EKONOMIA i ŚRODOWISKO

ECONOMICS AND ENVIRONMENT

Journal of the Polish Association
of Environmental and Resource Economists

No. **4 (83)** • 2022

Ekonomia i Środowisko

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Białystok 2022

ISSN 0867-8898
ISSN 2300-6420 (online)

Published by: Fundacja Ekonomistów Środowiska i Zasobów Naturalnych
15-092 Białystok, ul. Sienkiewicza 22
www.fe.org.pl; e-mail: czasopismo@fe.org.pl

Publishing: Agencja Wydawnicza EkoPress
Process Manager Andrzej Poskrobko / tel. 601 311 838

Printed by: Partner Poligrafia Andrzej Kardasz

www: www.ekonomiaisrodowisko.pl

Dofinansowanie w ramach programu Ministerstwa Edukacji i Nauki
„Rozwój czasopism naukowych" na lata 2022–2024 (nr umowy RCN/SN/0356/2021/1).

Funded under the program of the Ministry of Education and Science
"Development of scientific journals" for 2022-2024 (contract no. RCN/SN/0356/2021/1).

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THEORETICAL AND METHODOLOGICAL PROBLEMS

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STUDIES AND MATERIALS

GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

THEORETICAL AND METHODOLOGICAL PROBLEMS

Jerzy ŚLESZYŃSKI

NORMATIVE ECOLOGICAL ECONOMICS AS A CONDITION FOR SUSTAINABLE DEVELOPMENT

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ABSTRACT: This paper aims to highlight the absolute competitiveness between positive and normative economics. The article presents this controversy as a pretext to analyse a specific field of operation of ecological economics. The normative approach in the ecological economics is needed in the complex age of increasing deficits and confronting threats to biological and social sustainability. Reliable data from biology, physics, chemistry and medicine inform us what is dangerous. They also suggest directions of changes and their necessary scale. The normative approach, based on the guidelines from the basic natural sciences, allows for the creation of economic theories and models and then derives specific, quantitative premises for actions taken in the economy. The thesis of this article boils down to the statement that the effective involvement of ecological economics in the theoretical and practical solving of sustainable development problems is possible only through the use of the normative approach.

KEYWORDS: normative economics, ecological economics, sustainable development

No. 4(83) 2022 • pages: 8-19 DOI: 10.34659/eis.2022.83.4.516 JEL: P00, Q57, Q01

Introduction

Modern economics has moved to the position of descriptive science. This also applies to new and fashionable development directions of economics. Institutional economics, for instance, seems to grow in strength as unexpected and practical problems arise that cannot be confined to old theories or reduced to quantitative empirical research. More and more depends on specific institutional structures people are functioning in. On the other hand, behavioural economics brings back the human face of economics by asking questions about people's natural reactions and everyday behaviour. At the same time, however, these institutional or "laboratory-like" answers to research questions often have nothing to do with global problems. They do not intend to undermine the commonly dominant pattern of homo economicus.

Regardless of the competitiveness and disputes of fashionable schools dealing with economic theory, another methodological controversy continues almost silently. Reluctantly and not too openly in socio-economic practice, the debate continues whether the economics should deal only with the description of reality which leads to a positive economics or whether it should face challenges beyond dispassionate, dry, matter-of-fact, but not always an operationally efficient picture of reality. The many difficulties of the modern world call for a normative approach in which scientists are not afraid to give their value judgments clearly and openly. As they take up the challenge, they state ex-cathedra that some solutions are reprehensible and others recommended or even necessary. Therefore, they use pre-established values and norms that do not have to suit everyone and may be contested as too subjective.

This article aims to highlight the subcutaneous but actual conflict between positive economics and normative economics. However, presenting the controversy itself is only a pretext to indicate a specific and unique field of operation of ecological economics. The author does not intend to settle the advantages and weaknesses of both approaches in the mainstream of contemporary economics. The thesis of this article boils down to the statement that the effective involvement of ecological economics in the theoretical and practical solving of sustainable development problems is possible only through the use of the normative approach.

DOI: 10.34659/eis.2022.83.4.516

The beginnings of economics

An essential part of Tomáš Sedláček's book, significantly titled "The Economics of Good and Bad", is devoted to prehistory and the beginnings of modern economics (Sedláček, 2011). The author wanted to make the reader aware that we are not dealing with a slow, gradual and slight evolutionary change in the case of economic thought. He formulates his assessment in a provocative and quite radical way. "There has been an unusual twist. Adam Smith, Thomas Malthus, John S. Mill, and John Locke – the fathers of classical liberal economics – all of them were first and foremost philosophers dealing with morality." He adds that a century has passed, and economics has become a formalised science, utterly devoid of ethical reflection and normative considerations about society and its development. In theoretical and practical terms, economics has changed radically from social science in the 18th century to the science that pays the most attention in the 21st century to the application of quantitative methods and mathematical apparatus.

It is worth noting that some often repeated quotes are often very confusing. Bernard Mandeville introduced the phrase, "the immoral qualities of individuals can lead to the economic well-being of society as a whole." Adam Smith himself condemned Mandeville's views. Nota bene Mandeville was a natural-born immoralist who irritated his colleagues and the public with statements and publications proving that "there is nothing holy". He presented each virtue or noble behaviour, indicating how many misfortunes and evil resulted from them. In his view, charity and social assistance were mistakes because they led to laziness and idleness. Mandeville seemed to take pleasure in insisting that virtue does not exist at all and that all its manifestations are just a cover of selfish satisfaction. Adam Smith criticised such statements. Searching for good qualities and natural inclinations in a man, he was relieved to find that selfish individuals can cooperate, which may prove beneficial for the good of society as a whole. In this conciliatory way, we interpret the ideal image of the economy supported by the mechanism of perfect competition, even today.

The neoclassical school (with all its diversity) proved that theoretical considerations could be formalised and take the form of a complex model which does not fully reflect the economy. Still, due to the correct selection of variables and their functional relationships, it can quantify and describe the dependencies occurring in the real economy. What makes the model approach strong, however, is also its risk (Rodrik, 2016). Both the economist Joan Robinson and the writer Jorge Luis Borges pointed to the banal fact that a 1:1 map would not be of any help for a stray tourist. However, there is also no

DOI: 10.34659/eis.2022.83.4.516

single and "most appropriate" set of variables and their connections selected for a specific topic.

Each model is a challenge for the constructor and the user. The former should put into his pocket his prejudices and views that violate the objectivity of the research and devote all his energy to the identification of the most essential and functional variables. The latter should know very precisely the assumptions made so as not to tell nonsense in his interpretation of the results. Formal advancement, with advanced econometrics and mathematical statistics, increases both parties' expectations and challenges. When the language of description becomes formal and difficult, two dangers emerge, and these are apparent facts in modern economics. The first danger is the neglect of fundamental ethical questions (Sedláček, 2011): what will be good or bad for society or the environment? The second danger is hiding scientific doubt behind a screen of elite knowledge to avoid answering questions about the credibility, objectivity and usefulness of the obtained results (Rodrik, 2016). Often, a standard researcher's answer is enough: I got that result from the model.

There may be a regret for the past centuries of their lost values about the change in understanding and practising economics. This could be the ground for cultivating idealistic and, at the same time, completely unrealistic visions. I do not take up this topic at all. Regretting the removal of morality from the economy would now be too naive, late and counterproductive in the conditions of accelerated technological progress, permanent modernisation, mass consumption and increasing populism. The media brings us daily news emphasising irreversibility of civilisation and social changes. At the same time, they show the threats posed by mass culture and highlight examples of boundless selfishness in the individual, racial or national dimension. These are trends to be reckoned with, but they don't necessarily mean surrender. I recall the words of Czesław Miłosz from the "Treatise on Moral" (sic!): "The course of the avalanche changes depending on the stones on which it rolls".

Let the critical question become the starting point for further considerations: should economics be content with a descriptive approach based on models, collected data and research results, communicating numbers and suggesting relationships between them? Is the economist only to be statistically well-equipped and convinced of its infallibility person, as a public presenter of quantified events? Is she/he to be limited to the self-righteous and quirky statement: "I will show you how it is, in my opinion, and do what you want with yourself"? Suspiciously this sentence resembles a well-known reply of king Louis XIV who answered the ministers worried about the condition of the state and kingdom's future with a smile: "Après nous, le déluge."

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Positive economics and normative economics

Positive economics (Samuelson, 1947; Friedman, 1953), i.e. descriptive economics, is often presented as absolutely objective science. This usurpation seems to disregard that economics is a social science, not a natural and experimental science. Good economics textbooks clarify that economic laws and regularities have historical and statistical credibility, not absolute. Engel's law works but „so far" should be added. Data analyses seem to confirm specific ownership of consumer choices. However, research into trends in consumer preferences is needed to identify again the relationship between income and food expenditure. Moreover, these observed regularities are far from a reproducible experiment explaining the unconditional chemical reaction of a CFC compound with stratospheric ozone.

In ordinary perception and often in the scientific community, it is tacitly assumed that an economist, driven by the will to know, discovers a certain regularity that occurs objectively in reality and, of course, does it selflessly and entirely objectively. This is similar to the assumptions we know from the faith-based belief that the holy books of any religion cannot be wrong since they were written under the influence of the holy spirit. Thus this source cannot be a perfidious deceiver. This positive conviction, already present in Descartes' writings, accompanies us to this day. Trust in our senses and mental operations come from the religious belief that the supreme being enables us to know the truth. One forgets the complexity of human nature and its active role as a „transmitter" of reality that shapes its message in a specific social context. After all, philosophy and social science drew such a conclusion a long time ago and this is represented in the writings of Immanuel Kant.

An optimistic and positive economist, like some outstanding representatives of science in the early Enlightenment (circa 200 years ago!), is therefore treated as a thinker furnished with specific and unquestionable knowledge. Of course, the scientist selflessly instructs the little ones to her/his best moral standards. As part of a general positive interpretation, getting to know the economy is treated, similarly to the mechanistic worldview, as a finite set of facts about the universe. In other words, it is a practical and unauthorised application to the social science rules of reductionism, determinism and materialism (von Mises, 1957). We do not know everything about the economy yet, but we will apply economic theories and methods to our research- and eventually there will be no more economic secrets for us. Like the priest of knowledge, the economist gradually reveals the whole economic truth.

Within the framework of a positive economics, we observe, as far as we want to see it, the exceptional carelessness that accompanies the models used and the results announced. Apart from checking the formal correctness

DOI: 10.34659/eis.2022.83.4.516

of the models and the calculations themselves, the obtained results are not verified in terms of the influence of the cultural, ideological, and social context or simply the subjective approach of the researcher himself (Rodrik, 2016). As a rule, no questions about the consequences of implementing the proposed solutions are asked. The publication of the results is related to the gesture of Pontius Pilate. The scientist washes his hands and thus does not take responsibility for the activities of decision-makers and politicians he has provided with „objective" knowledge.

It does not take great inquisitiveness to notice phenomena in the media that openly undermine the absolute and indisputable objectivity of a positive scientific research. Two different packaging companies obtain two diverse expertises to promote their products and toundermine competitor. Another example can be the Life Cycle Analysis implementation taking into account the environmental impact of fossil fuels. LCA may indicate the supremacy of lignite since the analysis does not start with the "cradle", i.e. the creation of an open pit mine, but with the energetic use of lignite. By the way, idle discussions on the price of energy include the cheapness of hard coal, but the cost analysis does not consider external costs. Are we dealing with lies or scientific mischief? Well, most often not, because scientists whose work we would instead not recommend can easily lay claim to the objectivity of their approach just hiding some assumptions relevant to their outcome. Therefore, they take no responsibility for too far-reaching interpretations nor the impact on the environment and society.

A normative approach concerned with moral issues or the natural environment is sometimes criticised or even discredited by mainstream economists as being too clearly dependent on many social contexts and often not subject to testing. Moreover, in social sciences and politics, the normative approach is sometimes viewed with suspicion on account of discretion and possible abuses, the most dramatic expression of which was the racial and ideological crimes of the twentieth century. What is worse, populism very often appropriates and ridicules the normative approach by introducing into the media utterly devoid of scientific justification but still evaluating terms (examples typical for Poland): „better sort of people", „real Pole", and „national".

The odium of the lack of scientific trust affects the normative approach. At the same time however, these supposedly „description limited" economists advise active politicians in making normative decisions concerning the economy and society. Reading scientific publications and, above all, the media shows that setting the interest rate, subsidy amount, or minimum wage becomes the subject of strongly and politically conditioned decisions. The increasing threats to the prosperity of future generations are also subject to camouflaged and the most normative judgments of economists. In particular,

DOI: 10.34659/eis.2022.83.4.516

these are decisions regarding the scope and pace of exploitation of non-renewable natural resources. It is a kind of hypocrisy because there are positive economists who advise in goodwill behind the politicians' backs.

This article aims not to address the specific problems in which the descriptive and normative approaches collide. However, when it comes to future generations in the context of environmental living conditions and the availability of resources, it is hard not to mention "the tyranny of the discount rate". Simply speaking, it is about the highly normative approach of a positive economics to the problem of determining the present value of future benefits and costs. It is known that the commercial interest rate is inherently short-sighted and utterly entrenched in the current economy. And yet it often becomes a decision-making tool with a very distant horizon, affecting the welfare of future generations.

Perhaps the most sceptical critic of the positive approach was von Mises (1957), who exhorted economists to be humble, arguing that, like historians, they are most credible only when they talk about the past. Commenting on the present and forecasting, they attribute to themselves a level of certainty that belongs to experimental science. This is where my article ends with a general discussion of competing approaches: normative economics versus positive economics. The paper aims to focus on the part of the economics that deals with the subject of sustainable development. Further considerations will concern the only treatment of ecological economics, which is the field of economics in which interdisciplinarity and joint review of economic, social and environmental aspects of development are most clearly exposed (Perrings, 2008a).

Ecological economics

At the outset, it must be clearly stated that social sciences differ fundamentally from natural sciences (Śleszyński, 2021). The natural sciences also reveal various scientific and social contexts and subjectivism, but empirical research based on repeatable and verifiable experiences forms the basis for further and sufficiently objectified inference. They are, therefore, falsifiable theories according to Popper's justified requirements. The erroneous opinion about the absence of asbestos toxicity can be verified. As a result of appropriate tests, it can be assessed in what circumstances and doses this substance may be carcinogenic. Whereas wrong economic opinion regarding the lack of the threat of inflation will be verified later and eventually will become a bad experience for citizens in the future. Moreover, it will be a lesson that cannot be used creatively in the future as the following pro-inflationary situation will be completely different.

DOI: 10.34659/eis.2022.83.4.516

Biologists, geographers, chemists, physicists, and representatives of medical sciences have sets of numerical data and their sufficiently specific interpretations. Their achievements follow scientific advances but usually constitute a set of facts beyond discussion. These facts are entirely understandable for experts in a given narrow field of knowledge and rarely cause ongoing controversy and sharp disputes. Proper use of this knowledge would require introducing it into the bloodstream of the media flow and adapting it to the language and practice of social sciences. Conclusions from critical studies on harmful and dangerous environmental changes usually take the form of warning signals and normative recommendations. This is a challenge for the ecological economics, which should be able to take the correct position in the field of forest management, fisheries, the use of artificial fertilisers, the use of energy carriers, space management and many other issues. This position should express quantified guidelines for economists, activists, managers and politicians.

The natural sciences generate data and knowledge that ecological economics, fortunately, tries to adapt and transform into the language of economics. Sustainable catch-quota of fish, country forest cover, the rate of species extinction, the concentration of smog in the air or the accumulation of CO2 in the atmosphere are measurable phenomena that can be investigated empirically. Combined with the appropriate economic theory, they can be included in the most practical socio-economic considerations and the construction of development scenarios for fisheries or energy use. All in all, it is about one and the most critical strategy for the future – the sustainability scenario (Perrings, 2008b).

The ambition of the most creative scientists is to initiate discussions and formulate conclusions aimed at the sustainability of the biosphere and critical ecosystems, as well as the cohesion of dynamically changing societies. There are, of course, norms in these conclusions. Survival strategy translates into multiple goals, the imperfect but constantly improved formalisation of which are the Sustainable Development Goals proposed by the United Nations. They talk about fishing, eliminating pollution and social inequalities, and appropriate living conditions in the cities. These are all normative recommendations. Science created in such a context, dependent on verifiable theories and facts, can be both pragmatic and consistent with the guidelines of the sustainable development strategy.

Ecological economics, unlike environmental economics, does not only focus on applying neoclassical economic theories and tools to ecological problems (Martinez-Alier & Muradian, 2015). Its distinguishing features are the interdisciplinary problem analysis and the search for practical solutions that do not have to follow and meet the standard assumptions of neoclassical economics (Daly, 2007; Perrings, 2008a). For instance, the following assumptions commonly present in orthodox economics can be questioned: maximisation of narrowly understood utility, substitutability of all inputs, inexhaustible energy resource, natural resources as „priceless" non-market goods, and ecosystem services as phenomena devoid of economic value.

Normative recommendations in the economy should indisputably concern the exploitation of natural resources and the pressures on the environment. At the same time, while remaining in a significant relationship with economic reality, they should consider the implemented production patterns and the observed consumption patterns. Normative recommendations resulting from basic research, then reformulated by the ecological economics, should become the content of decisions concerning, first of all, the protection of life and health as well as the living conditions of people and the state of the environment.

At this point, there is usually suspicion of representatives of natural sciences who know the anthropocentrism of traditional economics and fear its domination in the implementation of social and economic development projects. Therefore it is necessary to strongly emphasise the change in economic approach and introduce new interpretation of the relationship of the environment with the economy in the ecological and systemic perspective to the economic education. When it is aware of its limitations and threats, anthropocentrism is an opportunity to solve problems at the interface between the environment and the economy while respecting normative guidelines.

In the twenty-first century, in economics textbooks, unfortunately, one can find a repeated or slightly processed and sometimes biased or disguised scheme showing the following simple and one-way relationships: Natural resources → Processing and production → Consumption. The so-called linear model of the „cowboy" economy, by referring to the conquest of the Wild West, fits well only in an ideal world of free goods. It is based on the following assumptions: resources are unlimited and free, production and consumption cannot harm the environment and reduce welfare, consumers only consume, and the relationship between consumption and the atmosphere is negligible. All these assumptions should be disregarded today, and there is hard empirical evidence for this.

We expect the ecological economics to change the description of the world and economy. Thus, the description of the relationship between the economy and the environment is now more ecological and systemic (Figure 1) and, therefore, more complicated but revealing all significant limitations and threats. Essential drawing comments emphasise concern for the system sustainability. First, this system depends on the inflow of solar energy. So there is no question of being sustainable forever. Sustainability on a human scale takes into account the measure of time that we apply to our civilisation and culture. The inflow of solar energy activates the processes that ensure the functioning of the biosphere presented here as natural capital with all its resources and ecosystem services. Man-made capital is closely dependent on it. Two types of input, energy and matter, are transformed and, to a large extent, accumulate in a man-made capital.

However, the provision of goods and services necessary for a human being does not occur without significant changes in this system. Firstly, the energy absorbed in the production and consumption processes is an irretrievably used resource. According to the second law of thermodynamics, successive energy transformations dissipate energy in the form of useless heat. In turn, the matter is not only accumulated in man-made capital but also returned to the environment in the condition of pollution and waste. This type of system impact has multiple consequences. Material redundant from the point of view of consumption may be toxic or accumulate and generate dangerous phenomena, including climate change. Unfortunately, recycling is still a phenomenon of marginal importance, despite the optimists and the closed-system conceptual model of the so called circular economy.

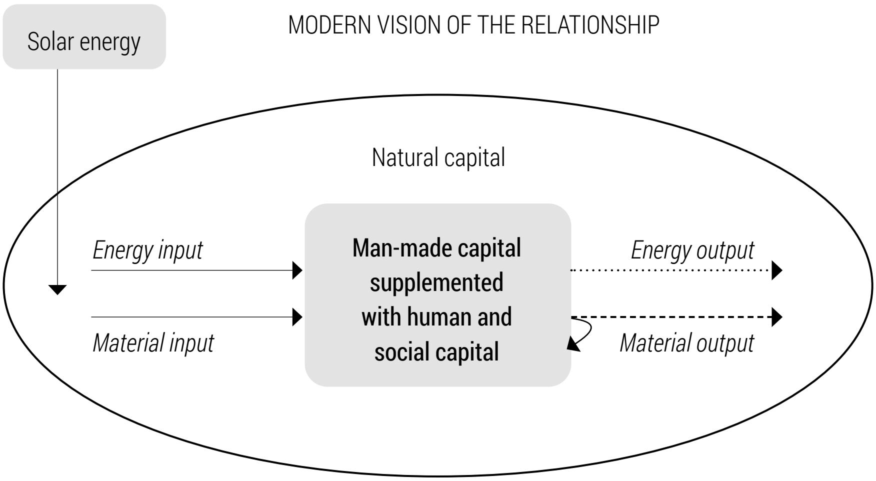

Figure 1. The relationship between the economy and the environment

The presented diagram brings some critical observations to the traditional description. First, it indicates a primary energy addiction. Since we are not green plants and will not survive thanks to photosynthesis, the limited availability of fossil fuels should be an essential element of any economic projection and analysis. Rather than juggling substitution within primary energy sources, it is desirable to prescribe the constraints imposed on the availability and lifetime of fossil fuels. Secondly, the matter released to the

DOI: 10.34659/eis.2022.83.4.516

environment from production and consumption poses threats to the proper functioning of biogeochemical cycles in the biosphere and local ecosystems. This must lead to the normative definition of emission norms, immission norms, product standards and technological standards.

Regarding energy and pollution, ecological economics has serioustasks to be performed. Ecological economics should demonstrate that economic studies and projects locate themselves in the world of fiction and represent false consciousness conducting research and analysis without introducing appropriate ecological norms and standards. They lose contact with reality and recommend exclusively wishful solutions. They can only deceive decision-makers and the public and, as a result, lead astray by promising a bright future.

Conclusions

A normative approach to the ecological economics is needed in the complex age of increasing deficits and confronting threats to biological and social sustainability. We have reliable data from such sciences as biology, physics, chemistry, and medicine, which are sufficiently exact to inform what is dangerous, and where the most significant threats come from and thus suggest directions of change and their necessary scale.

The normative approach, based on the guidelines from basic natural sciences, allows for the creation of economic theories and models and then derives specific, quantitative premises from them for actions taken in the economy. Of course, together with the cost-benefit analysis as complete as it could be. The possible multiplicity of opinions and the variety of normative solutions should be treated as an expression of flexibility, variants and caution of the normative approach, not as its weakness and the result of inevitable ideological conflicts.

The educational role of the marriage of ecological economics with basic sciences (introduced into the university education) is worth considering. It should strengthen acknowledgement and respect for sustainability: prevent the erosion of the active involvement of new generations in local affairs and global problems, increase the cohesion and quality of a democratic society, and prevent narrow and one-sided specialisation of scientists (Śleszyński, 2021).

„The miller believes that wheat grows only so that his mill can work" (Johann Wolfgang Goethe). An economist and especially an ecological economist should notbehave (in her/his professional scientific, educational and social activity) like that miller for whom the entire outside world is only material to be processed in the only way known to him – without having to

DOI: 10.34659/eis.2022.83.4.516

say whether wheat is worth to sow and reap and how to do it in terms of the consequences for the environment and other citizens.

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DOI: 10.34659/eis.2022.83.4.516

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PRINCIPLES OF MANAGEMENT IN IMPLEMENTING BALANCED AND SUSTAINABLE DEVELOPMENT – SELECTED PROBLEMS

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ABSTRACT: The study presents selected issues concerning management principles in implementing balanced and sustainable development. These include the principles of: (1) traditional extensive economy, (2) intensive traditional economy, (3) alternative economies, (4) eco-development, (5) Sustainable Development and (6) entropy sustainable development. Selected criteria for the evaluation of these principles were also characterised.

KEYWORDS: balanced and sustainable development, principles of implementation of balanced and sustainable development, criteria for assessing the principles of implementation of Sustainable Development

Introduction

In the vast majority of studies on *Sustainable Development*[1], the issue of management principles or, as some authors emphasise, management of various forms of capital (resources) necessary for its implementation appears to a different extent. This is not surprising because rules are the elements that organise how resources are used, or their dynamic version – capital (Becla et al., 2020). However, there are a few things to clear up in the introduction before moving on to discussing the principles themselves.

Attention should be paid to the very notion of a principle. The "Great PWN dictionary of correct Polish language" defines the concept of a principle as the basis on which something is based or a standard of conduct recognised as binding (Markowski, 2004). This allows for the correct treatment of balanced and sustainable development principles. Therefore, these are recognised and accepted, in the sense of the achievements of science and practice, methods of dealing with economic resources (forms of capital) used to achieve the goals of such a development strategy. We will omit here the discussion on the understanding of economic resources (in their static approach) and capital (in dynamic terms) because an entire chapter in the monograph "Barriers in contemporary economics and economy" (Becla et al., 2020) is devoted to this issue.

