez siebie obiektach, wysoko oceniając funkcjonującą tam bazę komunikacyjną, noclegową, gastronomiczną oraz szlaki i trasy rowerowe. Czynnikami decydującymi o wyborze ich miejsca pobytu, niezależnie od narodowości była cisza i spokój, atrakcyjne otoczenie oraz dogodna lokalizacja. Badani odpoczywali najczęściej w gronie rodziny lub znajomych/przyjaciół. Polscy turyści najchętniej korzystali z wyżywienia właścicieli obiektów wypoczynkowych, natomiast obcokrajowcy przyrządzali posiłki samodzielnie.

SŁOWA KLUCZOWE: dolina Bugu, turystyka, wybór miejsca

Krzysztof Paweł BORKOWSKI, Elżbieta CHOWANIEC, Marek DURMAŁA, Marcin KUBASIAK

OCENA RUCHU TURYSTYCZNEGO W TATRZAŃSKIM PARKU NARODOWYM W LATACH 2018-2020

STRESZCZENIE: Celem artykułu jest analiza przeprowadzonych w okresie pomiędzy 2018 a 2020 roku badań jakościowych i ilościowych w zakresie ruchu turystycznego na obszarze Tatrzańskiego Parku Narodowego. Dane przedstawione w artykule skupiają się na sytuacji, gdy istnieją ograniczenia mobilności przestrzennej. W celu zobrazowania wpływu zmian w zakresie możliwości realizacji i zaspokajania potrzeb podróży turystycznych szczegółowo przeanalizowano okres przed wybuchem pandemii wirusa SARS-CoV-2 z okresem charakteryzującym się drastycznymi ograniczeniami w zakresie możliwości przemieszczania się. Pozyskane dane pozwoliły na przedstawienie relacji pomiędzy ograniczeniami a zaspokajaniem wspomnianych potrzeb, co jest widoczne na przykładzie ilości turystów odwiedzających Tatrzański Park Narodowy w odcinkach 2020 roku, które charakteryzowały się różnym zakresem obostrzeń dotyczących mobilności społecznej.

SŁOWA KLUCZOWE: Tatrzański Park Narodowy Polska, Ruch turystyczny, Net Fear Score, Net Promoter Score, pandemia SARS-CoV-2

Lyubomir BEZRUCHKO, Tomasz PASIERBEK, Rakos JURAJ, Yuriy ZHUK

ORGANIZACJA SYSTEMU OCHRONY PRZYRODY I JAKOŚĆ ZARZĄDZANIA W PARKACH NARODOWYCH – WKŁAD DO DYSKUSJI

STRESZCZENIE: Celem artykułu jest porównanie prawnych i administracyjnych podstaw funkcjonowania parków narodowych jako czynników decydujących o jakości gospodarowania. Do analizy porównawczej wybrano parki narodowe w Polsce i na Ukrainie, które reprezentują różne systemy ochrony przyrody. Dane uzyskano z opublikowanych źródeł. Najważniejsze były akty prawne tworzące podstawy prawne systemów ochrony przyrody w obu krajach. Dostępne dane wykorzystano do analizy metodą desk research. Istnieje wiele różnic pomiędzy polskim i ukraińskim systemem obszarów chronionych, głównie ze względu na pozycję w strukturze rządowej (sposób tworzenia parku narodowego i instytucja odpowiedzialna za tworzenie). Mimo tych różnic można wyciągnąć ogólne wnioski. Ze względu na odrębną osobowość prawną poszczególnych jednostek, a także podporządkowanie różnym ministerstwom, nie ma wyraźnego powiązania między instytucjami. Utrudnia to przepływ informacji, raportowanie i komplikuje proces decyzyjny zarówno na poziomie poszczególnych jednostek, jak i pomiędzy parkami narodowymi.

SŁOWA KLUCZOWE: park narodowy, system ochrony przyrody, struktura organizacyjna, jakość zarządzania, proces podejmowania decyzji

Janusz KRUPANEK, Beata MICHALISZYN, Manuel MORENO

JAKOŚĆ ŚRODOWISKOWA PRODUKTÓW PRZETWÓRSTWA MIĘSNEGO I MOŻLIWOŚCI JEJ POPRAWY. PZRYKŁAD Z HISZPANII

STRESZCZENIE: Celem publikacji jest ocena jakości środowiskowej produktu oraz wskazanie możliwości poprawy jakości wyrobu w aspekcie jego wpływu na środowisko. Badania zostały przeprowadzone w ramach międzynarodowego projektu CIRC4Life na przykładzie firmy ALIA, Hiszpania. W publikacji wykorzystano metodę LCA oraz krytyczny przegląd literatury. Analiza została przeprowadzona dla podsystemów: produkcja paszy, hodowla świń, rzeźnia, zakład przetwórstwa mięsa. Stosując metodę ReCiPe porównano dwa scenariusze: bazowy i udoskonalony. W scenariuszu bazowym największe skutki środowiskowe związane są z intensywnym wykorzystaniem terenów rolnych 29%, zmianami klimatu 34%, transformacją terenów naturalnych 11% i wyczerpywaniem się kopalin 11%. Najbardziej krytyczną fazą jest produkcja paszy dla zwierząt. Analiza porównawcza scenariuszy pokazuje, że istnieje możliwość ograniczania wpływu na poszczególne kategorie oddziaływań przez wprowadzenie zmian w procesach i doborze surowców do produkcji pasz.

SŁOWA KLUCZOWE: ocena cyklu życia, LCA dla wieprzowiny, środowisko

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