The subject of the analysis in the following study is the principles of managing the forms of economic capital (resources) during the implementation of the strategy of sustainable and balanced development and, in fact, the ways of their formulation. Therefore, several theses can be formulated, which will be verified using the achievements of literature and practical experience. **First,** the multitude of such principles draws attention to the incredible complexity of the idea and the strategy of balanced and sustainable development. **Second,** a significant challenge is the cognitive and practical utility of such principles. Here there is a postulate that rules of this type should be more useful (therefore more detailed and applicable) the lower the level of implementation of sustainable and balanced development occurs (which confirms the concept of Agenda 21 – think globally, act locally). The direct contractors of individual projects should have more detailed guiding principles. **Third**, you should strive for a meaningful, preferably optimal, set of rules. In this case, optimality means the smallest number of them but the one that meets the conditions of economic efficiency and the effectiveness of the implementation of the strategy itself. **Fourthly**, the proposed principles should be

1 In the study, we use the term balanced and sustainable development because we treat the balance as the proper relationship between the elements of the human-society--economy-natural environment super-system and sustainability as their maintenance over time (Czaja, 2011).

DOI: 10.34659/eis.2022.83.4.489

unambiguous and understandable to recipients with different levels of intellectual predispositions, different axiological systems, often different motivations and attitudes („philosophies”) in life, as well as their susceptibility to the influence of false information or anti-ecological ideologies, which is particularly important in the information society and open access to information.

The article, apart from the traditional, short review of the literature, published only on the Polish publishing market, presents and evaluates selected principles of managing economic capital, starting from the traditional, extensive and intensive economy through its mainstream and heterodox modifications, taking into account contemporary economic challenges, social and ecological, to an approach consistent with the idea of sustainable development and proprietary proposals of a physical approach. The leading idea of the study is the need to take a more serious look at the principles of capital management in the spirit of Sustainable Development. The scarcity of such analyses results, among other things, in (1) too free, sometimes even ignorant, interpretation of the very idea of Sustainable Development, (2) unnecessary disputes over the issue of how to understand the principles of such management or (3) lack of agreement on the implementation of the sustainable and sustainable development strategy (Becla et al., 2014; Żylicz, 2016).

An overview of the literature

The currently required literature review regarding management principles in implementing a sustainable and balanced development strategy is challenging. The main barrier here is the multitude of Polish and international literature studies. Therefore, it is necessary to limit the number and publishing scope of the analysed publications. Trying to organise them, the following problem groups can be identified:

- studies focusing on the ways of understanding and defining Sustainable Development,
- works containing the identification and analysis of the principles of implementation of balanced and sustainable development, which is particularly interesting from the point of view of this article,
- works presenting attempts at the practical implementation of pro-ecological projects and policies,
- studies that attempt to model a balanced and sustainable development in the spirit of mathematical and formal analyses of contemporary economics,
- studies on the philosophical-axiological and ethical aspects of balanced and sustainable development,

DOI: 10.34659/eis.2022.83.4.489

- legal analysis of normative and institutional regulations in this area,
- works undertaking political and ideological polemics with opponents of the balanced and sustainable development strategy.

While focusing on Polish studies containing the identification and analysis of the principles of implementing the idea and the strategy of sustainable and sustainable development, the following works can be noticed:

- briefly mentioning such issues, somehow in terms of signalling,
- papers discussing these principles in greater detail and analysing their usefulness,
- work focused on single principles that are given detailed and critical discussion.

The first group is represented primarily by studies that appeared in Polish literature at the turn of the 1980s and 1990s during the preparation of the Earth Ecological Summit in Rio de Janeiro and attempt to implement its postulates (Żylicz, 1989; Kozłowski, 1997), as well as monographs and textbooks focusing on the implementation of and indicators of balanced and sustainable development (Czaja et al., 2002; Kiełczewski & Dobrzańska, 2009; Kiełczewski, 2009; Poskrobko & Dobrzański, 2007; Dobrzański, 2002; Borys, 1999; Borys, 2005; Kiełczewski & Dobrzańska, 2007). The problem of managing capital and economic resources in conditions of balanced and sustainable development takes the form of general rules that translate into specific actions (Fiedor, 2000). The latter concerned, for example, the issues of consumption (Kiełczewski, 2008), rural areas, and agriculture (Fiedor & Jończy, 2009; Burchard-Dziubińska & Rzeńca, 2010; Kryk, 2010), education (Poskrobko, 2010c), legal and institutional regulations (Czaja, 2007; Czaja, 2001; Poskrobko & Kozłowski, 2005), preservation of biodiversity, (Poskrobko, 2003), and naturally valuable areas (Poskrobko, 2011).

The second group consists of studies that discuss in more detail the issues of specific management principles, at the same time referring to the scope of their cognitive values (Czaja, 1997; Śleszyński, 2000) and implementation usefulness in socio-economic practice (Czaja & Becla, 2007; Poskrobko, 2011; Poskrobko & Poskrobko, 2012). They tried not only to introduce the issue of management principles but also sought to translate into appropriate and, at the same time, differentiated levels of knowledge, awareness, and ecological attitudes (Kośmicki, 2015; Kośmicki, 2009; Kośmicki, 2010). Studies focusing on the lowest levels, human and local communities, and the highest, global ones were especially valuable here.

The third group of studies dealing with managing capital and economic resources in implementing balanced and sustainable development focuses more on their selected, often single forms (Kiełczewski, 1999). Such considerations, for example, dealt with various, often surprising, challenges when interpreting such principles and applying them in practice. Then, social, poli-

DOI: 10.34659/eis.2022.83.4.489

tical, ethical-moral, or religious conflicts arise (Kryk, 2012; Czaja, 2003; Borys, 2003; Czaja, 2005).

Review of the principles of managing capital and economic resources in the context of balanced and sustainable development

The principles of managing capital and economic resources are formulated in various forms of balanced and sustainable development. They are presented, inter alia, in: (1) with reference to traditional models of growth (development), both in their extensive and intensive form; (2) as principles based on the idea of equilibrium between orders and preserving certain relationships of natural capital to other capitals; (3) in the form of in-depth principles of rational management; (4) in the form of principles combining the physical and economical approach, and (5) in the form of principles based solely on the physic-thermodynamic approach to the idea of balanced and sustainable development (Figure 1).

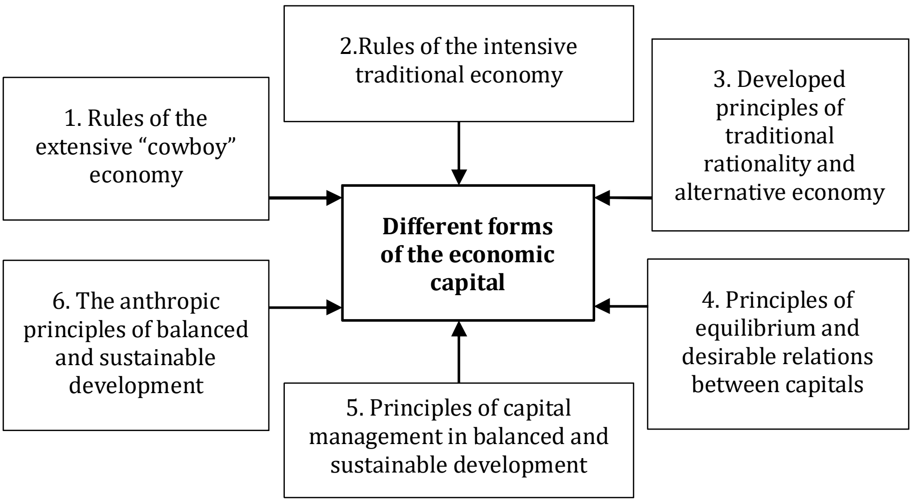

Figure 1. Selected groups of principles of managing various forms of capital and economic resources in traditional economics and the economics of balanced and sustainable development

The first approach is associated with traditional neoclassical models of economic growth, based on a paradigm using the following idealisation assumptions: (1) accepting the perfect competition model as a benchmark

DOI: 10.34659/eis.2022.83.4.489

for analysing various market structures; (2) recognising the legitimacy of the so-called Say's law, expressing the general ability of the economy to restore equilibrium and the related view of economic processes, (3) assuming the general rationality of behaviour of economic entities (homo economicus), (4) inclusion of cognitive and worldview and methodological individualism, related to subjectivism.

On the basis of this paradigm, several essential principles of managing capital and economic resources can be formulated, namely: (1) the principle of the domination of private property, (2) the principle of supremacy of the individual interest, (3) the principle of narrow individual rationality of management; (4) the principle of simple economic expansion into new socio-economic and geographic-natural spaces, similar to the cowboy economy, and (5) the principle of net profit maximisation as a criterion of operation. This way of understanding and applying economic principles remains essential, not to say dominant, especially in the developing economies of Latin America, Africa and Asia. The entities operating in them apply the above principles consistently, even in increasing social or environmental costs.

The second approach to the principles is also associated with the traditional economy, which is, however, of an intensive nature of economic exploitation. Within its framework, the hitherto critical criteria and management principles are modified better to use the available economic capital (resources). Thus, scientific and technological progress, human capital instead of labour (labour), knowledge and information, institutions and regulations, and relational social capital are included. This allows, inter alia, to formulate such principles of management as, for example: (1) the principle of extended economic rationality, taking into account a more comprehensive range of assessments and more sophisticated methods; (2) the principle of taking into account the social interest in addition to the still dominant individual interest; (3) the principle of more economically and praxeologically more effective use of capital; (4) the principle of applying the acceptable profit criterion instead of the maximum profit, and (5) the principle of transition to innovative forms of capital, with embodied and non-embodied technological progress or knowledge. As can be seen from the nature of the above principles, the transition primarily meant: (1) less wasteful use of available economic resources (the form of capital), (2) taking into account their increasing scarcity, i.e. including the temporal dimension, and (3) wider use of capital (resource) substitution. by replacing their "old" forms with "new" forms.

Further developed principles of the rationality of the traditional and alternative technology concept related to the evaluation criteria of the efficiency and optimisation assessment of management and management (Figure 2).

DOI: 10.34659/eis.2022.83.4.489

ECONOMICAL EFFICIENCY		
Goal – effect relationship (The criterion of purposefulness and effectiveness (usefulness of the effect))	Effect – outlay or outlay – effect relationship (Economic efficiency criterion)	Goal – outlay relationship (Criterion for assessing the feasibility of the selection of goals and the appropriateness of the selection of resources)
SOCIAL AND ECONOMIC OPTIMITY		

Figure 2. Criteria for the assessment of efficiency and optimisation of management

This approach, on the one hand, combines the issues of economic efficiency with economic and social optimality by expanding the range of criteria and dimensions of management, primarily through holism, globalism, ecologism, humanism and neo-them. This allows for the formulation of several interesting principles of management of economic capital (resources), such as (1) the principle of seeking the transition from economic efficiency to economic and social optimality by incorporating further assessment criteria, (2) the principle of a global economic perspective; (3) the principle of a holistic approach to economic, social and environmental problems; (4) the principle of humanistic treatment of the human place in management; (5) the principle of applying ethical criteria in management.

These principles were reflected not only in the models of mainstream economics (neoclassical economics, past-Keynesian economics) but also in alternative (heterodox) economics, such as in the model of rational market and economy by D. Korten. It includes such assumptions as: (1) life is a measure of all activities, which is in line with the ideas of deep ecology, and what is slightly less emphasizing the concept of sustainable development; (2) the costs are borne by those who decide what is included in the idea of sustainable development; (3) small enterprises with direct ownership by stakeholders, not shareholders, are supported; this element is exposed by all economic and quasi-economic doctrines of the present day, from liberalism to deep ecology; (4) striving for equality, which seems to be a postulate recognized in contemporary socio-political and economic thought; (5) preferring full information disclosure, considered in modern economic theory as the most crucial feature of an effective market and economy, (6) sharing (disseminating) knowledge and technology; (7) seeking diversity and self-sufficiency; the first element is regarded as desirable, the second (autarky) is regarded as a limitation of socio-economic development; (8) paying attention to the boundaries of management, which is also emphasized in the strategy of sustainable development; (9) respecting the necessary role of government; and (10) maintaining an ethical culture (Korten, 2002).

DOI: 10.34659/eis.2022.83.4.489

As a result, one can speak of a new way of seeing nature and society with the accompanying economy. They should be based on: (1) holism, treating the world as a whole; (2) abstinence or return to moderate consumption; (3) cooperation and mutual assistance in the implementation of individual economic undertakings; (4) ecological sensitivity, taking into account the ecological consequences of economic activity (production and consumption); (5) intuition when making decisions; (6) decentralisation of business ventures; (7) reducing the scale of the management processes carried out (Ernst Schumacher's "small is beautiful") (Schumacher, 1981) and (8) dehumanisation, i.e. restoring the human scale to these processes.

The following groups of management principles of economic capital (resources) are directly related to *Sustainable Development*. The first was related to the early version of such an approach, called eco-development in the literature. It used, inter alia, the following: (1) the principle of the domination of natural capital as the most difficult to substitute over other forms of capital; (2) the principle of rational management of all economic resources; (3) the principle of a radical reduction of anthropopressure in management processes; (4) the principle of applying the intergenerational equity criterion, especially in the management of natural capital; (5) the principle of reducing traditional economic growth (even to nil); (6) the principle of absolute protection of the natural environment and its resources, as well as (7) the principle of the necessary greening of all aspects of human life and society.

However, it turned out very quickly that the rather one-sided domination of the environmental dimension is practically impossible to reconcile with other challenges of the modern world, which were reflected, among other things, in the Millennium Development Goals. At the same time, this domination turned out to be almost entirely useless in solving these problems. For this reason, the following approaches to the Sustainable Development strategy highlight the principles that also emphasise the importance of social, economic, spatial and institutional order. Some of the principles of eco-development were also modified, the shots most mismatched to the current reality were removed, and new solutions were introduced. For example, the principle of intergenerational justice was enriched with the principle of intra-generation justice. The concept of zero growth was abandoned, and the principle of development based on sustainability and self-support was introduced. On the other hand, the principle of the necessary greening of all aspects of human life and society was replaced by the principle of developing people's environmental knowledge and awareness.

However, the principle of the balance of orders and the desirable relations between natural capital and other forms of capital aroused particular interest. While the first one is very difficult to define more precisely because it connects the desired, acceptable, but also objectively unattainable and

DOI: 10.34659/eis.2022.83.4.489

rejected by societies relations, in the second case, the problem was to choose the right solution. The sustainability of the maintenance of natural capital resources can be interpreted in four ways. This can be on the weak, sensitive, strong or restrictive principle of persistence. The first means maintaining the size of the total capital (natural, anthropogenic and social) without considering its structure. A sensitive principle requires that the entire capital and its appropriate structure be preserved. A strict rule highlights the need to preserve each capital resource separately, while a restrictive rule prohibits the depletion of any resource. The basic issue is, therefore, the choice of a solution (rules of conduct) and then adapting individual projects to the choice made. The above rules are directional and general. Therefore, they require explanation and clarification, preferably indicative, and have a macroeconomic dimension. This generates their biggest drawback – serious difficulties with operationalisation.

The authors, using the achievements of research on sustainable and balanced development and the previous experience of implementing such a strategy of civilisation transformations, proposed a more operational formulation of the principle of managing natural capital (Czaja & Becla, 2007). They can be specified as follows: (1) the principle of balancing resources and expenditures; (2) the principle of not depleting natural capital resources, fundamental natural capital; (3) the principle of maintaining the diversity of natural capital components; (4) the principle of substituting natural capital with other forms of capital; (5) principle of entropy source minimisation; (6) the principle of rational use of natural capital resources (application of the criterion of maximising the utility of natural capital) and (7) the principle of effective use of natural capital elements (excess of benefits over costs). Such an approach to management principles seems easier to use in practice and can be more precisely described by means of valuable indicators, which makes it easier to monitor and control both their application and the implementation of the balanced and sustainable development strategy.

The principles of entropy-balanced development are somewhat on the fringes of economic, social and ecological considerations. This is even more surprising because of the two dimensions of management – physical (natural) and financial – the former is more critical, and the latter remains a game of Platonic cave shadows. The former is subject to the influence of the first and second laws of thermodynamics in a unique way (Czaja, 1997; Czaja & Becla, 2007).

The principles of entropy-balanced development are of the most general nature. However, they provide precious clues for understanding the world around us and taking appropriate actions for humans (Figure 3).

DOI: 10.34659/eis.2022.83.4.489

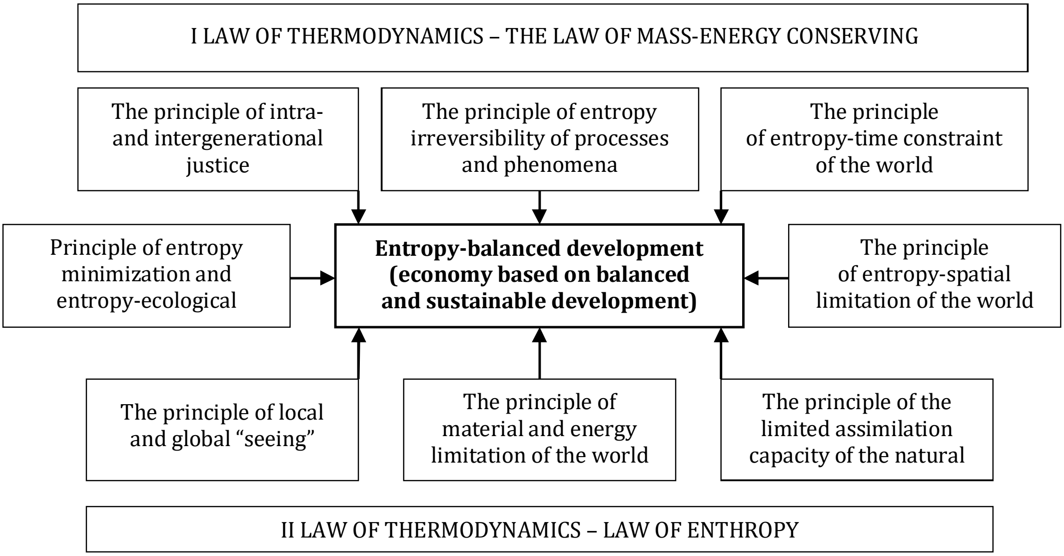

Figure 3. Principles of entropy-balanced development

The principles of entropy-balanced development take on a dual character. On the one hand, they expose the most important insurmountable limitations, on the other, they are guidelines for understanding development and its implementation.

General assessment of the principles of management of economic capital (resources) in the context of balanced and sustainable development

From the above-abbreviated presentation of the principles of managing capital in balanced and sustainable development, it can be seen that their assessment can be carried out on various levels in the context of appropriately selected criteria. They can be, for example: (1) the criterion of logical correctness of the rules, (2) the criterion of the legitimacy of their formulation from the perspective of sustainable and sustainable development, (3) the criterion of the generality of the form of principles in terms of the level of implementation of the development strategy, and (4) the criterion of utility. In the latter case, usability can be broken down into the practical, cognitive, and educational-awareness dimensions.

Using the logical correctness criterion, it can be concluded that each rule presented above meets them. It cannot be argued that they are wrong or logically incorrect. They result from the current identification of problems

DOI: 10.34659/eis.2022.83.4.489

(knowledge in this area) or from the adopted model assumptions. Even the most criticised principle of maximising net benefit (profit) cannot be accused of being illogical. It can be criticised for its consequences, it can be rejected, and it is possible to disagree with the methods of its implementation. However, its logical correctness cannot be questioned.

Greater possibilities of differentiated assessments are provided by the criterion of the legitimacy of their formulation in the context of balanced and sustainable development. A detailed assessment of a specific principle will depend on the way of understanding the development itself, the "have or be" relationship, the level of anthropocentrism adopted, and the impact of these principles on the long-term goals of civilisation changes. The axiological systems, ethical-moral systems and other modifying elements of the represented cultural circle, such as actual or declared life attitudes as well as religious and aesthetic views, are also important in such assessments. Undoubtedly, the price of legitimacy is also influenced by the level of environmental awareness and knowledge of the evaluator (Poskrobko, 2010a; Poskrobko, 2010b).

The use of the criterion of legitimacy does not allow for an unambiguous conclusion that the presented principles of management meet them unconditionally. The idea of balanced and sustainable development questions the principles of an extensive "cowboy" economy and some of the principles of an intensive, traditional economy. Subsequent ways of understanding the processes of management, economy and civilisation changes more effectively meet this evaluation criterion, which is logical and results from approaching such approaches to principles that are directly related to the idea and strategies of sustainable development. However, challenging such rules within them may be combined with the fact that they are redundant and / or duplicate. For if there are too many formulated rules or they overlap in terms of content, the phenomenon of information noise, which hinders the efficient (and therefore practical and efficient) implementation of the development itself, should be taken into account. When analysing the issue of the principles of balanced and sustainable development, these problems should be considered. The optimal number of such principles concerns their cognitive usefulness (a large number is acceptable), implementation (the need for them much more and less specific) and didactic, shaping attitudes (which requires a small number but is very expressive).

The third criterion of the generality of the form of rules is quite easy to use if one analyses their formulas and determines the functions that such rules should fulfil. As noted in the introduction, the rule is a reasonably general rule intended to indicate the choice made and facilitate the implementation of individual projects. It, therefore, has a directional, somewhat "philosophical" character. Thus, it can be seen, for example, that the principles of entropy-balanced development will have the most general scope and indicate

DOI: 10.34659/eis.2022.83.4.489

even global limitations. They are also common and cannot be "avoided" because the laws of physics condition them. The rules governing the relationship between the forms of capital or the balance between orders are also quite general.

The most important, in the context of active human activity, is the assessment of the usefulness of individual principles. It concerns the practical, cognitive, and educational-awareness dimensions. The practicality of managing capital (resources) combines detail with "indexing", which facilitates monitoring and controlling its implementation.

From the cognitive point of view, each principle has greater or lesser values, allowing to expand and deepen the knowledge about balanced and sustainable development and its consequences for human civilisation at various levels of its functioning. However, these qualities are essential for the intellectual elite, interested people, and not all people. From an educational and awareness perspective, helpful principles effectively create human attitudes appropriate for sustainable development and desirable for a society implementing such a strategy. This narrows the range of principles to the most expressive and, simultaneously, reduces the usefulness of the principles to the level of the human individual. In the implementation context, these principles should enable, or in fact force, efficient, that is, practically and economically effective implementation of the strategy of balanced and sustainable development. The assessment based on the above four proposed criteria should concern a specific principle of managing economic capitals and, therefore, should be individualised.

Conclusions

Identification and analysis of the principles of capital management in balanced and sustainable development is an extremely important problem, more critical and more multidimensional than it seems at the beginning. Such principles are connected not only with the very essence of development, which is understanding and clarification of the idea or strategy (this is the cognitive aspect that is emphasised many times) but also with the efficiency of implementing such a form of development in practice, at all levels, from single micro-ventures to the planetary dimension. These principles also directly relate to increasing and deepening knowledge about balanced and sustainable development, environmental awareness and, what is particularly important, shaping real-life attitudes.

Principles of management in implementing balanced and sustainable development are the significant problems. Indeed, these principles determine the correctness of implementing such strategies at all levels. They also

DOI: 10.34659/eis.2022.83.4.489

determine the ways in which sustainable development ideas and strategies are understood.

A great challenge is the cognitive and practical utility of such principles. This translates into the efficiency and effectiveness of implementing individual projects within the framework of sustainable development.

The number of such rules should not be excessive, as this translates into the transparency of the goals and challenges of sustainable development and reduces information noise in this area. In addition, too many rules cannot be followed. A large number of such principles can generate the phenomenon of internal contradiction.

In addition, the principles of sustainable development should be understandable and acceptable to people with different intellectual levels and motivations for realising undertakings and goals arising from such development.

However, if we wanted to limit ourselves to a few recommendations resulting from the study itself, then we should focus on finding answers to the following questions:

- Which principles are necessary for balanced and sustainable development?
- What are these principles meant for?
- How are they understood and put into practice?

Obtaining them would be an extremely valuable contribution to the understanding and implementation of balanced and sustainable development.

Acknowledgements

The project is financed by the Ministry of Science and Higher Education in Poland under the programme "Regional Initiative of Excellence" 2019–2022, project number 015/RID/2018/19 total funding amount of 10 721 040 PLN.

The contribution of the authors

The entire article and all its parts were created in collaboration between the two authors.

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DOI: 10.34659/eis.2022.83.4.489

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DOES BEING SOCIALLY GOOD SAVE FIRMS FROM BANKRUPTCY? A SYSTEMATIC LITERATURE REVIEW AND BIBLIOMETRIC ANALYSIS

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ABSTRACT: The purpose of the review was to find out, does being responsible saves firms from bankruptcy? What is the relationship between corporate social responsibility and default risk? What methods and measures are used in the literature to evaluate this relationship? And what is the theoretical underpinning of the studies? Moreover, to explore what are the gaps for future work, Web of Science and Scopus databases were utilised to obtain the relevant articles for review. A total of 24 articles were reviewed using PRISMA systematic literature review and bibliometrics. This review finds that the literature has an unidirectional inverse relationship between corporate social responsibility and default risk. Moreover, most literature utilises the stakeholder perspective as the theoretical framework. A research gap exists in explaining the relationship between different theories and extending the model with various aspects of macro- and micro-economics as well as finance. This article contributes to the theoretical aspect by classifying methods, proxies, and theoretical underpinnings used in the research for corporate social responsibility and default risk.

KEYWORDS: default risk, corporate social responsibility, systematic literature review, bibliometric analysis, PRISMA

 DOI: 10.34659/eis.2022.83.4.514 JEL: G00, G30, G32, G39

Introduction

Understanding corporate social responsibility (CSR)'s impact on default risk mitigation may be critical for improving ideas about the social side of corporate strategy and having practical consequences for firm management. Firms face many risks. However, default risk is among the most deadly ones (Mushafiq, 2021; Mushafiq et al., 2021; Mushafiq et al., 2022). First, CSR is a corporate investment that deviates from focusing on the firm's immediate clients (El Ghoul et al., 2011). This societal-focused endeavour may appeal to a larger spectrum of stakeholders than other corporate expenditures, resulting in a multi-faceted protective mechanism that shields the company from risks. Extending this protection to default risk highlights CSR's unique and previously unknown functions.

Second, CSR possesses a specific "attribution" feature that other strategic investments do not. Through CSR, customers might identify themselves as stakeholders and build deeper ties with firms (Korschun et al., 2009). Linking this one-of-a-kind function to baseline outcomes like default risk validates the possibility of implementing CSR activities strategically and encourages managers to explore CSR alternatives alongside other business expenditures. Third, existing research focuses on the impact of CSR on a firm's immediate success, such as consumer metric benefits.

Those advantages, while significant, cannot reflect the firm's overall health. CSR, for example, boosts financial benefits while consuming a large amount of financial and human capital (Galant & Cadez, 2017; Habib & Hasan, 2016). Default risk is an essential measure of the profits and costs of a company's investment. As a result, tying CSR to default risk is a more efficient approach to illustrate CSR's true worth. Default risk, on the other hand, is a company's forward-looking performance measure. Verifying CSR's relationship to this risk factor enhances the firm's strategic planning and expands its understanding of its long-term characteristics (Sun & Cui, 2014).

Nevertheless, the studies were primarily focused on the unidimensional relationship between default risk and corporate social responsibility. The idea remained simple as it is a direct relationship between corporate social responsibility and default risk. Moreover, only a few articles provide this relationship's theoretical underpinning. There has not been any study performing the systemic literature review on the relationship between default risk and corporate social responsibility. However, the work of (Breitenstein et al., 2021) is somewhat closer to this study as it discusses the general environmental responsibility for a firm's risk.

This research examines the fundamental research on default risk and its relationship with corporate social responsibility. The study focuses on four

DOI: 10.34659/eis.2022.83.4.514

major questions (1) Does being socially responsible save firms from bankruptcy? (2) What is the relationship between CSR and default risk? (3) What are the existing theoretical frameworks supporting and gaps for future works? and (4) What methods and measures are utilised to explore the relationship? To accomplish objectives, a systematic literature review based on the PRISMA statement is conducted to identify and discuss relevant quality research. A systematic literature review presents evidence of the dependency of a firm's default risk on corporate social responsibility. The theoretical idea behind this dependency is that socially responsible firms show lower default risk levels.

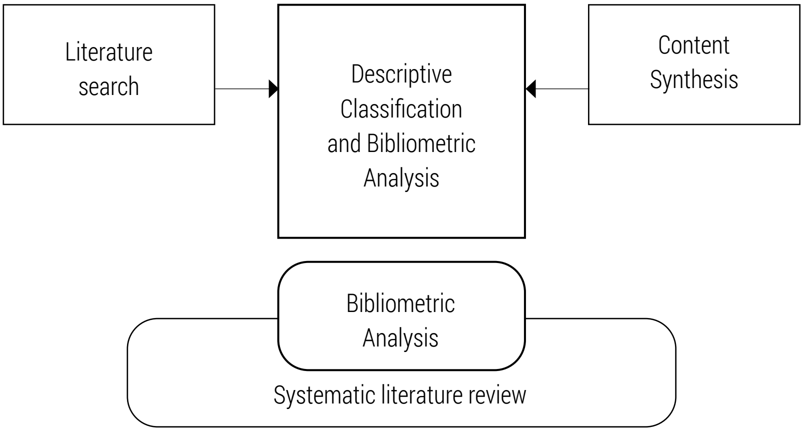

Figure 1. Pathway of the study

Figure 1 shows the pathway of this research, Section 2 discusses the systematic literature review and bibliometric analysis methods followed to obtain and narrow down the articles. Section 3 and 4 elaborates on descriptive classification and bibliometric analysis. Synthesis from the reviewed articles is done in section 5. The conclusion and future directions are mentioned in section 6.

Methodology

Systematic Search Results

This study utilised a search strategy to identify the relevant articles in the two significant sources, i.e., Web of Science Core Collection and Scopus. Only these two databases were included as the journals indexed in both databases are indexed with rigorous quality checks, enabling this study to focus on the

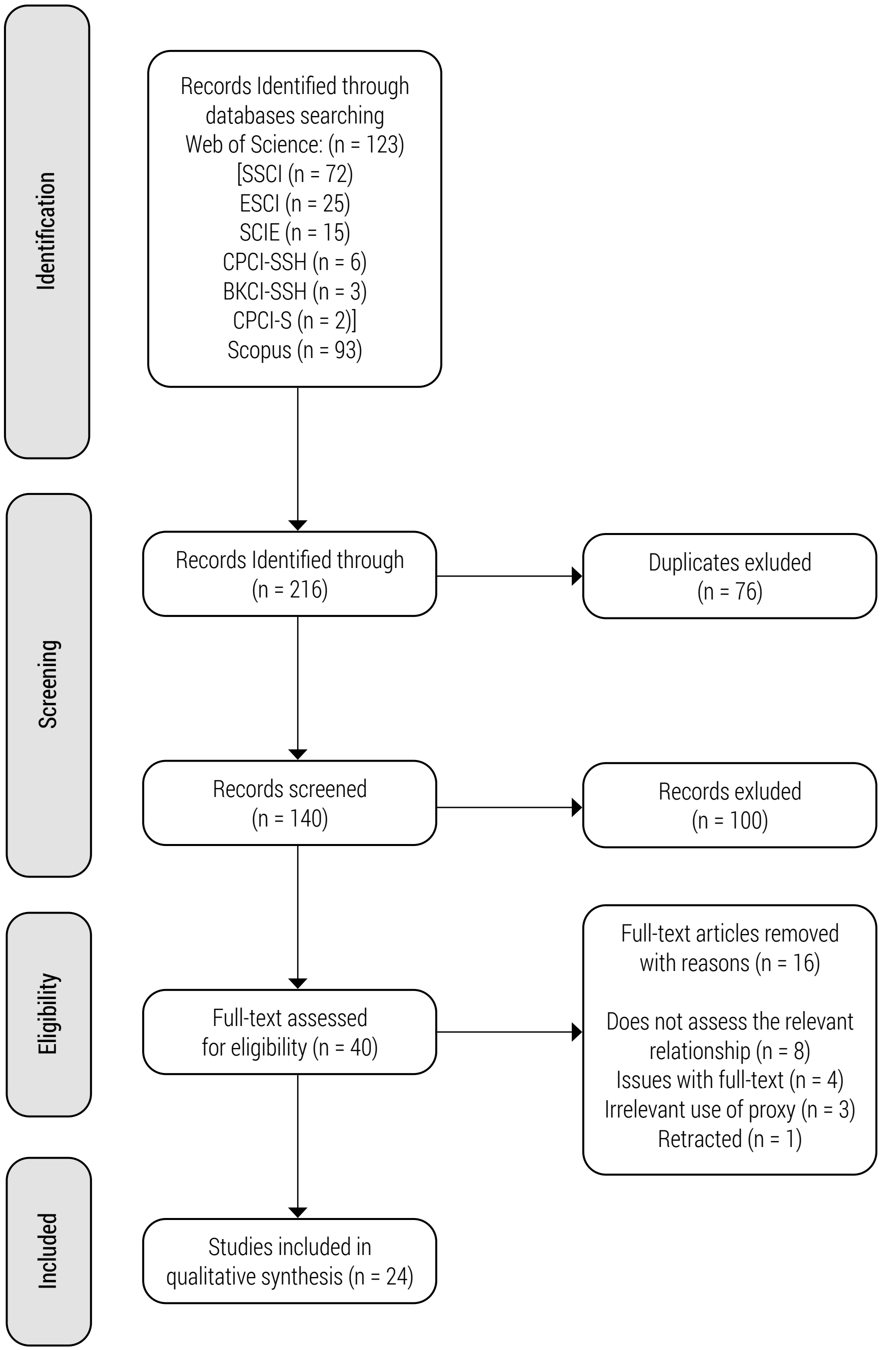

Figure 2. PRISMA flow chart of the conducted systematic literature review

articles published in reputable journals. The search strategy was ("Default Risk" OR "Probability of Default" OR "Bankruptcy" OR "Likelihood of bankruptcy" OR "Financial Distress") AND ("Corporate Social Responsibility" OR "Sustainable Performance" OR "Corporate Social Performance" OR "Environmental Performance" OR "Environmental, Social, & Governance")[1]. The search was not limited in terms of time or the type of articles. As stated in Figure 2, this systematic literature review follows the PRISMA statement 2020 (Page et al., 2021). The search strategy focused on mapping literature related to default risk and corporate social responsibility. It allowed for searching throughout the study based on the original journal articles, conference papers, and book chapters. Both databases' duplicates and available publications were removed at the initial screening stage. The following step was regarding screening the articles using titles and abstracts. All the titles, keywords, and abstracts were examined in detail to see if the article fulfilled the criteria of exploring the relationship between default risk and corporate social responsibility in some manner, i.e., direct or indirect relationship. At this review stage, out of 140 publications, 100 were excluded as the relationship between default risk and corporate social responsibility was not examined, and 40 were extracted for further screening.

The final screening process before synthesising the articles was about exploring the full-text articles for the relationship between the variables referring to corporate social responsibility and default risk. 16 articles were removed based on the following reasons. 8 of the articles did not explore the relationship between the default risk and corporate social responsibility. 4 articles' full text was either not accessible, or the available full text was not in English. 3 articles were excluded as they used an irrelevant proxy or had non-firm level data. 1 article was excluded as it was retracted from the journal based on plagiarism. Therefore, 24 articles were based on the following criteria (1) The study must have explored the relationship between default risk and corporate social responsibility (2) The articles were original publications in journals, conferences, and book chapters. (3) The articles must be in English. The first search yielded a total of 123 articles in WoS and 93 in Scopus. Therefore, no limitations in terms of the field area were made.

Bibliometric Analysis

Data statistics such as author, affiliation, and keywords are available through bibliometric analysis. Several software programs, including Gephi and VOSviewer, have previously been used for bibliometric analysis, each with its features and limitations. This study used the Visualization Of Similarities (VOS) viewer (van Eck & Waltman, 2010) due to the ease of use; with

[1] Databases were accessed on 2nd January 2022.

many advantages of VOSviewer, there are disadvantages as well. The major drawback of using the VOSviewer is the data inputting limitations. In this study, the issue was regarding how articles from the Webs of Science and Scopus can be analysed simultaneously, as the VOSviewer only accepts one format at a time. To resolve this issue, the base template of Scopus was used, and the articles from the Web of Science were manually inputted into the Scopus file. This allowed for the analysis of articles from both databases simultaneously. This study utilises the bibliographic coupling (Kessler, 1963) and co-citation analysis (Small, 1973) to explore the clusters of influence between the studies. When two documents cite the same third document, this is called bibliographic coupling. According Martyn (1964), "two papers that share one reference contain one unit of coupling, and the value of a relationship between two papers having one or more references in common is stated as being of strength one, two, etc., depending on the number of shared references." Citations are used in bibliographic coupling to provide insight into the similarities between two works, authors, institutions, or countries. This technique is based on the notion that two publications citing the third article are closely connected and should be concentrated in a visualisation map cluster solution. The total number of references or citations of other third texts they share determines the intensity of the bibliographic coupling. A co-citation network comprises nodes representing journal articles and edges or linkages reflecting the co-occurrence of the nodes (articles) in other publications. As a result, two publications are deemed co-cited if they appear in the reference lists of other works together. Papers often referenced together are more likely to provide comparable or related subject areas (Hjørland, 2013).

Classification of articles

Articles published in the year

Figure 3 depicts the total number of published articles and the trend in the articles. The number of articles published from 2012 to 2016 was 1 (4.17%) each year and dropped to 0 (0.00%) in 2017. From 2018, the increasing trend can be seen in the number of articles published. In 2018 2 (8.33%) articles were published, which increased by 1 article in 2019, totalling 4 (16.67%) articles. In 2020 5 (20.83%) articles were publish and 10 (37.50%) in 2021.

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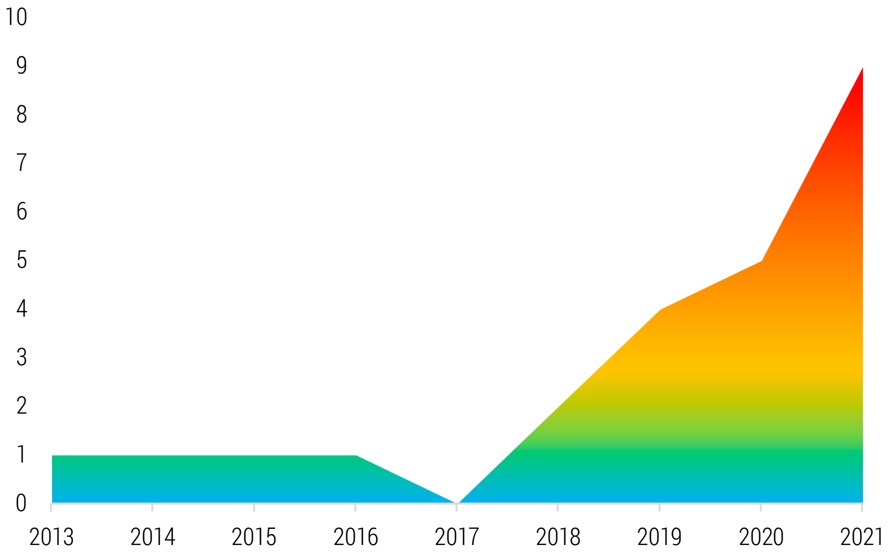

Figure 3. Articles published throughout the years

Articles in each index

Figure 4 depicts the classification of articles based on the indexes. Articles with the Social Sciences Citation Index and Scopus form a substantial chunk of the total studies accounting for 67% of total articles, which sums up to 16 articles. The next category belongs to the articles indexed in the Emerging Source Citation Index and Scopus, having 25% (6 articles) of the share of the total articles. The articles in only Emerging Source Citation Index and Scopus account for 8% (1 article each).

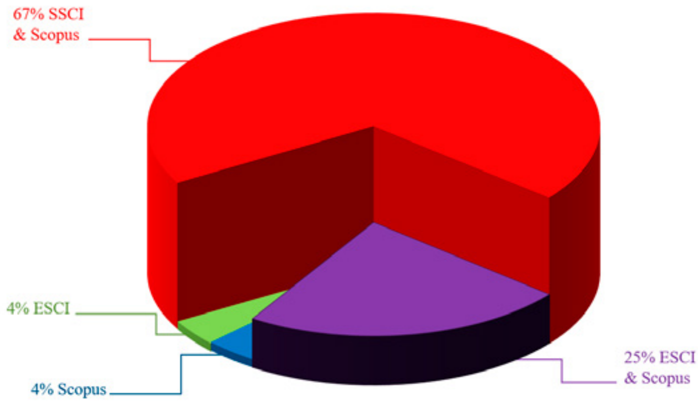

Figure 4. Classification of articles based on an index

DOI: 10.34659/eis.2022.83.4.514

Classification of the methods used

Figures 5 and 6 depict the baseline methods used to examine the relationships and procedures utilised as the robustness test results. The most used way to explore the relationship between default risk and corporate social responsibility is Fixed effect regression, as 10 (41.67%) utilise it. 8 (33.33%) studies have used ordinary Least Square. The model addressing endogeneity, i.e., generalised method of movements, has been used by 3 (12.50%) articles. 2 (8.33%) of the pieces use multiple models to assess the baseline impact of corporate social responsibility on default risk. 1 (4.17%) article used Probit regression to explore the relationship.

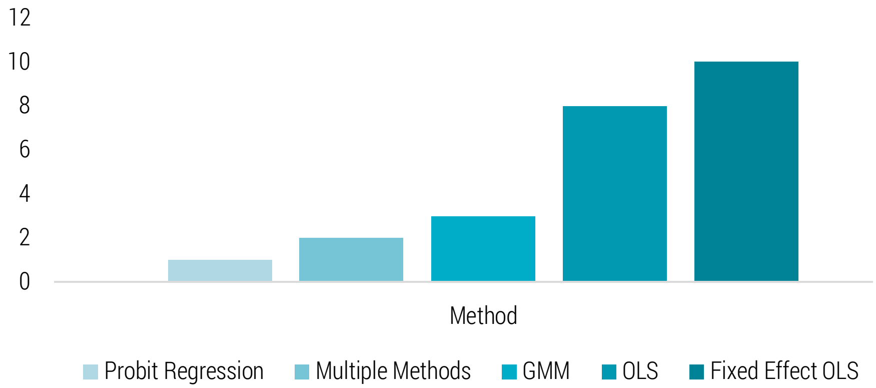

Figure 5. Classification of articles based on baseline methods used

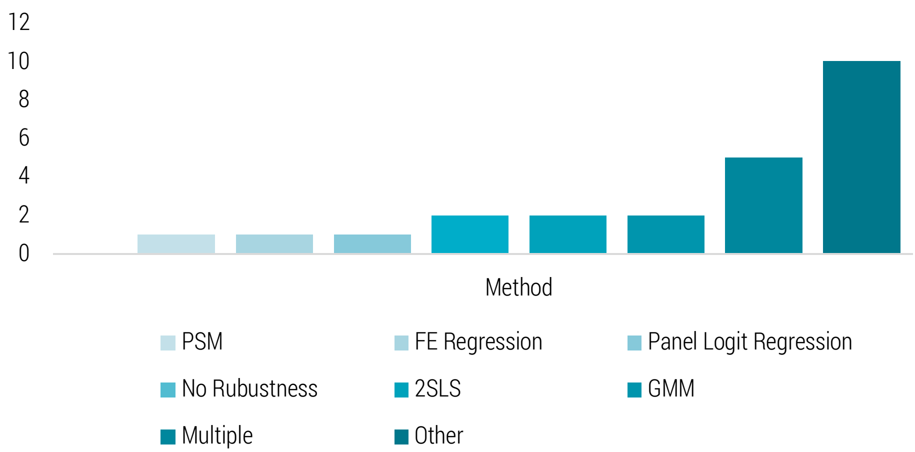

Figure 6. Classification of articles based on robustness methods used

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To evaluate the robustness of the results, 10 (41.67%) articles used different proxies in the model instead of using other econometrical models to prove that the results are robust. 5 (20.83%) articles used multiple models to assess the robustness of the results. A total of 4 (16.67%) articles used econometrical models that accounted for the endogeneity. The models included GMM and 2SLS. 1 (4.17%) article each used panel logistic regression, fixed effect regression, and propensity score matching as the methods to evaluate the robustness of the results. 2 (8.33%) articles do not use any kind of robustness tests.

Classification of the proxies

Figures 7 and 8 depict the classification of the articles based on the proxies used. The pareto chart shows that 50% of the studies have utilised the Altman Z-score (Z-Score) as the measure for the default risk. A total of 4 (16.668%) articles have used either the probability of default (PD) or distance to default (DD). For the proxy of Corporate Social Responsibility, most of the studies used the CSR Scores and Rankings (CSR Score, ASSET4, KLD Ranks) accounting for 54% of the total articles.

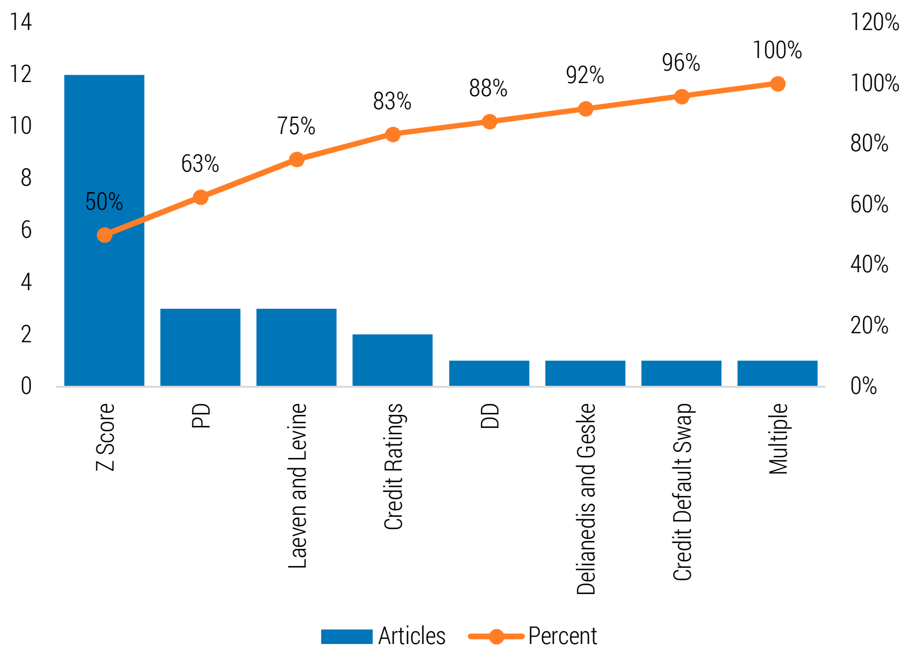

Figure 7. Classification of articles based on proxies used for default risk

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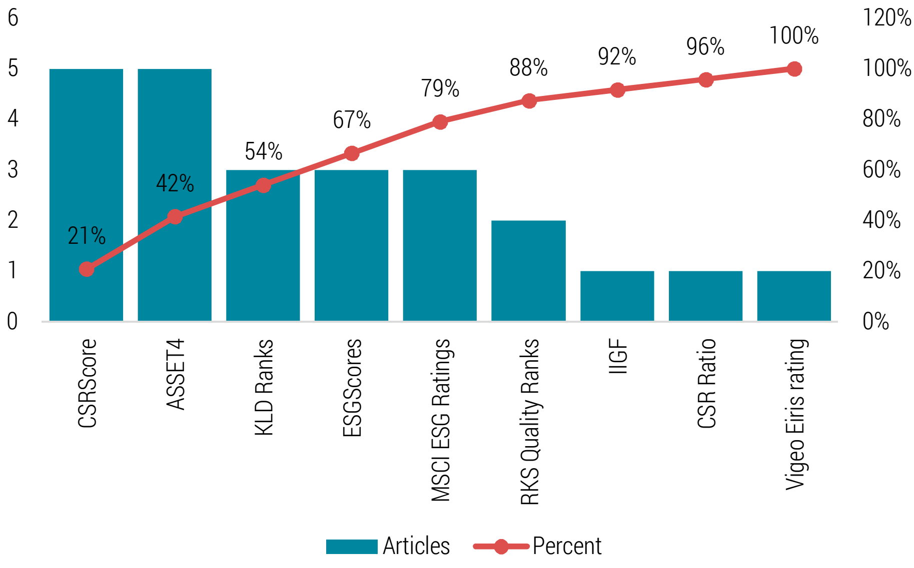

Figure 8. Classification of articles based on proxies used for CSR

Variable wise distribution

Figure 9 and Table A2 (in Appendix) show the box plot for descriptive statistics of variables of interest. The minimum mean value for the default risk is -1.525, whereas for CSR value is -0.311. To draw meaning to this number, we can see that most researchers used either Altman or Z-Score (Altman, 1968) or Probability of Default.

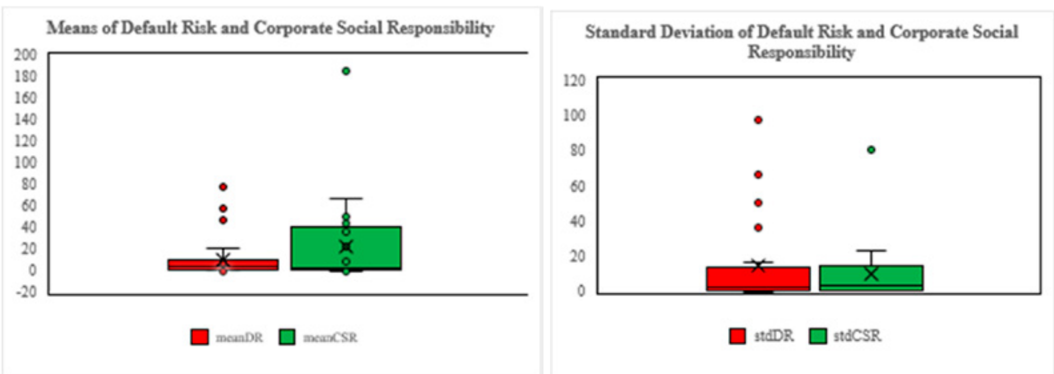

Figure 9. Percentiles of the mean and standard deviation of default risk and CSR

DOI: 10.34659/eis.2022.83.4.514

Interpreting from Altman Z-Score and Distance-To-Default perspective, as the output value of either variable is lower, it is regarded as closest to default. From the sample of the studies, the minimum value is almost zero, which interprets as a high default risk. For CSR, the minimum value is also harmful. This implies that the firms in the sample had a negative impact on their contribution towards society and the environment. The median mean value of 3.210 shows a lesser level of default risk. However, the value of the mean is affected by the outliers. The median, mean value for the CSR is somewhat closer to the actual median; however, still distorted by the outlier. The minimum standard deviation value for default risk and CSR is at 0.024 and 0.094, which shows that the dispersion around the mean is relatively low. The median, standard deviation value is highly skewed for default risk due to the outliers. From the box plot of mean values and standard deviation, it can be concluded that the interquartile range for mean default risk has a much tighter spread than that of CSR. However, the spread remains almost identical for the standard deviation values.

Network Analysis

Bibliographic Coupling

Out of 24 articles, 23 are bibliographically coupled. As shown in Figure 10, based on the bibliographic coupling, it is observed that there are 4 clusters formed. Clusters 1 to 3 are heterogeneous, whereas the cluster 4 is homogeneous in terms of the theme of the articles. Cluster 1, with eight articles, is dominated by the work of Sun and Cui (2014) and Jacobs et al. (2016). Sun and Cui (2014) explored the linkage between corporate social responsibility and default risk, and Jacobs et al. (2016) focused on exploring the link through operational productivity. Cluster 2 has 7 articles and is anchored around the work of Boubaker et al. (2020). Their work explored how corporate social responsibility can lower financial distress. Cluster 3 is more diverse than the first two; the article with the most citation Hsu and Chen (2015) and their work is more generic, belonging more to clusters 1 and 2 as it focuses on the relationship between financial risk and corporate social responsibility. Nevertheless, the 3 out of 5 articles in the cluster are specific regarding their evidence regarding banks. Therefore this cluster has a theme of evidence from banks. Cluster 4 has the work Shahab et al. (2018) as the anchor point; all the articles focus on somewhat specific country evidence. Shahab et al. (2018; 2019) focused on the Chinese firms, where Al-Hadi et al. (2019) focused on Australian firms.

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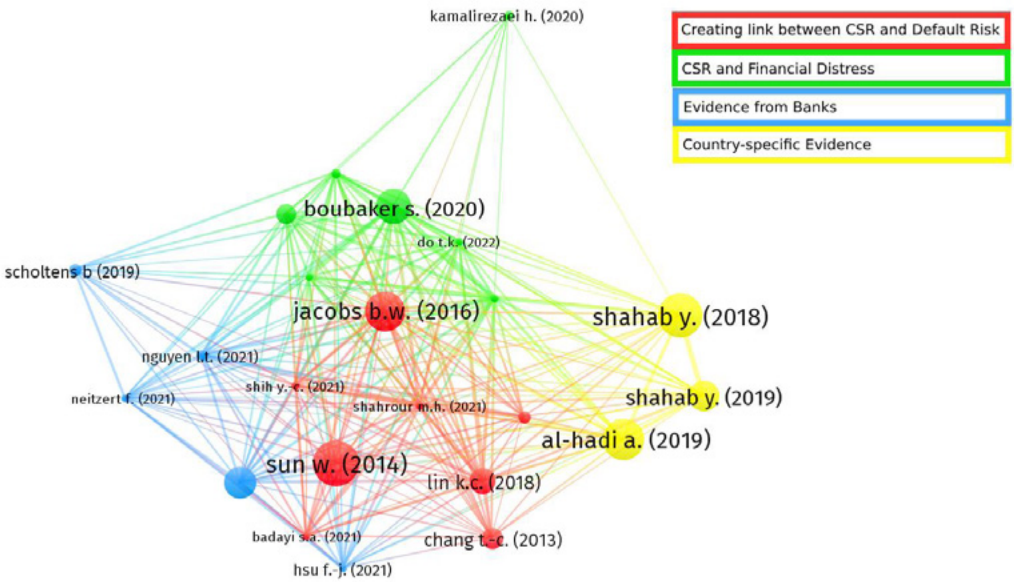

Figure 10. Clusters based on the bibliographic coupling

Co-citation Analysis

Figure 11 presents the co-citation analysis with a threshold of a minimum of 2 citations of the article; a total of 55 cited references remained part of the analysis out of 1527. In cluster 1, the node with the most strength is McWilliams and Siegel (2001), explaining the "ideal" CSR in a firm, Jo and Na (2012), exploring the CSR's ability to lower risk in the controversial industries. However, a higher number of articles in cluster 1 show a theme of ethical business. Cluster 2 is mainly dominated by Godfrey et al. (2009), whose work has focused on risk management and shareholder value maximisation through CSR. Other most dominant research is the work Sun and Cui (2014), who have explored the relationship between CSR and default risk. The generalised theme in cluster 2 refers to the applicability of corporate social responsibility in a firm. Clusters 3 and 4 are not anchored around a single work; their heterogeneous nature provides difficulty in generalising a theme. However, articles in cluster 3 focus on corporate social responsibility's impact on credit ratings and financial distress. The theme in cluster 4 is relevant to general risk management through corporate social responsibility.

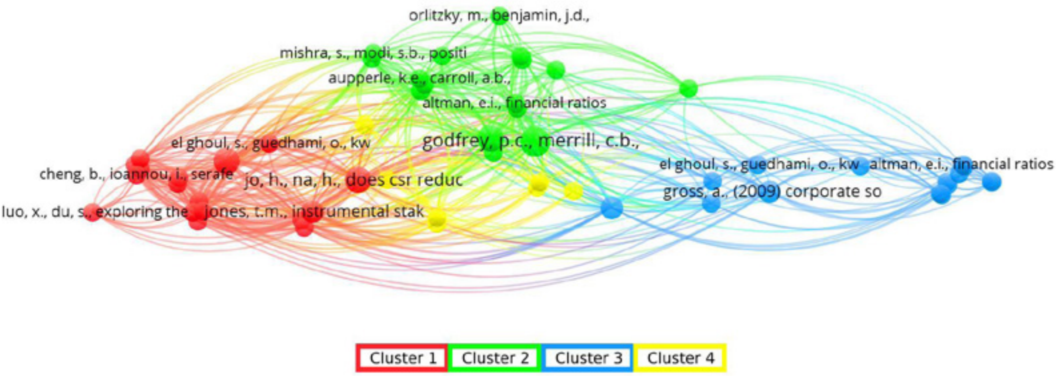

Figure 11. Clusters based on the co-citation

Discussion

The idea that corporate social responsibility can cause impact on the default risk was found to be accurate by modelling (Al-Hadi et al., 2019; Badayi et al., 2021; Boubaker et al., 2020; Chang et al., 2013; Farooq & Noor, 2021; Gangi et al., 2020; Hsu & Chen, 2015; Jacobs et al., 2016; Kamalirezaei et al., 2020; Lin & Dong, 2018; Nguyen & Nguyen, 2021; Saidane & Abdallah, 2021; Scholtens & van't Klooster, 2019; Shahab et al., 2018; Shahrour et al., 2021; Shih et al., 2021; Sun & Cui, 2014).

The discussion is based majorly on the relationship of CSR and default risk. Table 1 depicts the classification based on theoretical reasoning of the stakeholder's perspective as the baseline, extensive modelling[2], and the studies explaining the relationship in terms of the economic life cycle. Table A1 depicts the summary of the complete literature review. Hsu and Chen (2021) discovered that enterprises with superior CSR performance had a reduced distance to default conditioning during quantitative easing (QE) adoption. Firms had decreased default risk during the US QE program. Still, QE might have negative consequences due to higher risk premiums and volatility for stocks and low-grade corporate bonds, raising the total default likelihood. CSR can also reduce the default risk in the short run (Chang et al., 2013).

Good CSR ratings have a risk-mitigation effect in general. However, empirical evidence shows that the influence diminishes when the rating agency is anchored in its home nation's institutional environment, and the rated business operates in a country with a distinct culture or regulatory structure.

2 Extensive modelling means using the interaction terms (meditation/moderation) as part of the analysis.

DOI: 10.34659/eis.2022.83.4.514

Table 1. Classification of articles based on the significance, theoretical view, and extensive modelling

Author	Significance	Stakeholder Theory	Economic life cycle	Extensive Model
Al-Hadi et al. (2019)	x	x	x	
Badayi et al. (2021)	x	x		
Boubaker et al. (2020)	x	x		
Chang et al. (2013)	x			
Do (2022)	x	x		
Dumitrescu et al. (2020)		x		
Farooq and Noor (2021)	x	x		
Gangi et al. (2020)	x	x		
Habermann and Fischer (2021)		x	x	
Hsu and Chen (2015)		x		
Hsu and Chen (2021)	x			
Jacobs et al. (2016)	x	x		x
Kamalirezaei et al. (2020)	x	x		
Kölbel and Busch (2021)				x
Lin and Dong (2018)	x	x		
Neitzert and Petras (2022)*	x			
Nguyen and Nguyen (2021)	x	x		
Saidane and Ben Abdallah (2021)	x			
Scholtens and Van't Klooster (2019)	x			
Shahab et al. (2018)	x			x
Shahab et al. (2019)	x			
Shahrour et al. (2021)	x	x		
Shih et al. (2021)	x			
Sun and Cui (2014)	x	x		x
Note:*Paper was initially published as a early access therefore is considered as published in year 2021 in Figure 3 and Table A1.				

Source: authors' work based on the literature.

This shows that the `place of origin of a rating agency, as well as its embeddedness in that country's setting, plays an important influence in the link between CSR ratings and default risk (Kölbel & Busch, 2021). Saidane and Ben Abdallah (2021) reported that the performance in terms of the environment has a negative and considerable influence on the firm's stability.

Furthermore, findings indicate no direct relationship between the social dimension and business stability. Finally, we see a bidirectional link between the governance dimension and the stability of enterprises. According to their research, there is a virtuous loop between these two factors. In terms of sequencing, they argue that excellent governance practices should come first, followed by adopting social and environmental components. "Strong financial systems are founded on excellent governance," as the saying goes, (Honohan & Beck, 2007). These findings support the World Bank's governance strategy. Indeed, excellent governance appears to be an essential tool for ensuring stability.

The division the state-owned and non-state-owned has empirically demonstrated that CSR has a more remarkable ability to lower distress levels in non-state-owned Chinese enterprises than in state-owned Chinese firms (Shahab et al., 2019). The key driver of the decline in bank default risk and its input to systemic risk is the social component of sustainability rating (Scholtens & van't Klooster, 2019). This is consistent with the notion that banking is a service business that places a high value on human resources. However, it has little direct environmental imprint, and the corporate board is heavily regulated and supervised, limiting its ability to change governance.

Stakeholder's Perspective

Stakeholder Theory emphasises the linked interactions between a company and its customers, suppliers, workers, communities, and other stakeholders. According to the principle, a company should provide value for all stakeholders, not just shareholders (Freeman, 1984; Parmar et al., 2010). From the perspective of the relationship between default risk and corporate social responsibility, the stakeholders' theory is relevant as the internal stakeholders (shareholders) try to minimise the default risk while attempting to maximise the value for the external stakeholders (customers and society) and one of the main paths to doing so is through being socially responsible.

Businesses with greater CSR levels have lower financial distress risk (FDR), implying that superior CSR performance makes enterprises more creditworthy and has better access to funding, which is rewarded with fewer economic failures. This conclusion is resilient to utilising various FDR proxies and correcting for any endogeneity and is primarily driven by the CSR aspects of community, diversity, employee relations, and the environment. Furthermore, this link is more common in organisations with robust governance procedures and intense product market competitiveness. It is also increased for less troubled businesses and during non-crisis situations (Boubaker et al., 2020). From the economic status of the country's perspective,

DOI: 10.34659/eis.2022.83.4.514

Badayi et al. (2021) reported that developing countries tend to decrease default risk with the increase in CSR.

ESG's social and governance elements can explain cross-sectional and temporal differences in enterprises' future distance to default. The social dimension of CSR ratings has a causal impact on financial default. Financial restrictions and management focus on shareholders show that businesses with shareholder-oriented managers are more prone to incur the unfavourable consequences of social stakeholder involvement in financial difficulties. Because management competence is characterised in terms of efficiency targeted at profitability, earning quality is another indicator of the same (Dumitrescu et al., 2020).

CSR efforts lower agency expenses and financial risk by removing knowledge asymmetry among stakeholders (Kim & Kim, 2014). CSR can help listed companies increase information openness and empower public opinion to influence investment choices. Companies should pay greater attention to CSR as a form of social communication to minimise financing costs, broaden their investor base, and improve brand recognition. Positive CSR information is more likely to elicit a response from investors than negative CSR information. When a company embarks on a qualitative CSR strategy, its first aim must ensure future competitiveness, even if it means sacrificing current performance. Firms may then focus on the image of the brand or product to increase consumer loyalty and improve operational efficiency and financial performance once they have established CSR strength. Firms that are well-known for their dedication to CSR implementation are more likely to be rewarded with brand loyalty. This demands sound management methods and rigorous assessment of CSR concerns, particularly those connected to products, during the value-generation process. As a result, businesses should continue to invest in CSR initiatives in order to gain these benefits in the long run (Hsu & Chen, 2015).

Considering the stakeholder perspective on CSR and finding that CSR investment reduces the chance of financial difficulty, this link is more vital for enterprises with a greater engagement in international commerce (Farooq & Noor, 2021). These findings suggest that CSR is critical in rescuing firms from severe financial difficulties. Furthermore, the company's involvement in employee well-being and R&D saves the organisation from financial default, whereas a company's charitable contributions fail to demonstrate any connection with financial ruin.

The impact of CSR on business default risk is significant from a societal standpoint, given that CSR contributes to the development of a better community (for example, improved openness, reduced pollution, and better stakeholder interactions) and can assist in preventing the repercussions of bankruptcies (loss of assets and jobs, among others) (Shahrour et al., 2021).

DOI: 10.34659/eis.2022.83.4.514

Benefits of CSR and the development of a framework for describing how socially responsible conduct minimises the risk of default by decreasing its determinants. When descriptive evidence and empirical data are presented, CSR is adversely associated with corporate default risk. Thus, CSR may aid in risk reduction by providing insurance-like coverage, and enterprises would gain from socially responsible behaviour during economic crises. During a financial meltdown, CSR has a more significant influence on default risk likelihood than at other times, and all CSR components are adversely associated with company default risk.

Because the business unit cannot exist without the public, and society cannot function without a commercial company, there is a two-way connection between the two. CSR, as one of the most significant community-oriented initiatives, aims to create long-term economic growth by enhancing the quality of life of workers, their households, the ecosystem, and the community as a whole. CSR focuses on issues like ethics, ecology, safety, schooling, and civil rights. Although CSR has a direct cost to businesses, it is predicted that strengthening their reputation would cut expenses and boost sales in the long run, enhance their financial efficiency and competitiveness, and minimise risk, including the risk of bankruptcy (Kamalirezaei et al., 2020).

The role of the banking sector in long-term sustainability has been a source of debate, particularly after the global financial crisis of 2008. Customers and employees have lost faith in the industry due to unethical and unsustainable practices. Aside from that, given the world's growing climate change, even if a bank is not directly responsible for environmental damage, it may be held partially accountable based on its green strategy (Nguyen & Nguyen, 2021).

From the stakeholder and resource-based approaches, the more CSR participation, the lower the risk of financial default for the company. Furthermore, they investigate this relationship further by examining if there are any variations in the advantages of CSR activity for SMEs and large corporations. Their findings show that SMEs more involved in CSR benefit from lowering the risk of financial hardship than large corporations. This finding backs up the premise that CSR may help SMEs overcome common challenges (such as high financing costs and budgetary constraints, as well as issues in innovating and attracting/retaining high-quality staff) and improve their competitiveness (Gangi et al., 2020).

CSR has a negative relationship with the likelihood of default. The long-term impact of CSR is more significant than the short-term impact. Overall, the outcomes of this study support the idea that CSR decreases transaction costs and improves access to capital markets, lowering the risk of default. Furthermore, organisations that participate in high levels of CSR can reduce

DOI: 10.34659/eis.2022.83.4.514

their risk of default and enjoy higher credit quality due to increased trust and reputation (Do, 2022).

Before CSR engagement, social capital is decomposed into the exchange and moral capital. The relative importance of the two resources in understanding how prior CSR activity decreases the chance of bankruptcy is next assessed. The work of (Lin & Dong, 2018) highlights the intricate web of interactions between a company and its stakeholders in determining the efficacy of CSR involvement.

CSR and default risk from the perspective of the economic cycle

From the perspective of economic life cycles, Al-Hadi et al. (2019) proved that businesses with greater CSR levels have lower default risk, implying that superior CSR performance makes enterprises more creditworthy and has better access to funding, which is compensated with reduced defaults. Positive CSR performance and life cycle development have been experimentally linked to financial distress. These findings significantly affect business management and other stakeholders since companies' access to resources and capacity to compete with their peers would differ throughout the life cycle stages. Similarly, companies' sensitivity to the financial crisis can vary consistently across different life cycle periods. Firms that participate in suitable CSR activities are more likely to be able to lower the risk of financial hardship during the most vulnerable periods of life cycle development.

However, Habermann and Fischer (2021) argued that corporate social responsibility does not impact the default risk in the specific case of the economic upswing. The evidence found that the positive impact of corporate social performance (CSP) on stakeholder relationships does not manifest in thriving company contexts. Thus, the costs of raising CSP outweigh the benefits and increase the chance of bankruptcy. CSP investments, on the other hand, might be viewed as a balanced measure because they lessen financial default risk in following crises.

Extensive Models

Through extensive modelling, Sun and Cui (2014) established the CSR and company capability and environmental dynamism/complexity, offering a more detail-oriented model of CSR's role under various internal and external contexts. The findings demonstrate that CSR significantly impacts default risk reduction and that this effect is more significant on enterprises in high-dynamism settings than firms in low-dynamism environments.

The diverse dynamics of top management teams influence the connection between environmental performance and financial distress (Shahab et al., 2018). The presence of conventional top management team minorities (e.g., females) and politically connected females in top management teams significantly accentuates the negative impact of environmental performance on Chinese enterprises' financial hardship. However, they discovered a detrimental influence of senior management team members' international exposure on the link above.

Improving firm-level efficiency is crucial but insufficient to affect financial performance and risk. Instead, firm-level progress in comparison to peers in the sector is crucial. Managers can advance their careers by concentrating on various elements of operations and social responsibility (Jacobs et al., 2016). Concentrating on any particular dimension of operational productivity or corporate social performance does not appear to be intrinsically favourable; instead, managing trade-offs to obtain or maintain the efficient frontier appears to be the key. As a result, managers have options in handling corporate social performance and operational productivity to enhance financial success while minimising risk.

Conclusion and Future Directions

From the extensive literature review, it is concluded that the firms do get rewarded for being socially responsible and have lower chances of bankruptcy since the default risk and corporate social responsibility have an inverse relationship. As the firm invests in corporate social responsibility, the default risk decreases; this relationship is unidirectional. From the theoretical perceptive, stakeholder theory (Freeman, 1984; Hart, 1995; Jones, 1995; Russo & Fouts, 1997) proposes an explanation for CSR's bankruptcy-deterrent impact. The review has found that Least Square Regression is one of the most used methods in evaluating the relationship. The selection of CSRScores and ASSET4 as a measure of CSR is popular.

Similarly, Z-Score and Probability of Default are reasonable measures for default risk. This review finds that most of the studies have utilised the stakeholder's perceptive as the basis for the study, and it is best suited as the stakeholders [both internal (board and management) and external (customers)] want to lower the financial distress and the internal stakeholders do that by giving back to the society. According to the stakeholder theory, firms that successfully serve the social demand from stakeholders would survive better.

The future work can be extended in terms of different theoretical frameworks. For instance, agency theory can explain the relationship from the perspective of managers with a competitive advantage over company information and significant discretionary power, allowing them to achieve their objectives, and are thus more likely to use CSR initiatives to their benefit

DOI: 10.34659/eis.2022.83.4.514

(Park & Lee, 2020). Such agency issues can influence default risk. Moreover, the extension in this area of research can be done by providing a broader perspective of micro-economic and financial aspects. For instance, explaining the relationship between CSR and default risk from the perspective of Melitz (2003)'s firm heterogeneity, exploring the relationship in terms of how they perform in each sector and relation to their intra/international trade can provide an extensive explanation of the relationship between CSR and default risk. Additionally, proposing new research models with extended financial variables can be a good opportunity for future work. For instance, how can innovation influence the relationship, or does the total financial performance and efficiency influence the relationship between CSR and default risk?

Appendix

Table A1. Summary of the articles included in literature review

Author	Year	Type of Firm	Sample Period	N	Significance	Direction	Stakeholder Theory	Extensive Model
Al-Hadi et al. (2019)	2019	Non-Financial	2010-2017	651	x	CSR -> DR	x	
Badayi et al. (2021)	2020	Non-Financial	2010-2017	3,968	x	CSR -> DR	x	
Boubaker et al. (2020)	2020	Non-Financial	1991-2012	9,262	x	CSR -> DR	x	
Chang et al. (2013)	2013	Non-Financial	2007-2010	4,080	x	CSR -> DR		
Do (2022)	2021	Non-Financial	2002-2016	28,439	x	CSR -> DR	x	
Dumitrescu et al. (2020)	2020	Non-Financial	1991-2015	35,711		CSR -> DR	x	
Farooq and Noor (2021)	2021	Non-Financial	2008-2019	1,878	x	CSR -> DR	x	
Gangi et al. (2020)	2020	Non-Financial	2010-2015	8,227	x	CSR -> DR	x	
Habermann and Fischer (2021)	2021	Non-Financial	2010-2019	6,696		CSR -> DR	x	
Hsu and Chen (2015)	2015	Non-Financial	1991-2018	121,938		CSR -> DR	x	
Hsu and Chen (2021)	2021	Non-Financial	2000-2014	31,182	x	CSR -> DR		
Jacobs et al. (2016)	2016	Non-Financial	1999-2009	2,086	x	CSR -> DR	x	x
Kamalirezaei et al. (2020)	2019	Non-Financial	2009-2016	1,600	x	CSR -> DR	x	
Kölbel and Busch (2021)	2021	Non-Financial	2011-2016	11,289		CSR -> DR		x
Lin and Dong (2018)	2018	Non-Financial	2000-2014	4,163	x	CSR -> DR	x	
Neitzert and Petras (2022)	2021	Financial	2002-2018	3,949	x	CSR -> DR		
Nguyen and Nguyen (2021)	2020	Financial	2008-2017	300	x	CSR -> DR	x	

DOI: 10.34659/eis.2022.83.4.514

Author	Year	Type of Firm	Sample Period	N	Signifi-cance	Direction	Stake-holder Theory	Exten-sive Model
Saidane and Abdallah (2021)	2021	Non-Financial	2010-2019	1,270	x	CSR -> DR		
Scholtens and Van't Klooster (2019)	2019	Financial	2002-2016	645	x	CSR -> DR		
Shahab et al. (2018)	2018	Non-Financial	2009-2014	2,984	x	CSR -> DR		x
Shahab et al. (2019)	2019	Non-Financial	2009-2014	3,171	x	CSR -> DR		
Shahrour et al. (2021)	2021	Non-Financial	2003-2017	1,916	x	CSR -> DR	x	
Shih et al. (2021)	2021	Non-Financial	2012-2017	1,482	x	CSR -> DR		
Sun and Cui (2014)	2014	Non-Financial	2008-2010	829	x	CSR -> DR	x	
Summary								
Description	Signi-ficant	Not Significant	Non-Financial	Financial				
Articles	20	4	21	3				

Source: authors' work based on the literature.

Table A2. Percentiles of mean and standard deviation of default risk and CSR

	Mean of DR	Mean of CSR	StDv of DR	StDv of CSR
Minimum	0.0030	-0.3110	0.0240	0.0940
25th Percentile	0.7300	0.3395	0.6533	0.2695
Median	3.2100	1.9660	2.8100	3.1147
75th Percentile	11.454	40.190	11.827	12.980
Maximum	77.220	185.870	97.464	80.307

The contribution of the authors

Muhammad Mushafiq and Błażej Prusak conceptualized the article and finalized the methodology. Muhammad Mushafiq performed data acquisition, data curation, formal analysis and visualization as well as wrote the initial draft. Błażej Prusak supervised, edited the multiple drafts and made some corrections and improvement.

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ENVIRONMENTAL POLICY AND MANAGEMENT

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THE EUROPEANIZATION OF POLISH CLIMATE POLICY

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ABSTRACT: The goal of the work was to analyse the positions of the selected Polish political parties about the European Union climate policy and to assess whether and to what extent the process of Europeanization is taking place in Poland. Climate change negatively influences economic growth: it affects food security and limits industrial output and economic development. It reduces labour productivity and influences international trade. The scope of this impact will depend on political decisions and the effectiveness of climate protection measures taken by individual governments. The negative attitude of political parties to climate policy may make it challenging to undertake the necessary adaptation and mitigation measures, even despite changes in social perception in this regard.

KEYWORDS: climate policy, political parties, election programs, Europeanization, social perception

 DOI: 10.34659/eis.2022.83.4.482 JEL: Q54, Q580

Introduction

It is generally recognised that climate change's effects negatively influence economic variables. It affects, among other things, the agriculture sector and food security (Zhang et al., 2017; Karaczun & Kozyra, 2020) and limits the industrial output and economic growth (Chen & Yang, 2019). It will reduce labour productivity (Zhang et al., 2017) and influence international trade (Dellink et al., 2017). As Tol (2009) points out, the scope and strength of this impact will depend primarily on political decisions and the effectiveness of climate protection measures taken by individual governments. The negative attitude of political parties to climate policy may make it challenging to undertake the necessary adaptation and mitigation measures. As a consequence, it may affect economic and economic development.

Therefore, climate change is becoming one of the key themes in the politics of the European Union (EU). Since the beginning of climate negotiations, the EU has been striving to adopt a legally binding international agreement that would set out the obligations of individual states in the field of climate protection (Schreurs & Tiberghim, 2007; Kilian & Elgström, 2010). To prove its position, it adopted a strategy of "leadership by example," associated with adopting ambitious climate goals. The strategy has proved effective, at least in the initial period of the climate negotiations (Yamin, 2010). However, in the first decade of the 21st century, the differences in the approach to climate policy between countries became too large for the "good example" strategy to still be effective. This led to a change in the EU's strategy – from striving to be a leader in international negotiations to accepting the role of a mediator whose activity supports reaching a consensus between parties (Fischer & Geden, 2015; Bäckstrand & Elgström, 2013).

But the European Union has not abandoned its ambitious plans. The belief that actions should be consistent with the results of scientific research further honed the EU's priorities in the following years. In December 2020, the European Council approved the increase of the reduction of the greenhouse gas emission target from 40% in 2030 (compared to 1990) to 55% (European Commission, 2021).

Achieving this goal will largely depend on the activity of individual member states. Apart from the countries supporting ambitious climate policy goals, there are also countries that are far more sceptical. One is Poland, which is supported by some new member states (Skjærseth, 2018).

There are many contradictions in Polish climate policy. On the one hand, Poland is a country of climatic success. Despite the significant increase in GDP, greenhouse gas emissions have decreased significantly and are now 32% lower than in the base year (Ministry of Climate and Environment,

DOI: 10.34659/eis.2022.83.4.482

2021). The need to undertake actions in this area Polish government noticed in 1991 when it accepted the First National Ecological Policy (Resolution, 1991). A year later, Poland became a signatory to the UNFCCC, and in 1994 it ratified the Convention. In December 1997, Poland signed the Kyoto Protocol, committing itself to the annual average reduction of greenhouse gas emissions in 2008-2012 by 6%, and ratified it in 2002. At that time, the activities aimed at protecting the climate corresponded to the activities aimed at protecting the environment. As a result, throughout the 1990s, despite the growing social problems caused by the economic crisis induced by the transition from a centrally planned economy to the free market and the collapse of many large state-owned enterprises, politicians did not deny the need to undertake actions to reduce greenhouse gas emissions (Karaczun et al., 2020). Nevertheless, in view of the urgency and importance of many problems caused by the transformation (e.g., inflation, drop in production volume, high unemployment, reduced profitability of agricultural production), decarbonisation was not treated as a priority.

In 2003 Polish Government adopted the Climate Policy (Ministry of the Environment, 2003). The document set a target of reducing greenhouse gas emissions by 40% by 2020 compared to 1988. This goal was higher than that presented by the EU at the time. However, it soon turned out that there needed to be a political will to achieve this goal.

On the other hand, Poland is seen as one of the leading opponents of European climate policy (Ancygier, 2013; Karaczun, 2018; Skjærseth, 2018). Kryk (2019) points out that Poland is decarbonising its economy slower than the EU average and warns that the situation may not improve, as it is predicted that fossil fuels will dominate the energy market even until 2050. Therefore, accomplishing the EU energy policy goals by Poland will require faster decarbonisation of the economy. However, in the opinion of Skoczkowski et al. (2018), there is no political will for such actions. This approach of the Polish government may be due to two following reasons:

- different approaches of Poland and the EU to climate policy,
- the conflict over adopting the third EU Energy and Climate Package (2013–2020).

The Polish government did not deny the need to reduce greenhouse gas emissions, as shown by its high activity during the international UN Climate Convention negotiations. However, it opposed the approach adopted by the European Union, which recognised decarbonisation as the primary goal of climate policy. The fast pace of energy transformation was also difficult for the Polish government to accept. It was due to the continuing dominant role of coal (both hard and lignite) in energy production. This resulted from the autarky policy pursued until 1989 and the belief that only basing energy production on own resources would ensure energy security. In the following

DOI: 10.34659/eis.2022.83.4.482

years, the second reason has become even more critical due to the increasing dependence of many EU countries on natural gas imports from Russia.

In 2007 as a part of the work on the EU Energy and Climate Package 2013–2020, the European Commission proposed a radical change in the system of emission allowances allocation. Until this date, Poland's power sector was not heavily troubled by the EU ETS because power installations received all the emission allowances (EUA) needed for free. The Commission proposed to replace the allocation based on historical emissions with a mix of auctioning and output-based allocation. It suggested that the distribution through auctions would cover 40% of the EUA in 2013, 70% by the end of 2020 and 100% by 2027 (Skoczkowski & Wronka, 2017). Although the negotiations on this solution lasted throughout 2007, they were disregarded by the Polish administration. It was not until the beginning of 2008 that the report was published at the request of the Polish Electricity Association (EnergSys, 2008). The report indicated how much the proposed solutions might affect the market and energy prices in Poland. It had a significant impact on the reception of climate policy in Poland and the belief of most politicians that European climate policy does not take into account the interest of Poland. This was reflected in the negative attitude towards climate policy expressed by the Polish decision-makers in the following years (Karaczun et al., 2020).

The main aim of the article is to determine whether the Europeanization of climate policy was taking place in Poland when it comes to the impact of EU patterns on the programs of parliamentary political parties. The authors defined the Europeanization process following the Ladrech (1994) concept as an "*Incremental process re-orienting the direction and shape of politics to the degree that EC political and economic dynamics become part of the organisational logic of national policy-making*". This definition was further developed by Radaelli (2003) who pointed out that it is also a diffusion process of public policies, shared values and norms into public discourse and political structures. It is both direct, primarily to the national political circles in which the parties of the member states operate, and indirect (Mair, 2007). Ladrech (2002) also distinguished areas in which a potential impact may take place. We decided to analyse one of them, i.e., "policy / programmatic content," about the single policy area (climate policy). It results from the assumption that the abovementioned issue was not present on Poland's party agenda before the EU's accession. It is the sphere of policy in Poland, which should be considered driven (directly and indirectly) by the EU institutions, decisions and expectations.

DOI: 10.34659/eis.2022.83.4.482

Research methods

The paper analyses the evolution of parliamentary political parties' views on climate policy in subsequent parliamentary elections starting with Poland's accession to the European Union in 2004 and ending with the parliamentary elections in 2019. The decision to assess the standpoints of the selected Polish political parties based on the analysis of their elections programs was made following the assumption that they are developed by the parties' key authorities, constituting the most tangible form of presenting views and announcing actions on the issues mentioned above.

The research consisted of two stages. The first was a content analysis of 26 parliamentary parties' election programs from 2005-2019. This phase provided empirical data for conducting Social Network Analysis (SNA – the second stage of the study). The social network perspective focuses primarily on links between individuals (in this case, between the parties positions and indirectly between the parties themselves), providing an opportunity to analyse and graphically present the structure of relations extracted on this basis (Batorski & Zdziarski, 2009). SNA enabled the development of a map of linkages between political groups that share the same views on climate issues (configurations of parties)—sharing the same ideas among parliamentary parties allows us to pursue a coherent policy towards the EU. This type of research is helpful because it makes it possible to present how the structure of the climatic concepts of Polish parties has changed in recent years.

The categorisation key takes into account the coding schemes created by The Comparative Manifestos Project (CMP) and The Comparative Agendas Project (CAP). Both of them identify parties' attitudes towards environmental issues. However, considering the Polish context, we decided to create a unique coding scheme. We use quasi-sentences as the unit of observation. After a pilot study of elections programs, we created fourteen main categories of statements included in the final qualitative content analysis – party attitude to: "further coal extraction," "replacement of coal stoves," "prosumer energy programs," "energy efficiency (and/or thermal modernisation)," "limiting carbon dioxide emissions," "development of renewable energy sources," "afforestation," "nuclear energy," "natural gas," "shale gas," "exclusion of coal as an energy source," and "UE Climate Package." Due to the fact that in the Polish public debate, the anthropocentric paradigm of climate change has been denied for years, we also decided to distinguish additional categories, i.e., "global warming (acceptance of the human influence theories)" and the "denial of anthropogenic climate change." The attitude to the above-mentioned issues was presented by political parties 109 times in the 26 programs covered by the analysis.

DOI: 10.34659/eis.2022.83.4.482

Social Network Analysis was conducted in UCINET with visualisation in NetDraw. The affiliation networks were created (between parties and statements – announced in their programs from each electoral year). Then, the so-called 2-mode networks (parties – statements) were simplified to 1-mode networks presenting linkages between parties in different electoral years. The expression of the same electoral demands by different parties in a given election year was considered a linkage between them. The network data is undirected and binary. This procedure paved the way for a statistical comparison between party networks regarding the agreement on climate issues before every election since 2005.

Results of the research

The linkage network (2-mode, reduced to “anti-transformational” statements) is presented in Figure 1.

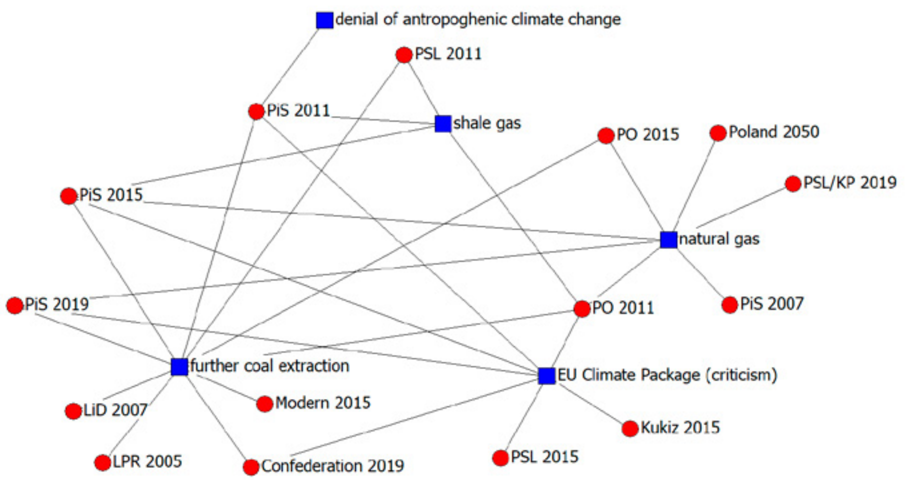

Figure 1. The linkage network (between parties and “anti-transformational statements”)

Among the group of “anti-transformational statements,” the highest value of the degree is attributed to the electoral demand to keep coal as an energy resource. The number of electoral requests regarding the issue of maintaining coal as a source of energy has changed over time. However, the idea of coal extraction was still supported in 2019 by the ruling party (PiS) and the right-wing Confederation. In addition, during the last elections campaign, both right-wing parties added to their manifestos the demand to mitigate (PiS) and terminate (Confederation) the EU Climate Package. The criticism of

DOI: 10.34659/eis.2022.83.4.482

the current obligations for Poland resulting from the package has been present in the PiS program since 2011 and was also present in the manifestos of the following parties: the PO (2011), the PSL (2015) and the Kukiz'15 (2015). Currently, among the issues that can be treated as having a negative impact on the climate, the demand to continue the combustion of natural gas is supported by three parties (PiS, Poland 2050, PSL/KP), while other political groups did not express their opinion on this subject before the last elections. In addition, during the analysed period, the parties abandoned the demand to use shale gas as a source of energy. Also, the current ruling party no longer denies the impact of human activity on climate change. As shown Table 1, every party with its representatives in the Polish parliament declared support for anti-climate issues at least once. However, the SLD made such statement only in 2007 (when it formed a part of the Left and Democrats). The above data indicate a gradual evolution of the party's positions towards the assumptions of the European climate policy. The number of supporters of coal-based energy has significantly decreased. Currently, no party officially denies the impact of human activity on climate change.

The cumulative network considering "pro-transformational and anti-transformational" issues (statements – parties network) is presented in Table 1. In the cells of the table, the presence of X denotes the existence of an issue in the individual program. The presented data allows tracking changes in the same groups' programs over time.

Data presented in Table 1 showed that over the years, the parties have most often demanded support for the following: "development of renewable energy sources" (18 times), "afforestation" (13 times), "energy efficiency (and/or thermal modernisation)" (12 times). Other pro-climate issues were mentioned fewer than 10 times. The parties` support for the first three listed issues can be described as increasing over time and already appearing in the programs of 2005 and 2007. However, until elections in 2011, parties` election programs were not sated with climate policy content. The first broader reference to the assumptions of the EU strategy can be described as rather restrained – the parties defended the system of energy production based on the combustion of fossil fuels, and the first clear change took place only before the 2019 elections.

DOI: 10.34659/eis.2022.83.4.482

Table 1. Issues raised in the parliamentary parties' election programs in 2005-2019

Party	Development of renewable energy sources	Nuclear energy	Energy efficiency	Afforestation	Exclusion of coal	Global warming (acceptance of the human influence theories)	Limiting carbon dioxide emissions	Prosumer energy programs	Replacement of coal stoves	Shale gas	UE Climate Package – criticism (willingness to mitigate)	Natural gas	Denial of anthropogenic climate change	Further coal extraction
PiS 2005														
PiS 2007												X		
PiS 2011	X	X		X						X	X		X	X
PiS 2015	X			X						X	X	X		X
PiS 2019	X	X	X	X		X	X	X	X		X	X		X
PO 2005														
PO 2007	X													
PO 2011	X	X	X	X			X			X	X	X		X
PO 2015		X		X				X	X			X		X
KO 2019	X		X	X	X	X	X	X	X					
PSL 2005	X		X	X										
PSL 2007	X			X										
PSL 2011	X						X			X				X
PSL 2015	X										X			
PSL/KP 2019	X		X			X	X	X	X			X		
SLD 2005														
LiD 2007	X		X	X		X	X							X
SLD 2011	X		X	X		X								
Self-Defence 2005	X		X											
LPR 2005	X		X											X
Left 2019	X		X	X	X	X	X	X	X					
Palikot`s Movement 2011														
Kukiz 2015											X			
Modern 2015	X		X	X				X	X					X
Confederation 2019		X									X			X
Poland2050 2019	X		X	X	X	X	X	X	X			X		

DOI: 10.34659/eis.2022.83.4.482

To compare party links with "pro-climate demands," five 1-mode networks were created. The detailed data for every electoral year are presented in Table 2.

Table 2. Parties' linkage network

Network (parties)	# of nodes	# of not valued ties	Avg. degree	Density	Components	Fragmentation
2005	6	6	1	0.2	4	0.8
2007	4	6	1.500	0.5	2	0.5
2011	5	12	2.400	0.6	2	0.4
2015	5	10	1.167	0.5	2	0.4
2019	6	22	3.667	0.7333	1	0

Table 2 indicates a high polarisation of the parties' positions on pro-climatic issues in recent years. During the 2005 elections campaign, parliamentary parties did not present a climate policy that can be considered coherent, which is proven by a small number of shared issues, a high degree of network fragmentation, and the presence of multiple components. Before the last elections, the number of shared issues, the average degree, and the density of the network were more than three times higher, while the number of parliamentary parties was the same as in 2005. Since the ideological composition of the Polish parliament was similar to the one in 2005, the main transition can be observed in the centrist and right-wing party attitude. The 2019 network has only one component, which means that each parliamentary party shares at least one pro-climate statement.

Discussion

The analysis has revealed that direct references to climate issues appeared in electoral programs for the first time in 2011. The main parliamentary parties, i.e. the Law and Justice (the right-wing) and the Civic Platform (centre-right), criticised the EU climate policy, including the solutions implemented under the EU energy and climate package. On the other hand, the left-wing political groups, although they maintained their opinion on the impact of man on climate change, did not declare support for activities aimed at climate protection at the time.

The first clear shift in the attitude of the Polish parliamentary parties took place in 2015 and was visible mainly among the opposition, left-wing, and centrist political groups. However, the views of individual parties on climate issues at that time were still not fundamentally different.

DOI: 10.34659/eis.2022.83.4.482

A significant change occurred during the last election campaign in 2019. Not only were there parties that supported the need to implement active measures to protect the climate, but there was also a clear polarisation of positions in this regard. The right-wing parties (both the ruling Law and Justice and Confederation) pointed to the need to tone down the European climate policy. At the same time, the Confederation announced that it would take steps to abandon Poland's obligations imposed by the EU's energy and climate package. On the other hand, the left-wing and centre-right parties have declared their readiness to support climate protection and resign from fossil fuels.

The strategies adopted by Polish political parties were pragmatic. Before joining the EU and in the first years of Poland's membership (2004-2007), climate issues were not discussed in public, and they were absent from the political debate.

At the negotiation table, Poland stipulated several conditions be met for the Polish government to adopt the Package, including a transitional period for the energy sector in the new member states. During the period, some allowances were to be free (the mechanism for selling 100% of allowances was to be introduced in 2020) and the creation of a solidarity mechanism under which richer EU countries were to transfer a part of their revenues from the sale of emission allowances to poorer member states. The EU accepted most of the conditions, adapting the package architecture. In the following years, the European Commission made attempts the introduction more ambitious climate goals trying to take into account the situation of the "new" EU member states. This seems to be confirmed by the observation of Börzel (2003), which indicates that the Europeanization process is of a two-way nature and also means a change in the way the EU institutions operate under the influence of the Member States.

After the 2015 elections, a coalition of right-wing parties with an ambivalent approach to Poland's membership in the EU came to power. The changes introduced in the judiciary system led to a conflict with the European Commission and raised concerns about Poland's future in the EU. In the face of those mentioned above, the opposition parties started to change their approach to climate policy. They pointed out the negative impact of the government decisions affecting the country's importance in the European debate. By doing so, they could no longer criticise the need to protect the climate, which the EU considers an environmental, social and economic priority. The shift in the position was also facilitated by the fact that potential voters of the opposition parties recruit from groups open to environmental ideas (Cybulska, 2020).

Politicians also could not ignore the growing awareness of climate change in Polish society, which is evident in survey results. As indicated by Głowacki

DOI: 10.34659/eis.2022.83.4.482

(2018), since 2009, the number of people declaring that climate change is one of the greatest threats to modern civilisation has increased from 15% in 2009 to 26% in 2021. In 2016, only 45% of respondents were, to a considerable extent, concerned about the state of the environment in Poland. Over the next two years, there was a jump of more than 23 percentage points. The highest level of concern was found among people living in the largest cities (69% of responses), and the lowest – was in rural areas (20%) (Głowacki, 2018). Certainly, this impacted the election programs of parties referring to the city electorate – KO and Poland 2050.

Conclusions

The analysis results indicate that in Poland, there has been a process that could be described as a "pragmatic, delayed Europeanization" of the Polish climate policy. Within its framework, the following three main phases have been identified.

The first phase was between 2007 and 2011 when the parliamentary political parties referred to pro-climate issues more frequently than in 2005. In this context, it needs to be mentioned that the 2011 election campaign stood out because the parties present in the Sejm directly quoted on the EU Climate Package for the first time. It should also be noted that the views presented by them negated the assumptions included in the Package. Most likely, it resulted from the conflict between Poland over the European Commission on allocating emission allowances (EUA) after 2012. The unanimous, negative attitude of Polish parliamentary parties to the solutions proposed by the EU presented in their election programs in 2011 probably contributed to the fact that in the following years, the Polish government vetoed three times the European Commission's proposals to tighten the climate policy (Karaczun et al., 2020).

The second phase, the year 2015, was when the main party of the 2007-2015 government coalition departed from its criticism of the Package, and the PiS, which was coming into power, did not renew the previously expressed opinion that denied the impact of human activity on the climate. The pragmatic nature of the Europeanization process is evidenced by the fact that despite the opposing view on the European climate policy expressed in its election program, PIS, which won the 2015 elections, did not pursue an anti-climate policy in the EU arena. In the following years, Poland supported tightening the European climate target from a 40% reduction to 55% and did not veto the EU climate neutrality target in 2050. Poland has also not become an outsider of European climate policy, although it was certainly not one of its leaders (Karmowska, 2019).

DOI: 10.34659/eis.2022.83.4.482

The third phase (2019) was when two right-wing parties expressed a negative attitude to the EU Package. Still, at the same time, for the first time, the electoral programs of three parliamentary parties included the electoral to exclude coal as an energy resource. The distinctiveness of the third phase from the previous two is best reflected in the indicators of the network created based on the co-existence of pro-climate content in the election programs of parliamentary parties (presented in Table 2), including, among other things, an over 2.5-fold increase in the number of connections between the parties. Therefore, it can be expected that Poland will be less and less opposed to developing the EU climate policy in the following years. It is also because the political polarisation in this area, which took place after 2015, indicates that creating a broad, anti-climate coalition of Polish political parties seems impossible. Nevertheless, Poland's probability of pursuing a more pro-climate policy is also tiny.

The contribution of the authors

Piotr Swacha – 40% (conception, literature review, acquisition of data, analysis and interpretation of data).

Zbigniew M. Karaczun – 40% (conception, literature review, analysis and interpretation of data).

Daria Murawska – 20% (analysis and interpretation of data).

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MUNICIPAL WASTE MANAGEMENT AS A POLYCENTRIC SYSTEM – THE EXAMPLE OF POLAND

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ABSTRACT: In developed countries, the main burden of waste management rests on the organised (formalised) and massive municipal waste management system. The functioning of these systems is regulated by legislation at the local, national, and international levels. At the same time, some waste fractions are entirely or partially excluded from this system (e.g. bulky waste, second-hand clothing, food, green waste, or metals). As in developing countries, they are partially managed through informal undertakings, the organisation of which, including the mode of operation, scale, or spatial coverage, are diversified. The formal system is organised hierarchically and strictly regulated by law. On the other hand, informal activities are governed by terms and conditions or sets of everyday rules. Thus, municipal waste management in developed countries forms a complex mosaic of activities, organisations and institutions that contribute to reducing waste and its nuisance.
The paper aims to determine whether waste management systems in developed countries have the characteristics facilitating the achievement of the benefits resulting from a polycentric management system. The analysis was conducted using the Polish waste management system as an example. For this purpose, a Theoretical Model for the Commons (Carlisle & Gruby, 2019) was used.

KEYWORDS: municipal waste, common good, polycentrism

Introduction

The municipal waste system can be considered to be a common good system, having in mind two aspects of the notion, i.e. (1) classic common pool resource (CPR) and (2) a system in which the common pool resource is the environment, and any actions aimed at reducing the amount of waste or its nuisance are resources conservation actions that protect the resource (Ciechelska, 2021). Waste as CPR has been discussed many a time with regard to developing countries, including Brazil, India, China, or Egypt (Bose & Blore, 1993; Cavé, n.d.; Chaturvedi & Gidwani, 2011; Chen et al., 2018; Pires Negrão, 2014). In contrast, the system of municipal waste as common good in developed countries has been little studied. Unlike in developing countries, efforts are being made in developed countries to get all generated municipal waste covered by a system, which is supposed to ensure safety and efficiency as well as a steady, relatively homogeneous waste stream from which raw materials can be extracted and the waste residue neutralised through technology. In the literature, the formal system is very well described, although not in the context of common good (except for the sharing of facilities). In the common good model, they become frequent and diverse players, undertaking various actions in relation to the common good resources. This group includes not only businesses (including plant owners) and households, but also public sector organisations. In different countries, and even in different regions within one country, these players are organised differently; they are subject to different sanctions and laws, different monitoring obligations, as well as rules and tools for enforcing the established laws. Furthermore, the governance of the system (under the common good model) becomes more complicated as there are parallel centres of power at the international (e.g. EU), bilateral (e.g. waste export/import conditions), national, and local levels, which turn out to be both the originators and background of the players' actions. Similarly, the effects of resources conservation activities can be observed from different perspectives, i.e. taking into account international, local, and individual responsibilities.

The system is regulated at the national and international levels (e.g. at the level of the EU), but its organisation and related regulations are established locally. A similar approach can be observed in many developed countries, although the instruments and the way of cooperating with local residents differ. The system is quite expensive as it requires expenditures on high-tech installations. In addition, several organisations administering the system are also involved. However, apart from the formal system, waste owners (residents) take up different efforts to reduce waste or minimise its nuisance, i.e. resource conservation actions. These activities involve different

DOI: 10.34659/eis.2022.83.4.541

waste fractions, vary in scope and scale, and vary in their degree of formalisation. Whether the waste finds its way into the system, is managed otherwise, or is directed to the environment depends on the individual decisions of individual waste generators (households). Therefore, international and global waste problems result from the aggregation of individual actions and decisions. While making a global agreement, which would cover all these individual situations, takes time and a great deal of work, the construction of fair and effective global instruments seems unlikely anytime soon (Ostrom, 2012). That is why particular countries or groups of countries, such as the European Union, implement their policies in this regard, which they then operationalise at the local level. Various measures are also taken to reduce the amount of waste or its nuisance by waste generators themselves. Thus, by reducing the amount or nuisance of waste, the entities benefit on different scales, ranging from the individual to the global (Ostrom, 2012). Therefore, concerning municipal waste management, we can speak of a polycentric system.

Polycentrism

Polycentrism is a concept widely discussed and studied in the works of Vincent and Elinor Ostrom. It denotes a complex form of government with multiple decision-making centres with a certain degree of autonomy (Aligica et al., 2012). It is a common phenomenon, especially concerning the environmental resources management system. Decision-making centres in a polycentric system may operate at different levels, such as local, national, international, or transnational, being simultaneous, subject to legislation at these different levels, sometimes at several in parallel (the phenomenon of overlapping centres (E. Ostrom, 2010b; Paavola, 2016). At the same time, they must exhibit some level of coordination in their activities by considering one another in terms of competitiveness, conflict resolution, or cooperation (V. Ostrom et al., 1961). Polycentric systems function as a governance alternative to centralisation, decentralisation, and community-based governance. Polycentric systems are neither worse nor better than them (V. Ostrom et al., 1961).

Ostrom's works examine polycentrism, considering the metropolitan area governance, characterised by a multiplicity of overlapping decision-making units. Suppose such an organisation operates based on the market economy. In that case, such a system of governance can produce comparably greater efficiency in the production and delivery of public goods and services than if the government was responsible for it, e.g. responsiveness. At the same time, decision-making centres can act coherently and predictably as they consider one another in their decision-making processes (V. Ostrom et al., 1961). Therefore, polycentric systems can provide the following benefits:

DOI: 10.34659/eis.2022.83.4.541

- increased efficiency,
- fewer susceptibility errors generated by the whole system,
- mutual learning,
- taking into account human limitations of information processing,
- consideration of the scale diversity,
- consideration of the existence of multiple objectives in resources management,
- recognition of the diversity of human interests and values associated with most complex natural resource systems (Folke, 2007; Heikkila et al., 2018; McGinnis & Walker, 2010; E. Ostrom, 2010b).

Polycentrism in the management of the common good can, furthermore, provide better access to local knowledge, better contextualisation of policies, reduced risk that a resource will cease to function across the region due to multiple opportunities for policy experimentation, better information transfer through overlap, and increased capacity for adaptive management (Heikkila et al., 2018). However, it is impossible to point to ideal examples of polycentric systems or a set of characteristics that determine such a system. All systems are more or less polycentric (Tiffen & Mortimore, 1994).

Research method

The theoretical model of a polycentric resources management system used for the analysis makes it possible to show the benefits of using such a system if it exhibits specific characteristics. These relationships were initially studied by Ostrom (McGinnis & Ostrom, 2014; E. Ostrom, 2006; V. Ostrom et al., 1961), and the model was later extended and modified by Gruby (Carlisle & Gruby, 2019). Ostrom identifies three features of the system that determine the occurrence of certain benefits. Gruby reduces them to two but still distinguishes supporting conditions that increase the likelihood of occurrence of a given benefit. This model does not fully explain the success of a given resource system as it prevents the multiplicity and interplay of factors that can contribute to such a success. It focuses only on the institutional features of the system. In the model, institutions are understood broadly, i.e. as formal and informal, including organisations, rules, standards, and strategies that structure human interactions (McGinnis & Ostrom, 2014). The model distinguishes the following benefits:

- increased adaptability of the system to social and environmental changes,
- possibility of good institutional fit for resources conservation in complex natural systems,
- reduced institutional failures and resource losses due to the redundancy of players and variability or redundancy of management institutions (Marshall, 2009; Van Kamp et al., 2003).

DOI: 10.34659/eis.2022.83.4.541

On the other hand, the following features and conditions were distinguished as conducive to the occurrence of the benefits mentioned above in polycentric natural resources systems:

1. Overlapping decision-making centres – favourable conditions include that decision-making centres are organisationally distinct; they operate at different levels and in different jurisdictions, and the scope of their authority and jurisdiction overlaps with the boundaries of the environmental problem.
2. Decision-making centres include others in their actions through cooperation, competition, conflict and conflict resolution mechanisms. Supportive conditions comprise the fact that the rules and standards structure the actions taken in the system. Decision-making centres are interconnected; they participate in mediation and learning processes and apply accountability mechanisms for decisions and conflict resolution mechanisms (Carlisle & Gruby, 2019). The relationship between the characteristics of a shared resources system and the benefits of this type of management is shown in Figure 1.

The institutions in a polycentric system can be divided into decision-making centres and supporting institutions. According to the SES Ostrom model, they are Collective Players. Decision-making centres are only those entities that independently create sets of standards and rules in a given area (McGinnis, 2011). They are most often identified with government bodies at various levels and self-organising communities of the resources users; however, they can also be formal and informal institutions with different ownership and organisational structures, which exert strong influence on policy or provide important technical and/or financial support, but do not formally exercise authority. Supporting institutions, on the other hand, make their competencies (e.g. scientific and practical knowledge, organisational, technical or social skills) available to decision-making centres, increasing the effectiveness of the system. Cooperation between decision-making and supporting centres can be permanent or periodic; they can merge or cooperate in different ways.

The diversity of institutions present in the system (with regard to geography, different scales of operation, different organisational forms, subject to different jurisdictions, standards, and rules) facilitates better and faster adaptation to changes than in centralised systems (Folke et al., 2005; Oakerson & Parks, 2011). This is particularly important in natural resources systems, where changes are often rapid and non-linear (A. Poteete, 2012; Sovacool et al., 2017). The diversity of institutions makes them more durable as they better take into account the characteristics of the particular natural resources system they deal with (Folke et al., 2007). In such systems, players do not pursue a single and consistent policy, but take advantage of the diver-

DOI: 10.34659/eis.2022.83.4.541

Attribute	Enabling Condition	Advantage		
		Enhanced Adaptive Capacity	Good Institutional Fit	Risk Mitigation/ Redundancy
Multiple,overlapping decision-making centers with some degree of autonomy		X	X	X
	Decision-making centers employ diverse institutions	X	X	X
	Decision-making centers existat different levels and across political jurisdictions		X	X
	The jurisdiction or scope of authority of decision-making centers is coterminous with the boundaries of the problem being addressed		X	
Choosing to act in ways that take account of others through processes of cooperation, competition,conflict, and conflict resolution		X	X	
	Generally applicable rules and norms structure actions and behaviors within the system	X		
	Decision-making centers participate in cross-scale linkages or other mechanisms for deliberation and learning	X	X	
	Mechanisms for accountability exist within the governance system	X		
	A variety of formal and informal mechanisms for conflict resolution exist within the system	X		

Figure 1. Theoretical Model of a Functional Polycentric Governance System for the Commons
Source: Carlisle & Gruby, 2019.

sity of principles and standards that guide institutions, choosing those that are most effective. Alternatively, however, there is no optimal set of standards and rules to guarantee success, so each institution is more or less effective (E. Ostrom, 1999). Institutional fit can consist of adapting institutions to the temporal, spatial and functional characteristics of the ecosystem or adapting to the social system – to the value system, beliefs, or psychological needs of a given social group (Folke et al., 2005). For the effective operation of a polycentric system, it is not the number of institutions in the system that is important, but the existence of multiple opportunities that the players take advantage of when taking actions to preserve the resource. Hence, frequent overlapping of institutions is possible, as well as:

DOI: 10.34659/eis.2022.83.4.541

- better flow and access to information, including about the activities that ensure the success of the system (Marshall, 2009) and learning, as a result,
- considerable autonomy of institutions (actual rather than formal (Marshall, 2015)) and lack of central coordination of their activities (E. Ostrom, 2010b).

At the same time, independent decision-making centres can cooperate, compete, be in conflict or resolve it (E. Ostrom, 1999). Cooperation allows for greater capacity to act or outsource some tasks to more competent entities. In turn, the close spatial proximity of decision-making centres promotes competition, which contributes to the exchange of information. However, intense competition can reduce cooperation (A. R. Poteete & Ostrom, 2004); hence the need of developing effective conflict resolution and accountability mechanisms for decision-makers.

Polycentric waste management system in Poland

The Polish system of municipal waste management is similar to systems operating in developed countries. It can be regarded as a system of the common good, where the resource is the environment, and all activities aimed at reducing nuisance and minimising waste are activities that conserve the resource. In this context, a formal system and informal activities can be distinguished in the waste management system (Ciechelska, 2021). The formal system is based on municipal waste management systems. Their formalisation is intended to ensure the efficiency of these systems by ensuring the continuity of relatively homogeneous waste streams for treatment facilities. To this end, municipalities (or their associations) organise a method for collecting waste from waste generators, divided into mixed waste and individual fractions destined for recovery and recycling. The waste is then sent to processing plants, where individual fractions are separated from both mixed waste and selectively collected waste. These fractions are then covered by the recycling (material or energy) or management processes. Only residual waste goes to landfills.

The rules for the organisation of these systems by municipalities derive from national regulations, and these, in turn are subordinated to the EU regulations and the goals of a closed-loop economy (Ciechelska, 2017). However, municipalities and their associations have a certain autonomy in establishing rules and principles that constitute local laws (Agovino et al., 2021). They adapt them to local conditions (e.g. frequency of waste collection), to principles and values adhered to by local residents (e.g. labelling of bags with improperly sorted waste), and to adopted methods of communication (e.g. an official delivers information personally to homes). In setting local regula-

DOI: 10.34659/eis.2022.83.4.541

tions, municipalities may consult with residents and sometimes with waste collection and processing contractors selected by tender.

Municipalities can cooperate with other neighbouring or distant municipalities, similar or with different characteristics (e.g. urban and rural, but located in the mountains) in the collaborative organisation, management, or operation of the waste management system. In addition, they can use the expertise of advisory centres (including experts, universities, or industry associations). Several players are involved in the operation of formal systems, i.e.:

- transport companies and plant owners,
- operators-companies involved in the operation of treatment facilities,
- operators and companies involved in the process of waste treatment and disposal facilities, companies involved in the management of the system (including monitoring, sanctions, etc.),
- authorities with its agencies operating at the local, national or EU level, sometimes acting based on multilateral agreements, thus increasing their reach,
- institutions that organise and are responsible for the efficiency of the system, i.e. a local authority with separate organisational units or business entities established for this purpose,
- contractors – companies engaged in waste collection and transport, waste trade (including for recycling), recycling, and waste recovery (Munguía-López et al., 2020),
- recovery organisations – monitoring and "certification" of proper waste handling,
- waste owners and generators, i.e. households, housing cooperatives, or housing communities,
- research centres and constructors of installations, for example,
- industry associations (e.g. city associations, directors' associations, etc.).

In parallel with the formal system, a number of informal activities are being developed, undertaken by residents – waste generators, such as:

- zero waste movements, promoting and implementing activities that reduce waste generation,
- the backyard and community composters for the bio and food fractions used by local livestock farmers, community refrigerators, online platforms for selling food with short shelf life (stores and restaurants are the bidders), or charitable organisations (Lazell, 2016),
- online exchange and sales platforms for bulky waste and electrical and electronic equipment, "Garbage truck is on its way" information platforms; inter-neighbourhood and family exchanges; inter-neighbourhood displays of second-hand goods, roadshows and flea markets, charities, Repair Café",

- for the second-hand clothing fraction – donation to clothing stores accepting second-hand clothing, circular boutiques, inter-household exchanges with varying degrees of familiarity, online platforms and stationary places for buying and exchanging second-hand clothing, charity stores, charitable organisations, campaign collections, such as the Noble Gift project (Degenstein et al., 2021),
- metals and paper fractions – appropriated by local collectors for resale to return and buy-back centres (now less and less popular due to increasingly difficult access to the waste and decreasing profitability) (Porras Bulla et al., 2021; Rendon et al., 2021).

Within those mentioned formal and informal resources conservation activities, decision-making centres can include:

- centres of power, with agencies at the EU, national, and local levels,
- system operators setting the rules for the system (how to organise the waste treatment system in the region and how to use available facilities),
- waste generators, i.e. households and housing cooperatives and communities,
- enterprises intermediating in the trade of second-hand goods (online platforms),
- charity and aid organisations,
- informal social groups (e.g. Repair Café or a Facebook group "Garbage truck is on its way") as well as family and friend groups participating in the second-hand goods trade,
- art collectives and individual artists,
- farms using their own and collected food and bio waste from other generators.

They are assisted by consulting and research centres, such as universities and experts, local governments, and various professional forums, associations, and NGOs.

Informal resource conservation activities can be permanent or action-based. Participating players may act individually or cooperate in groups with varying degrees of involvement and frequency. The players (individual and collective) form a very diverse mosaic of different institutions in terms of organisation (Pieroni et al., 2020), ownership, and the ways the activities are carried out.

Conclusions

The multiplicity of diverse decision-making and advisory centres makes it possible to classify the municipal waste management system as a polycentric system. In addition, the hierarchical nature of the organisation and regulations (especially the formal system) indicates that it is a well-anchored

DOI: 10.34659/eis.2022.83.4.541

system (Ostrom). Decision-making centres vary in their form of organisation; they include enterprises, public entities, social groups, NGOs, and even households. Some were established by law (e.g. regional waste treatment facilities), other were created as a result of the existing law and system (second-hand stores), and still, others are the result of community initiatives (e.g. Repair Café). Formal and informal activities are carried out at different spatial scales and jurisdictions, for example:

- Participation of households, municipalities and their associations in the formal system – spatial scope: local; the scale of operation: local.
- Waste treatment, recycling, recovery and marketing companies – spatial scope: regional to international; the scale of operation: local to global.
- Power centres – spatial scope: local to international; the scale of operation: local to global.
- Second-hand goods brokering companies (Vinted, Allegro) – spatial scope: local to international; the scale of operation: local to global.
- Households exchanging things with family, neighbours and friends (in different ways), e.g. inter-neighbourhood displays of second-hand goods, roadshows and flea markets, or Repair Cafés – spatial scope: local; the scale of operation: local.
- Charities, upcycling and recycling businesses – spatial scope: local to international; the scale of operation: local to international.
- Local farms – spatial scope: local; the scale of operation: local.

The development of technology has enabled wide and widespread access to various types of waste of varying value (e.g. designer clothing), which were produced at a considerable distance from the place of their appropriation. Thus, the scale of waste trading and the carbon footprint associated with its transport has increased significantly, including internationally (e.g. Vinted). Technology has also contributed significantly to the development of information-sharing and learning processes. These processes have traditionally been part of the formal system and have been implemented through various information exchange fora, such as conferences, consultations, bilateral and international cooperation, and industry associations. An example can be the regular conferences organised for the entire waste industry by Abrys, a publisher of trade journals, with speakers representing various decision-making and consulting centres. Another indicator is the opportunity to participate in public consultations in changing legislation, which is one of the ways to mediate and develop a legal consensus. Participants in informal activities, thanks to the opportunity to exchange experiences and opinions (through influencers, for example) and to learn, as well as thanks to social media, could leverage their scale of activity. They form various types of social groups, where they exchange information (e.g. The garbage truck is on its way) and promote various ideas that favour resources conservation activities, e.g. zero

DOI: 10.34659/eis.2022.83.4.541

waste; still, however, they can express their opinions with regard to the formal system, its players and ways of conducting resources conservation activities, e.g. through the possibility of online, anonymous submission of comments and requests to the municipality.

Different types of resource conservation activities are subject to formal and informal regulations, which often include accountability mechanisms for decision-makers and conflict resolution mechanisms. Relatively thoroughly and transparently, these issues are resolved in the formal system. Every institution operating in this system, regardless of the level at which it operates, is subject to regulations. Regulations describe the type and manner of its activities; hence, the ability of the formal system to adapt to a changing situation is limited. In addition, legal regulations are well-anchored, but they are tailored to the national scale. They regulate the principles of operation of specific institutions, e.g. legal regulations on the operation of municipalities in the organisation of the waste management system cover only the national and local level. However, they are subordinated to the overarching objective of the EU policies and the circular economy goals.

Meanwhile, municipalities, and cross-border municipalities, in particular, point out that, in their case, it could be reasonable to create a cross-border waste system. They may undertake bilateral cooperation in this regard, but no provisions reflect the cross-border nature of the problem. The situation is also similar concerning informal activities. Individual modes of operation are regulated by various types of regulations (e.g. the neighbourhood exchanges regulations or the Allegro regulations). However, they do not address the problems of the worsening waste situation resulting from their development. Formal laws do not regulate this issue, either. As a result, waste can quite freely transgress national borders through informal activities and increase the spatial scope of negative impacts. Correspondingly, the literature confirms that most often, there is a lack of adequate regulations of the operation of decision-making centres regarding cross-border areas (E. Ostrom, 2010a).

Liability control mechanisms in the formal system have a hierarchical arrangement and result from legally imposed obligations subordinated – on the one hand –to the establishment and operation of effective municipal waste management systems and – on the other hand – the achievement of circular economy goals in the form of appropriate recycling rate levels. They are tailored to the specifics of individual decision-making centres. Furthermore, these regulations include specific monitoring rules and sanctions for failure to meet obligations. Despite these regulations, numerous pathologies are observed in this area, such as fires of stored waste, import of waste from Western European countries, or illegal landfills. Accountability mechanisms fail regarding plant operators and power centres, and households, as numer-

Attribute	Enabling Condition	Advantage		
		Enhanced Adaptive Capacity	Good Institutional Fit	Risk Mitigation/ Redundancy
Multiple,overlapping decision-making centers with some degree of autonomy		×	×	×
	Decision-making centers employ diverse institutions	×	×	×
	Decision-making centers existat different levels and across political jurisdictions		×	×
	The jurisdiction or scope of authority of decision-making centers is coterminous with the boundaries of the problem being addressed		-	
Choosing to act in ways that take account of others through processes of cooperation, competition,conflict, and conflict resolution		×	×	
	Generally applicable rules and norms structure actions and behaviors within the system	×		
	Decision-making centers participate in cross-scale linkages or other mechanisms for deliberation and learning	×	×	
	Mechanisms for accountability exist within the governance system	_		
	A variety of formal and informal mechanisms for conflict resolution exist within the system	×		

Figure 2. Model of a Functional Polycentric Governance System for the Commons in Poland

ous cases of abandonment of municipal waste in public places, such as forests, are observed. This is illustrated in Figure 2.

As a result of existing regulations at the EU level, waste management systems in developed countries are pretty similar to the Polish system. There are numerous and diverse decision-making centres operating at different levels, on different scales, and within different jurisdictions. However, as in Poland, the scope of institutions does not always coincide with the scope of the existing regulations, especially in a cross-border context. Hence, it can be concluded that municipal waste management systems in developed countries, operating as polycentric systems, show increased adaptability and lower environmental risk. In contrast, the good institutional fit is limited due to the partial matching of the scope of authority of decision-making centres with the scope of the problem.

Indeed, decision-making centres in Poland and developed countries consider other centres when making decisions within the formal and informal systems. Examples include information-sharing platforms, experience-sharing fora, social media, or speeches delivered by influencers. Decision-making centres are reciprocal, although they may operate on different scales. Their operation may be regulated in various formal and informal ways, expressing slightly different rules and standards. Thus, Poland's and developed countries' municipal waste management systems shall demonstrate an excellent institutional fit and increased adaptability, limited by imperfect accountability mechanisms. With that said, different developed countries show differences in accountability, sanctions, and enforcement, so the level of benefits from the latter feature of the system may vary from country to country.

Acknowledgements

The project is financed by the Ministry of Science and Higher Education in Poland under the programme "Regional Initiative of Excellence" 2019 -2022 project number 015/RID/2018/19 total funding amount 10721 040,00 PLN .

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Agnieszka Ciechelska – 70% (conception, literature review, analysis and conclusions).

Marta Kusterka-Jefmańska – 15% (e.g. literature review, conclusions).

Sabina Zaremba-Warnke – 15% (literature review, conclusions).

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MODELING OF WATER AGE CHANGES IN WATER DISTRIBUTION SYSTEMS IN TIME AND SPACE

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ABSTRACT: The paper presents a particularly important research variant in the process of modelling water distribution systems (WDS), which is the age of water. The age of the water in the pipes is a parameter that determines the freshness of the water. The main goal of the presented research was to analyse changes in water age by observing the basic parameters: pressure and water flow. As a result of the assumed simulations, potential places of secondary contamination were distinguished. The result of solving the situation was the introduction of all works aimed at eliminating and improving the negative changes by much more frequent monitoring of water in this area for physicochemical and bacteriological properties and regular flushing of pipelines. The research is carried out based on the mathematical model of the water supply network. The Epanet software is used as a research tool, which allows modelling changes in the age of water in the entire water distribution system over time. The basis of the conducted research became the time factor, which plays a particularly important role in the process of managing the water distribution system. Taking into account the time, it was observed how much water remains on a given section from the moment it flows from the inlet and is mixed with water already present throughout the network. A number of simulation options were analysed in terms of the operation of the water distribution system, where the key problem was water stagnation. It should be noted that stagnation of water is particularly dangerous in the case of WDS, the obtained results showed visible places on the tested model. Simulations lasting more than 8, 10 days showed a clear deterioration in its quality. The above studies are of particular importance from the point of view of managing the efficiency of the water supply network. The analysis of water in water supply systems, stagnating and thus ageing, shows that the efficiency of the system significantly decreases. The variability of conditions in the water distribution system also makes the performance of WDS, and especially of pumping units, variable.

KEYWORDS: mathematical model, water distribution system, bacteriological properties, water ages, fresh water flows

Introduction

Research on the operation of the water distribution system is primarily a thorough analysis of the operation of its individual elements, which requires constant discoveries and studies as the problem of its variability over time has not been fully resolved so far. Design, construction and operation are among the main elements of the technical process of waterworks. The latter element guarantees the standard of provided water supply services. The operation has an impact on the rational and effective management of devices, buildings, networks and water supply systems. Water supply systems are classified as critical infrastructure because, in normal, emergency and crisis situations, they play a key role in ensuring the safety of citizens.

The use of computer modelling in water companies is already a common standard. Implementation of the application allows for the organisation of the operating costs of water and sewage systems, increasing the efficiency of enterprise management and supporting the investment process. Having information about the operation of the water system is the basis for the proper functioning of the enterprise. Therefore, it seems advisable to use the hydraulic model of the water supply network as a tool supporting the operation process of the water supply system.

System modelling is based on the most reliable reconstruction of real working conditions, taking into account the variability of water consumption and its distribution. The introduction of more data allows for the rebuilding of the working conditions of the water supply network for random events, i.e. water abstraction for firefighting purposes, breakdowns, and their impact on other recipients of the water supply network (Ostfeld et al., 2011; Marchi, 2012). The hydraulic model of the water supply network gives excellent opportunities to make informed decisions regarding the modernisation, operation and expansion of the water supply system, but most of all, computer support is a guarantee of the smooth functioning of the model (Butler et al., 2016; Gora, 2011).

The scope of considerations carried out in order to obtain the most dynamic character of the work of WDS is modest, and the process of reaching the final results is too simplified. The work undertaken so far covers the vast majority of issues related to the assessment of the functioning at the stage of designing water distribution systems (WDS). As part of the research issues, the results of the analysis of statistical data on damage are presented (analysis of types and causes) and observed under steady-state conditions, and therefore limited to appropriately selected water uptake values (Sitzenfrei et al., 2011).

DOI: 10.34659/eis.2022.83.4.498

Research methods

Water supply for the research area

Computer simulations were carried out using the Epanet software (Rossman, 2000), generally available in scientific and professional environments. Digital maps were used to map the network of pipes with exact diameters, lengths and ordinates. In the process of creating the model, the results of field tests were used, which enabled the adjustment of the values and their parameters to real conditions. Pressure measurements were the basic part of these tests. The obtained data allowed for the calibration of the models. The article pays particular attention to the variant concerning water age changes and conducts a simulation analysis to regulate the pressure and water flows.

Currently, the demand of the studied area for drinking water and other social, living and economic purposes is covered from three water intakes located in different parts of the analysed area. The study was conducted in an area with altitudes from 120 to 130 m above the sea.m level, located in north-eastern Poland, in the North Podlasie Lowland, above the Upper Narew Valley (Figure 1). The area is located in the buffer zone of the Narew National Park. Deep water intakes are located in:

- water supply station No. 1 (production 525 m^3/d, pressure 3,8 bar),
- water supply station No. 2 (production 173 m^3/d, pressure 3,8 bar),
- water supply station No. 3 (production 667 m^3/d, pressure 3,8 bar).

The total length of the cable network in the commune is 23 km. Population: 16,167.

Figure 1. The area of activity of the water distribution system
Source: ZWiK in Lapy, Poland.

In the process of creating the model, the available results of field research were used, on the basis of which the values of individual elements of the system and their parameters were adapted to the actual operating conditions. A fundamental part of these studies were pressure measurements. The obtained data allowed for calibration of the models made.

DOI: 10.34659/eis.2022.83.4.498

Water cutting in individual nodes was obtained on the basis of a previously prepared database that is reading from water meters containing data on the average daily water consumption. The average daily breakdowns in the network nodes were determined by grouping by address.

The model of water supply networks was made using the Epanet software. The basis for building the model was a raster map, processed into a primer for a computer model.

The WDS research model consists of 248 nodes, 3 reservoirs, 315 pipelines, 3 pumps (Figure 2). Total length of sections: 51 312 m.

Losses in water flowing through the pipeline due to friction against the walls were calculated using the Darcy-Weisbach formula (1) (Rossman, 2000):

$$h_f = f\left(\frac{L}{D}\right) \times \left(\frac{v^2}{2g}\right), \tag{1}$$

where:
h_f – the function of head loss (m),
f – friction factor,
L – length of pipe work (m),
d – inner diameter of pipe work (m),
v – velocity of fluid (m/s),
g – acceleration due to gravity (m/s^2).

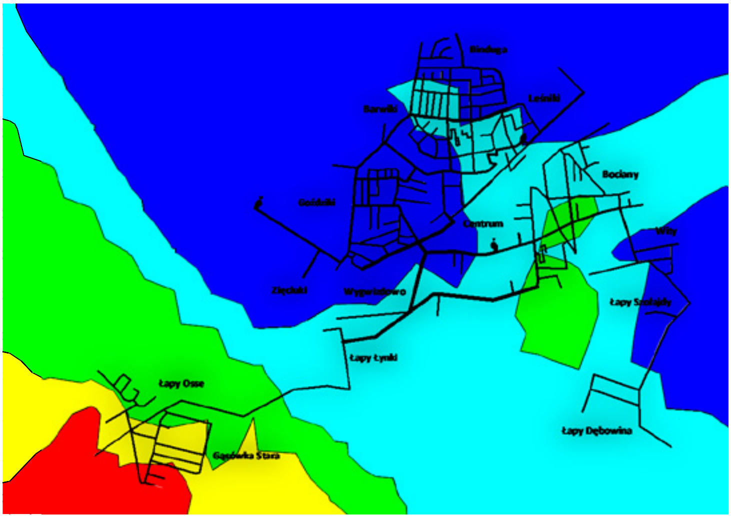

Figure 2. Numerical model of the water supply network, taking into account the height of the terrain

It should be noted that despite the above actions, the received model slightly deviates from the actual conditions. The reason was the lack of com-

DOI: 10.34659/eis.2022.83.4.498

plete data on the materials from which the pipelines are made and the time that has elapsed since their installation, which results in an inconsistent degree of pipe roughness. Creating a model supplemented by these values would require time-consuming field research and studies on the archival documentation of the network.

For research purposes, the degree of roughness for new pipes and uniform roughness values of steel and plastic pipes were assumed.

Results of the research

The water distribution system has been designed for a much greater demand than the current one. The reason for the decreasing consumption is, first of all, the decline of local industry, negative birth rate and impoverishment of the population. As a result, the current water supply network is oversized. Water flow velocities in most sections of the network are lower than the recommended 0.5 m/s, and even the phenomenon of water stagnation occurs. In fear of secondary water pollution, the manager is forced to take preventive measures – washing the network and developing strategies to improve water quality by rebuilding the network. The reconstruction of water intakes is considered to be the most important problem at present. It is considered to switch the supply of the network from the three existing intakes to one intake by switching off the redundant ones and putting into operation only one, located in the northern point of the commune.

Fresh water flows into the network from reservoirs or a source. The age of the water in the pipes should be considered as the main parameter in determining the freshness of the water (World Health Organization, 2017). Due to the assumed problem, which is the age of the water, the Epanet software is used, which makes it possible to carry out the assumed tests with great precision, taking into account the parameter, which is the time when the water stays on a given section from the moment it flows from the intake and is mixed with the water already present. on the Web (Muranho et al., 2012; Filion et al., 2007). Epanet software provides modelling of changes in water age throughout the distribution system, which is an added advantage in forecasting and design (Machell et al., 2014).

The WDS analysis carried out, and the research presented in the paper showed areas where stagnant water ages without an outlet and does not give way to fresh water. Water stagnation is particularly noticeable in the northwest parts of the area red (Figure 3). When the analysis lasted 240 hours (10 days), it was noticed that the water in this area is more than 8 days old, which has a particular impact on its quality. Research has shown that this is a potential site for secondary contamination. Due to the results obtained, additional

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measures were taken to monitor the water in this area more often in terms of physicochemical and bacteriological conditions and to regularly flush the pipelines (Diao et al., 2010).

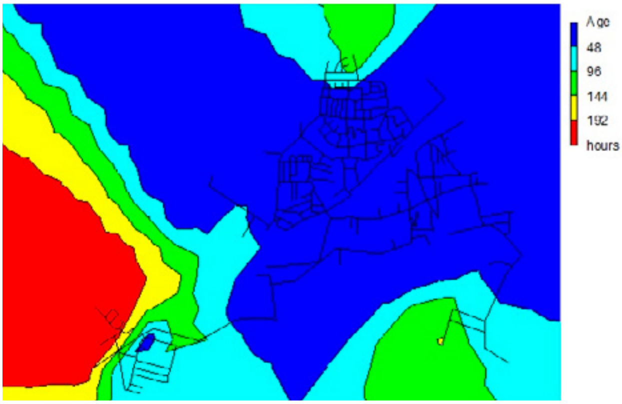

Figure 3. WDS water age during the simulation lasting 240h on the scale of 1: 25,000

Other areas where the deterioration of water quality was observed are the northern district of the area, where the water age may exceed 6 days. The observed situation results from the considerable distance from the shots. These areas are the farthest from the intakes, and naturally, transported water arrives here at the latest.

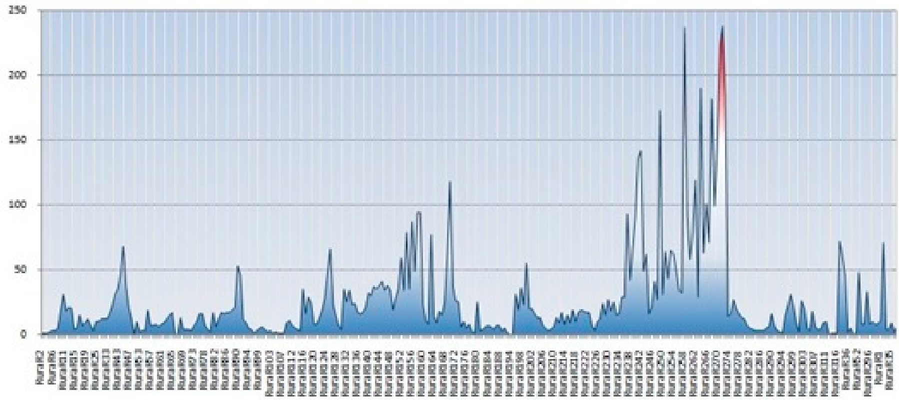

Figure 4. Temporary description of the age of water after a period of 10 days of work

Figure 4 shows a rope that defines the age of water in individual pipes. The differences in height between individual points indicate the degree of variation in the freshness of the water in the network.

DOI: 10.34659/eis.2022.83.4.498

The analysed problem reflects with great precision the time course of water age changes for selected connections (Figure 5). For the R30 connection, it was noticed that the water age stabilised after 40 hours, while for the R264 section, it did not reach a stable value until the end of the analysis.

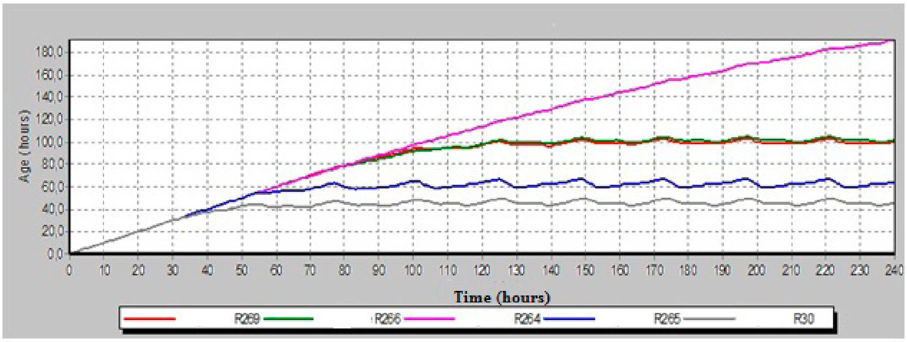

Figure 5. Time course for selected connections

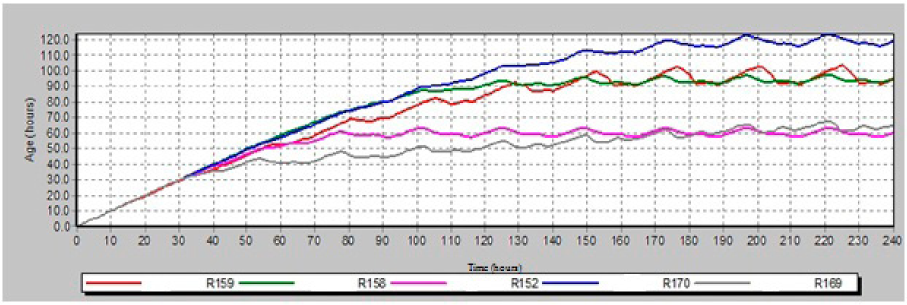

Figure 6. Time course for selected connections due to the analysed location

An important parameter in the model when analysing water quality in terms of age is the duration of the simulation. This fact is very often emphasised in numerous publications. (Masters et al., 2015; Prest et al., 2021). Figure 5 shows that by completing the analysis after 150-160 h, the results could be read by describing the water for the R169 connection as fresher than that flowing in the R152 connection, while the long-er-lasting analysis starts the line transition in favour of the R169 section. A similar situation occurred in the previous example due to the duration of the analysis, where segment R264 did not reach the maximum value of the characteristic curve.

A very helpful research tool of the Epanet software is the ability to instantly find an anomaly in the model under consideration (Machell et al., 2014). It should be noted that a necessary step in this direction is the most accurate reflection of the actual operating conditions of the water distribution system. Figure 7 clearly shows sections R258 and R272, in which water stagnation occurs. When analysing the situation involving the insertion of non-return valves in them, no improvement was obtained, hence the conclusion that the manager should consider the possibility of disconnecting the tested sections from use.

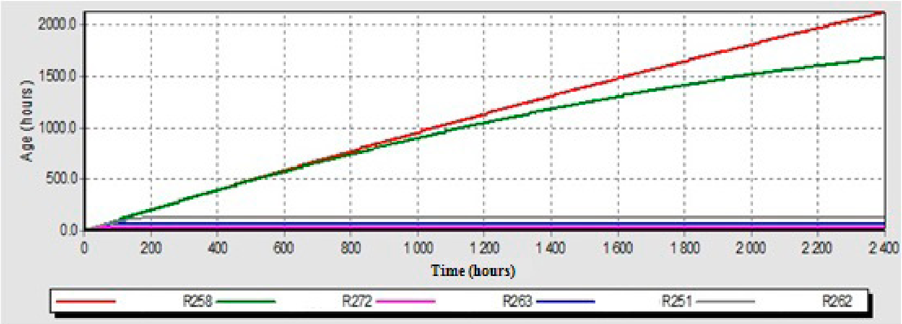

Figure 7. Parameter observation: water age, lasting 100 days

By analysing subsequent possible problem scenarios, a deterioration in water quality due to network oversizing was observed on the developed WDS model. Especially in the northern part of the district, where stale water reaches the recipients. The analysis of the situation shows another advantage of the Epanet software as a tool for monitoring the freshness of water. Generally, until hydraulic calculation software is available on the market, a water freshness report would not be possible without time-consuming field research. The resulting simulation model provides these needed results immediately. It is only limited by the computing power of the machine, and the amount of data initially entered into the calculations. This problem has also been highlighted in numerous publications (Tamminen et al., 2008; Shokoohi et al., 2017).

It should be noted that the problem of research on the change in water age and the related efficiency of water distribution systems has not yet been fully solved. The scope of considerations carried out as part of obtaining the most dynamic nature of the work of water distribution systems is modest, and the process of reaching the final results is too simplified.

The work undertaken so far concerns the vast majority of issues related to the performance assessment at the design stage of the system (Kurek et al., 2013; Diao et al., 2012). This way of considering it has become the subject of many publications, in which the most important point was the development of an appropriate mathematical model and its numerical implementation to precisely determine the functioning of the WDS and, at the same time, affect

DOI: 10.34659/eis.2022.83.4.498

the savings in the time of all calculations. This can be observed in various studies: (Blokker et al., 2016; Butler et al., 2016).

Another factor confirming the complexity of the described problem is time, which is pointed out by the authors of the following publications (Preis et al., 2010; Machell et al., 2014). Sets of corresponding lattice states are formulated, and these states are analysed at a given moment of time (Masters et al., 2015; Filion, 2008). Water should be delivered at any time, depending on the needs of the recipients. As a result of their considerations, the authors of the following publications note this (Machell et al., 2014; Sitzenfrei et al., 2012).

The problems and topics, taking into account the need for further research in this area, have been identified in various studies (Kanakoudis et al., 2019; Shokoohi et al., 2017; Walski, et al., 2003).

The analysis of the current state of knowledge about research on changes in water age and the related functioning of the water distribution system shows that research issues are given much less space than design issues. However, there is no research on the analysis of the impact of basic hydraulic parameters – pressure and water intensity in terms of time and space.

Conclusions

The presented computer simulation revealed the existing deficiencies in the management of the water distribution system of the water supply network in a given area and allowed by mapping the time course of water intake to much deeper information about the operation of the entire system and the possibility of improving its functioning. It has become a helpful tool enabling the development of a method of inferring the variability in time of characteristic parameters of the water distribution subsystem. It reflects their impact on water age changes with great precision and allows for obtaining information about the behaviour of individual real objects based on observation of the developed model of the water distribution system simulating their behaviour.

The analysis of two very important problems, which were: the speed of water flow in the pipes and the analysis of the age of the water in the pipes, required an in-depth analysis. This was mainly due to the fact of checking the correctness of operation with fixed momentary values of parameters without taking into account the events that occurred earlier. Thus, the operating conditions of the water distribution system adopted in the classical method may have never existed in practice, as the actual behaviour of individual elements of the adopted system may have turned out to be different from those adopted for calculations.

DOI: 10.34659/eis.2022.83.4.498

The simulations carried out proved that the analysed network qualifies for modernisation. Thanks to the tool that Epanet has become, it was possible to carry out a number of important and difficult to imagine situations in terms of correct functioning and forecasting possible changes in SDW, find problematic network parameters and consider concepts of engineering solutions.

Based on the results of simulation calculations, the working conditions were first of all developed, with different conservative states. The conditions of WDS operation with randomly occurring failures were mapped, and their impact on the parameters of water intake by consumers was analysed.

The emerging variability of the pumping station's operating parameters and the variability of water consumption by the city have for a long time required the creation and use of a research tool that would allow for the mapping of the dynamic nature of the work because the classic method used so far did not provide such opportunities and in a very cursory manner presented the parameters illustrating the operating conditions of the WDS.

The presented method of computer simulation has cognitive and utilitarian values, and, as a computer technique, it will also be applicable here, pointing to the necessary conditioning of repair works by means of mathematical calculations. The analysis of the results gave a clear goal to optimise the network through modernisation.

Acknowledgements

The research was accomplished at the Bialystok University of Technology as part of the grant WZ/WBIIS/2/2022 financed from subsidies of the Polish Ministry of Science and Higher Education.

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COMPOSTING OF STABILIZED MUNICIPAL SEWAGE SLUDGE WITH RESIDUES FROM AGRI-FOOD PROCESSING IN POLAND

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ABSTRACT: Stabilized municipal sewage sludge and selected waste from agri-food processing can be used for agricultural purposes, which is part of the circular economy. Therefore, chosen residues were tested for the possibility of using them for fertilisation purposes. They were then subjected to the process of composting in a bioreactor with artificial aeration. The compost mixtures were prepared to take into account their contents of, among others, carbon, nitrogen, phosphorus, and water; in the case of sewage sludge, the contents of biological contaminants and heavy metals were also determined. Based on the conducted studies, it has been found that organic waste from agri-food processing and stabilised municipal sewage sludge can be used in the composting process. At the same time, the obtained compost is characterised by good fertilising properties. Considering the physicochemical properties of the obtained compost, it was found that it can be a precious fertiliser used as a soil additive.

KEYWORDS: compost, fertilisation, agri-food processing, sewage sludge

No. 4(83) 2022 • pages: 103-116 DOI: 10.34659/eis.2022.83.4.509 JEL: Q16, Q24, Q53

Introduction

The issue of sewage sludge management is one of the priority tasks in wastewater management. One of the ways of managing this type of waste is composting, i.e. a natural and environmentally friendly method resulting in a high-quality end product in the form of a fertiliser or soil improver (Brod et al., 2012; Kootenaei et al., 2014). Sewage treatment is accompanied by the formation of sewage sludge, the stabilisation and management of which is an increasingly significant financial burden for water and sewage companies. The amount of sewage sludge produced results directly from a load of pollutants on the sewage treatment plant (Klaczyński, 2020). Production of sewage sludge is a continuous process which gives constant access to manageable waste. Producers of sewage sludge are willing to dispose of the material as national, and EU laws prohibit sewage sludge storage (Nedelciu et al., 2019; Rosiek, 2020). However, it should be remembered that composting of sewage sludge must be carried out in accordance with the conditions specified in the decision on waste treatment in the R3 recovery process (Regulation, 2015). It is currently observed that the construction of new sewage treatment plants and the modernisation and expansion of the existing ones is leading to increasing amounts of municipal sewage sludge, which requires management (Sogn et al., 2018; Ding et al., 2021). This increase in the mass of generated sewage sludge observed in recent years, and the prohibition of its storage make the management of municipal sewage sludge a significant environmental, technical, and economic problem (Bień et al., 2011).

According to the Strategy for the Treatment of Municipal Sludge in Poland for 2019-2022 developed by the Ministry of Environment (2018), one of the recommended management methods is to use it for fertilisation purposes in the composting process. However, applying municipal sewage sludge on the ground is only possible under conditions imposed by the waste legislation. The purpose of municipal sewage sludge recovery on the Earth's surface is to make use of its valuable agronomic properties and fertilising potential, i.e. the organic matter and the nutrients needed by plants, such as nitrogen (N), phosphorus (P), and microelements contained in it. Additionally, it should be emphasised that an essential element of the composting process is control of the composition of the compost mixture. This contributes to a stable and environmentally safe product (Lu et al., 2009). Meeting the quality criterion and ensuring that the correct process conditions are in place makes it possible to obtain a high-quality product. However, to ensure the desired product quality, it is estimated that the share of sediment in the compost mass should not exceed approx. 30% by weight (Stürmer & Waltner, 2021). Therefore, composting sewage sludge is only possible with other substrates. It seems

DOI: 10.34659/eis.2022.83.4.509

that the best solution would be to add organic waste from agri-food processing, characterised by the appropriate physicochemical properties (including in terms of fertilisation), which would allow us to obtain a compost mixture with suitable characteristics (including the C:N ratio). A proper selection of raw materials and parameters of the composting process would make it possible to obtain a product with the best fertilising properties, one that would be safe for the environment (Liu et al., 2020). Taking the above into account, it is possible to obtain a product (fertiliser or plant conditioner) meeting the criteria for placing it on the market according to the provisions on fertilisers and fertilisation.

The management of organic residues (sewage sludge, waste) for fertilisation purposes is an important issue due to the contents of fertilising components in soils in Poland. Data obtained from the Central Statistical Office (GUS, 2019) indicates that the availability of macronutrients such as phosphorus, magnesium, and potassium in Poland in the years 2015-2018 is low or medium. Therefore, composted sludge and organic waste can constitute undisputed sources of these components. Furthermore, given that today's agriculture relies on the use of mineral fertilisers to provide nutrients to crops and that global resources of fossil fuels and phosphate, i.e. the raw materials used for the production of mineral fertilisers, are depleting, they need to be replaced by another source of nutrients to ensure food security in the future. This deficit can be rectified by using waste from agri-food processing plants and sewage sludge, i.e. extensive sources of humus-forming organic matter and nutrients needed by plants while composting these resources into valuable and safe fertilisers restore the soil's value (Piwowar, 2013). In addition, it should be noted that the management of sewage sludge and waste from agri-food processing is part of Poland's environmental policy and the concept of circular economy, which has been a priority in European Union countries since 2015 (Sulewski et al., 2021). In addition, considering the current social and economic situation in Poland and other European Union countries, attention should be paid to the increasing prices of mineral fertilisers and their availability. Therefore, it is advisable to look for solutions that would meet the fertilisation needs of agriculture.

Mixing various types of waste in order to improve the conditions of composting processes would allow obtaining a product that meets the requirements of the Act on Waste; the resulting final product can be used for environmental purposes, which is of great ecological value, favouring the improvement of sludge management in sewage treatment plants and the circular economy. Hence, this study aimed to assess the possibility of using stabilised municipal sewage sludge in a composting process with residues from agri-food processing.

DOI: 10.34659/eis.2022.83.4.509

The study aimed to examine whether stabilised municipal sewage sludge and selected waste from agricultural and food processing can be used for agricultural purposes. Selected residues were examined for the possibility of their application for fertilisation purposes; then, they were subjected to a composting process in a bioreactor with artificial aeration. The compost mixtures were prepared so that attention was paid to the contents of carbon, nitrogen, phosphorus, and water. In the case of sewage sludge, biological pollutants and the content of heavy metals in the soil were also determined.

Research methods

The research material consisted of stabilised municipal sewage sludge and selected residues from agri-food processing obtained from plants operating in the Podlaskie Voivodship. In order to prepare a suitable compost mixture, laboratory analyses were carried out to determine the basic properties of the substrates. These tests included, among others, the determination of nitrogen (N) and carbon (C) contents in order to calculate the C: N ratio, a knowledge of which is essential for the preparation of the compost mixture. Based on these determinations, the following biodegradable waste types were selected for further analysis (according to the types of waste included in the Regulation of the Minister of Climate of 2 January 2020 on Waste Catalogue):

- waste plant mass,
- pomace, sludge and other waste from the processing of plant products,
- biodegradable kitchen waste,
- biodegradable garden and park waste.

The examined waste is food scraps obtained from selective waste collection, i.e. the so-called biodegradable kitchen waste and fruit processing pomace. In addition, waste from gardens and parks, i.e. urban landscaping, harvest residues such as straw and hay, and organic waste from urban markets representing, among others, vegetable and fruit residues and leftovers, were used as a structural substrate. According to the requirements for composting and the National Waste Management Plan 2022 (2016) applicable in Poland, the waste in question is biodegradable and can be used for compost production. Tests of stabilised municipal sewage sludge were carried out using reference testing methods specified in the Regulation of the Minister of the Environment of 6 February 2015 on Municipal Sewage Sludge (Table 1).

In order to determine the selected physicochemical properties of waste and compost, methods regarding pH, dry and organic matter contents, and nitrogen and total phosphorus contents specified in Table 1 were used. Moreover, the content of organic carbon was determined using the catalytic combustion method, and the content of potassium using a flame photometer.

DOI: 10.34659/eis.2022.83.4.509

Table 1. List of reference research methods

Indicator	Method
pH	potentiometric determination in aqueous solution
dry matter content	drying at 105°C, weighing
organic matter content	roasting at 600°C, weighing
total nitrogen content	acid digestion with addition of catalyst
total phosphorus content	mineralization to phosphorus (V) and spectrophotometric determination
calcium and magnesium content	digestion with acid mixture and determination by atomic spectrometry
heavy metal content: lead, cadmium, mercury, nickel, zinc, copper and chromium	atomic absorption spectrometry after digestion in concentrated acids
presence of pathogenic bacteria of the genus *Salmonella*	culture on multiplex and differential selective media
number of live eggs of intestinal parasites *Ascaris* sp., *Trichuris* sp., *Toxocara* sp.	isolation of live eggs from a representative sample of the sediment and microscopic examination

Based on the determined nitrogen and carbon contents in the composted substrates, the C: N ratio was calculated, which allowed determining the optimal composition of the mixture intended for composting. The first phase of the composting process was carried out in a laboratory bioreactor with a capacity of 30 dm^3 and aeration of 3 dm^3/min (Figure 1).

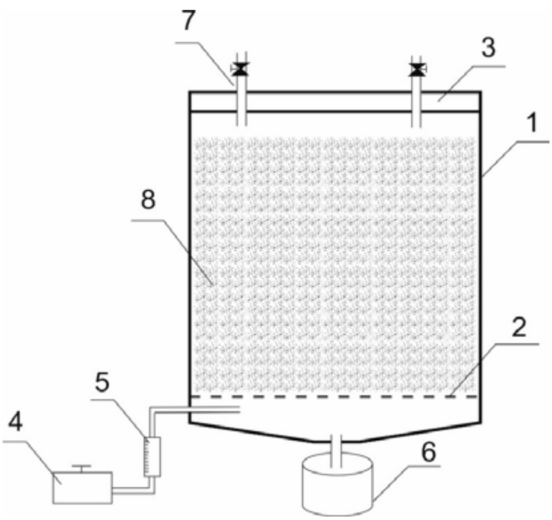

Figure 1. Diagram of the laboratory bioreactor:
1 – enclosure, 2 – perforated bottom, 3 – sealed cover, 4 – air pump, 5 – flow meter, 6 – leachate container, 7 – air vents with air flow regulation, 8 – composted biomass

DOI: 10.34659/eis.2022.83.4.509

With the correct operation of the bioreactor, the temperature was about 70˚C, and the decomposition of the matter was very intensive. This was followed by intense decomposition of the organic matter, decreasing over time, resulting in a successive drop in temperature down to 35˚C. After 14 days, fresh compost was placed on a heap. The compost heap was turned once a week, and the finished compost was obtained after 8 weeks.

Research results

Properties of stabilised municipal sewage sludge

Based on the laboratory analyses, it was found that the tested stabilised municipal sewage sludge is safe in terms of sanitation, and the content of heavy metals indicates that it can be used in agriculture. Moreover, based on selected physicochemical properties, it was found that the sludge has good fertilising properties (Table 2).

Table 2. Physical, chemical, and biological properties of the tested stabilised municipal sewage sludge

Indicator	Unit	Result
pH	-	7.8
dry matter	%	17.0
organic matter	% d.m.	57.6
total nitrogen	% d.m.	4.0
total phosphorus	% d.m.	2.9
calcium	% d.m.	6.4
magnesium	% d.m.	0.5
lead	mg/kg d.m.	20.5
cadmium		1.8
mercury		0.4
nickel		12.0
zinc		621
copper		154
chromium		17.2
presence of pathogenic bacteria of the genus *Salmonella*	-	not detected in 100g
number of live eggs of intestinal parasites *Ascaris* sp., *Trichuris* sp., *Toxocara* sp.	pcs/kg d.m.	0

DOI: 10.34659/eis.2022.83.4.509

The pH value of the tested stabilised municipal sewage sludge is alkaline. According to the literature, pH can range from 5 to 9, influenced by the quality of wastewater, the treatment methods, and the season when the parameter is tested (Bauman-Kaszubska & Sikorski, 2014; Maćkowiak, 2000). On the other hand, the content of organic matter of approx. 58% suggests that sewage sludge has a high potential for being used for agricultural, i.e. fertilisation purposes (Kazanowska & Szaciło, 2012; Singh & Agrawal, 2008). The contents of nitrogen, phosphorus, calcium, and magnesium compounds, i.e. those components that determine the fertilising value, indicate the possibility of using the tested sludge to produce compost. Moreover, among the properties tested, the content of impurities is an important issue. The performed tests show that the contents of all heavy metals do not exceed the values permissible in Poland, as specified in the Regulation of the Minister of the Environment of 6 February 2015 on Municipal Sewage Sludge. Therefore, the results of this research confirm that it can be used for the production of compost due to its not being contaminated with heavy metals; in addition, neither pathogenic bacteria nor live intestinal parasite eggs were found in it. Hence, the tested sewage sludge is characterised by good fertilising properties; it also constitutes a suitable raw material for compost production.

Composition of the fertiliser mixture

In order to determine the composition of the compost mixture, tests were carried out to establish the carbon and nitrogen contents of selected food processing waste. On this basis, the C: N ratio was calculated, allowing to determine the optimal composition of the mixture for composting (Table 3; Figure 2).

Table 3. Carbon (C) and nitrogen (N) contents in the analysed waste

Type of waste	C [%]	N [%]	C:N
municipal stabilized sewage sludge	33	4	9
waste plant mass	86	1.5	61
pomace, sludge and other wastes from the processing of plant products	18	2	11
biodegradable kitchen waste	52	2	28
biodegradable garden and park wastes	74	1.5	51

DOI: 10.34659/eis.2022.83.4.509

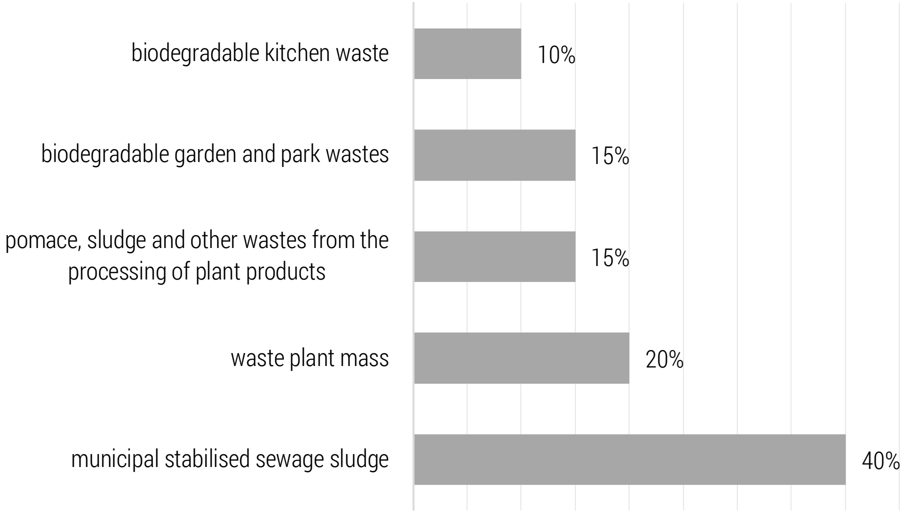

Figure 2. Composition of the compost mixture

Properties of the obtained compost

As a result of the composting process, fully mature compost was obtained, i.e. an organic fertiliser that can benefit soil fertility. The compost was characterised by its dark brown colour, uniform structure, and the peculiar smell of fresh soil. Table 4 shows the results of determining the fertilising properties of the finished compost obtained in laboratory tests.

Table 4. Physicochemical properties of the compost (mean value ± standard deviation)

Indicator	Unit	Result
pH	–	7.6 ± 0.4
dry matter	% d.m.	60 ± 2.3
organic matter		52 ± 1.8
N		1.70 ± 0.3
P		0.5 ± 0.1
K		1.25 ± 0.2
Ca		2.90 ± 0.7
Mg		0.50 ± 0.1

DOI: 10.34659/eis.2022.83.4.509

The compost, with a 40% content of stabilised municipal sewage sludge and organic waste, has good fertilising properties. In the course of the study, it was found that the pH of the obtained mature compost was about 7, which indicates its neutral character. Compost from sewage sludge obtained by Radziemska et al. (2021) was also characterised by a reaction close to neutral. A study by Bożym and Siemiątkowski (2018) and another by Curci et al. (2020) showed the pH of composts to be around 7. Such a value of pH is favourable for compost's use under crops. Given that most soils in Poland are characterised by the acid reaction, using such a fertiliser would not worsen the soil reaction (Rutkowska, 2018). An appropriate dry matter content, and thus also its moisture content, is conducive to the decomposition of organic matter in the soil. In addition, the obtained compost was characterised by an organic matter content exceeding 50%, thus meeting the requirements for organic fertilisers. According to the Regulation of the Minister of Agriculture and Rural Development of 18 June 2008 on the Implementation of Certain Provisions of the Act on Fertilizers and Fertilization, the content of organic matter in composts should amount to at least 30% of organic matter on a dry matter basis. Studies conducted by other authors have also shown that the organic matter content of composts can exceed 50% (Bożym & Siemiątkowski, 2018). In the case of the obtained compost, the contents of nutrients such as nitrogen, phosphorus, potassium, calcium, and magnesium, i.e. those elements that affect the suitability of organic fertilisers for fertilisation, indicate good fertilising properties. The nitrogen content of the obtained compost was 1.7% d.m., whereas, in a study conducted by Bożym et al. (2014), the full content of this component was approx. 0.9%.

In studies conducted by other authors, the phosphorus content was similar to the values obtained in this study, i.e. 0.462% in the case of green waste compost (Wei et al., 2015) and 0.451% for one-year compost (Bożym et al., 2014). According to Gorlach and Mazur (2002), the phosphorus content of cattle manure is 0.28%, which makes the compost obtained in this study richer in phosphorus. Studies conducted by other authors have also shown that sewage sludge compost can be a good source of phosphorus (Stürmer & Waltner, 2021). In addition, the potassium content is also similar to that obtained in a study conducted by Bożym et al. (2014), where it was 1.24% and 1.21% for one- and two-year compost, respectively. However, according to Gorlach and Mazur (2002), sheep manure is the richest in potassium, containing 1.19% of the component. The higher potassium content of the tested compost compared to manure means that the resulting fertiliser has the potential to be used as an organic fertiliser to supplement potassium deficiencies in the soil. In addition, the compost had a high calcium content. In a study by Czop and Żydek (2017), green waste compost contained only 0.69% calcium. The high content of this element results in the resulting

DOI: 10.34659/eis.2022.83.4.509

fertiliser having many valuable properties, such as reducing the soil's acidity, creating a favourable environment for the growth of soil bacteria, and improving the air and water conditions of the soil (Czop & Żydek, 2017).

On the other hand, the content of magnesium is within the range reported by Wasiak et al. (1999), who determined that the content of this component in various composts ranges from 0.36 to 1.41%. The magnesium content in manure is only 0.1%, and given that magnesium is an essential component in plant nutrition and its deficiencies are found in Polish soils, fertilisation with the use of the resulting compost can have a beneficial effect on plant growth and yield (Mazur, 2002). As research by other authors has shown, sewage sludge and compost obtained from it are characterised by good fertilising properties and are rich in fertilising ingredients (Ghulam et al., 2012; Kirchmann et al., 2017; Moretti et al., 2015).

However, it should be remembered that the contents of the individual nutrients necessary for the development of plants and microorganisms in the soil are influenced by the quality of the substrates used in the composting process (Bożym & Siemiątkowski, 2018; Uçaroğlu & Alkan, 2016). At the same time, this translates into the quality of the finished product (compost), whose physicochemical properties affect the course of the processes in the soil environment and stimulate plant growth (Gorlach & Mazur, 2002). Therefore, considering the chemical composition of the resulting compost, it was concluded that it could be an unquestionable source of nutrients for plants.

Conclusions

In order to obtain the finished product, i.e. an organic fertiliser (compost), the most efficient composting method was used in the study (two-stage – container), performed in a bioreactor. Composting of bio-waste in closed reactors is accelerated by optimising aeration, hydration, and process temperature control. Hence, the method in question is the most effective and fastest due to the possibility of controlling the process conditions. Controlled temperature and humidity enable the intense processes of biochemical decomposition of organic mass with the participation of aerobic fermentation (with an optimal air supply). Heat thus generated (up to 70ºC) accelerates the growth of mesophilic and thermophilic microorganisms, which is related to the hygienization of the compost mass. This phenomenon is essential for the composting of sewage sludge.

When preparing compost mixtures, particular attention was paid to the physical, chemical, and biological properties of waste used as substrates for compost production. Based on these studies, it was found that stabilised sew-

DOI: 10.34659/eis.2022.83.4.509

age sludge has good properties and is not contaminated with heavy metals. Therefore, it could serve as a substrate for compost production. In addition, based on the calculated C:N ratio, the best proportion of waste in the compost mixture was determined, i.e. the content of the tested sewage sludge should be 40%.

Compost produced from sewage sludge and organic waste from agri-food processing was characterised by high contents of organic matter, nitrogen, phosphorus, potassium, calcium, and magnesium, which made it helpful in fertilising. Therefore, a fertiliser was obtained that meets the requirements for this type of product and can be used to improve the properties of soils.

In connection with the above, based on the conducted research, compost was obtained from stabilised municipal sewage sludge with an organic waste content, which is part of the areas of innovative technologies of waste treatment using biological and physical methods and the area of neutralisation of sewage sludge with organic co-substrates constituting organic waste. In addition, waste management for fertilisation purposes is part of the circular economy and the national waste management plan, as under Art. 14 of the Act of 14 December 2012 on Waste, in force in Poland, waste used for the production of compost ceases to be waste, and becomes a substrate for the recovery-composting process.

Acknowledgements

This was carried out as part of team project no. WZ/WB-IIS/2020 and financed by the Polish Ministry of Science and Higher Education.

The contribution of the authors

Małgorzata Krasowska – concept, literature review, acquisition of data, analysis and interpretation of data – 33.33%.

Małgorzata Kowczyk-Sadowy – concept, literature review, acquisition of data, analysis and interpretation of data – 33.33%.

Sławomir Obidziński – concept, literature review, acquisition of data, analysis and interpretation of data – 33.33%.

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SUSTAINABLE DEVELOPMENT IN RURAL AREAS IN THE PERSPECTIVE OF A DECADE OF ECOSYSTEM RESTORATION

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ABSTRACT: Rural areas are included in the concept of sustainable development, and they are characterised by a great variety of flora, fauna, and habitats; apart from the function of food production, they can fulfil numerous functions related to the protection and shaping of the environment. The paper characterises the impact of agriculture on the natural environment. Selected parameters of agricultural plant production were described for the European Union, the Netherlands, and Poland. Factors significant in the context of the United Nations Decade of Ecosystem Restoration (2021-2030) were indicated. The features of agriculture in Hajnówka county (where over 50% of the area is under protection) were selected as a reference point for the expected results, treating it as a model of an organisation for the harmonious development of agriculture in the 21st century. The study highlights the importance of biodiversity in rural areas for building a sustainable human welfare strategy. The use of ecosystem services will be permanent when the elements of the Decade of Ecosystem Restoration are widely disseminated and rooted in the civic consciousness of the inhabitants of Poland and similar spaces in Europe. This decade must be advertised as widely as possible for this to happen, writing about it in various contexts.

KEYWORDS: Rural areas, limiting anthropopression, Decade of Ecosystem Restoration (2021-2030)

 DOI: 10.34659/eis.2022.83.4.535 JEL: Q15; Q19; Q34

Introduction

The development of the world economy accelerated exponentially. While it took humankind 36 years to achieve two per cent growth in the twentieth century, we get ten per cent after seven years (Popkiewicz, 2013). Rockström et al. (2009) identified global processes that require slowing down and setting the limits of their safe growth for the proper functioning of people on Earth. According to these authors, the limits have now been exceeded in at least four processes: climate change threatening human security, destabilisation of the nitrogen and phosphorus cycle, high rate of biodiversity loss, and loss of a significant area of arable soil.

In April 2022, the UN Global Land Outlook 2 (UNCCD, 2022) report was released. The study was developed over five years in cooperation with 21 partner organisations. The report states that 20 to 40% of the planet's land surface has already been degraded, including farmland, wetlands, forests, and meadows. Half of humanity is experiencing the direct effects of this damage – including desertification, soil degradation, and drought.

Agriculture is an activity that significantly affects the environment: it shapes the living conditions of many species of plants and animals, and at the same time, in some cases, destroys their populations. The progress of civilisation gives excellent opportunities to shape the environment, including rural areas. Currently, agriculture can function at high unit productivity from plant and livestock production obtained from modern methods, means of production, or transgenic plant species (GMOs). However, it influences the reduction of the nutritional value of the food produced in this way and the deterioration of the condition of the environment. Therefore, many producers and consumers have become supporters of organic (ecological) farming, producing plant and animal products using environmentally friendly methods. In discussions on the future of agriculture, arguments supporting the globalisation of the agricultural market and the development of large agri-corporations continue to clash; at the same time, arguments supporting local and family management are essential for many. In some European countries, agriculture promotes the welfare and regulatory function of the state relating to this sector of the economy.

Meanwhile, large-scale livestock farming on an industrial scale emits about 14% of greenhouse gases into the atmosphere (FAOSTAT, 2022). Carbon dioxide is mainly emitted from areas undergoing agricultural change, where plants are deprived of vegetation, for example, due to deforestation or the removal of permanent meadows and pastures (Rykaczewska, 2010). In Poland, with a productivity of about 40 dt of hay per 1 ha, meadow biomass absorbs 1.5 tons of CO_2/ha. It allows about 4.7 million tons of CO_2 to be

DOI: 10.34659/eis.2022.83.4.535

reduced annually in meadow biomass. The 1st Climate Agriculture Congress, organised in Germany in 2021 by two non-profit organisations: *Climate Farmers* and *Akademie Schloss Kirchberg,* pointed to the need to create a regenerative food system to reduce greenhouse gas emissions and restore soil carbon (BESH, 2022).

Therefore, contemporary agriculture is faced with many challenges that should be solved for the good of humankind. There is an overproduction of food, and at the same time, about 25% of the human population on Earth (Africa and South Asia) suffers from chronic malnutrition or starvation. According to the current estimates and forecasts of the FAO, the European Commission, and other international organisations, negative phenomena and processes occur in agriculture and its surroundings: shrinking agricultural space for field crops, the concentration of large animal farms, waste (according to WHO), about 30% of food produced, higher and higher use of chemical means of production. At the same time, agriculture intervenes in semi-natural areas by liquidating wet river valleys and deforestation. As a result of the advancing climate change, extreme phenomena occur in agricultural areas: droughts and floods and the spread of diseases, including livestock and crops.

In light of regenerative farming, the demands on the world's agricultural corporations are increasing, but that is not enough. Other system solutions are needed. Agricultural land use in the 20th century separated agricultural production from areas managed to conserve biodiversity. This principle is no longer applicable in the 21st century. The Millennium Ecosystem Assessment (2005) confirmed that agriculture had a clear impact on the environment and increased its ecological footprint. Preserving biodiversity in the agricultural landscape thus requires urgent and extensive research, policy coordination, and strategic support for farming communities. The sustainable agriculture system is an essential component of many of the 17 Sustainable Development Goals agreed upon by the UN in 2015 (United Nations, 2022). A holistic approach to modern agriculture can protect and restore rural biodiversity more effectively and thus develop ecosystem services in agricultural and semi-natural areas (Smol et al., 2020). Agriculture that considers biodiversity offers a chance for a symbiotic coexistence of a system in which food production and nature can develop favourably (Scherr & McNeely, 2008).

To diversify large-area monoculture crops dominated by cereal and fodder plants, science and practice draw attention to the need to introduce plants of minor or marginal importance to cultivation, favouring the biodiversity of villages and new crops (Kiryluk & Kostecka, 2020). The variety of values of rural areas motivates many people to introduce a new lifestyle and a new model of social development in the countryside. The comfort of living and the attractiveness of these areas largely depend on the condition of the

DOI: 10.34659/eis.2022.83.4.535

natural environment and natural values. Rural areas in Poland, relating to some EU countries, are characterised by high values resulting mainly from the preserved large landscape and biological diversity. The concept of sustainable development in rural areas is an idea that is difficult to implement in the current economic and social conditions (Kozłowska-Burdziak, 2020). The positive and acceptable attitude of farmers to environmental protection issues often loses to the prevailing need to maximise profit and economic calculation. The adaptation of, for example, Polish agriculture to the standard agricultural policy of the EU and competition with agricultural producers in the food market inspire farmers to take pro-ecological activities. The increase in people's pro-environmental awareness and sensitivity toward nature and its resources may result in attempts to introduce into everyday reality the concept of violence on the natural environment and biodiversity (Butt & Kostecka, 2019; Kostecka & Butt, 2019). It can help in the faster spread of a negative attitude towards society, for example, towards such practices as:

- everyday and often unjustified use of chemical plant protection products (insecticides, herbicides, fungicides),
- mineral fertilisation, not adapted to the current fertility of the soil,
- fertilising permanent grassland with too high doses of slurry,
- simplifying the technology of tillage, eliminating crop rotation and traditional plough crops,
- accelerated introduction of genetically modified plants to cultivation.

The study aims to indicate selected parameters of the impact of agriculture on the environment (mainly on the example of agricultural land) against the background of changes in agricultural plant production in the European Union, the Netherlands, and Poland. Rural areas require reducing human pressure, so the activities significant in the context of the United Nations Decade of Ecosystem Restoration (2021-2030) are also listed. The agriculture features in Hajnówka county were chosen as a reference point for the expected results, where a large share of protected areas allows for preserving and restoring ecosystem services using possible solutions limiting anthropopressure.

Research methods

The article uses statistical data available in publications and electronic materials of the Central Statistical Office, Local Databases, Eurostat, Faostat, the Institute of Soil Science and Plant Cultivation, Agency for Restructuring and Modernization of Agriculture. The method of analysing structural and quantitative changes in the following areas was adopted in the study of agricultural intensification and its impact on the environment:

DOI: 10.34659/eis.2022.83.4.535

- the European Union (the average of 27 member states is given) is an organisation dynamically developing conventional agriculture and a high impact of agriculture on the environment. As a result of the Common Agricultural Policy of the EU, European agriculture has been integrated, and there is a tendency to equalise its character and level of productivity in individual member states,
- the Netherlands as a country achieves the highest unit efficiency rates in plant and animal production, using the most advanced technologies and biotechnological achievements, as well as applying innovative production methods and the best pro-environmental solutions,
- Poland, as a country that, in over a quarter of a century, has significantly changed the character of agriculture to a medium-intensive one while maintaining, however, traditional cultivation methods and maintaining high-quality products of plant and animal origin,
- Hajnówka county is a research area.

The analysis of agriculture characteristics was carried out mainly for 2005, 2010, 2015, 2019, and 2020 because Poland was formally included in the Common Agricultural Policy in 2004. Hajnówka county in the province of Podlasie is presented as a rural area with slightly changed agriculture, medium and small-scale farms and a large share of protected landscape areas. This county can be considered a model for the harmonious development of so-called sustainable agriculture and activities to restore rural ecosystems. The data on Hajnówka county come mainly from the author's research and exploration.

Results of the research and discussion

Characteristics of the agricultural area in the world and Europe

In 1961-2003, world agriculture was characterised by increased crops. The slowdown of this tendency can be observed in the following years of the 21st century (Figure 1), which can be explained by the improvement of cultivation techniques, the introduction of high-yielding varieties, and the growing demand for food.

In the last decades of the 20th century and at the beginning of the 21st century, there were changes in plant production in Europe (also in Poland). Large-scale agriculture began to dominate, ensuring high food production and negatively impacting the natural environment. Soil, water environment, air, landscape, ecosystem and species biodiversity are subject to intense and negative pressure from agriculture. Agricultural production is a burden on the natural environment. In the world, agricultural areas cover about 35% of

DOI: 10.34659/eis.2022.83.4.535

the area and show a slight upward trend of several percent, which may be related to the expansion of cultivated areas due to deforestation. In the European Union, agricultural areas in 1961-2020 decreased on average from 52.9% to 41.0%. In the Netherlands, there was also a decrease in the area of agricultural land in the analysed period by 14.7%. In Poland, agricultural areas decreased by 19.4%, and the most significant decrease was recorded after 2005 (Figure 1).

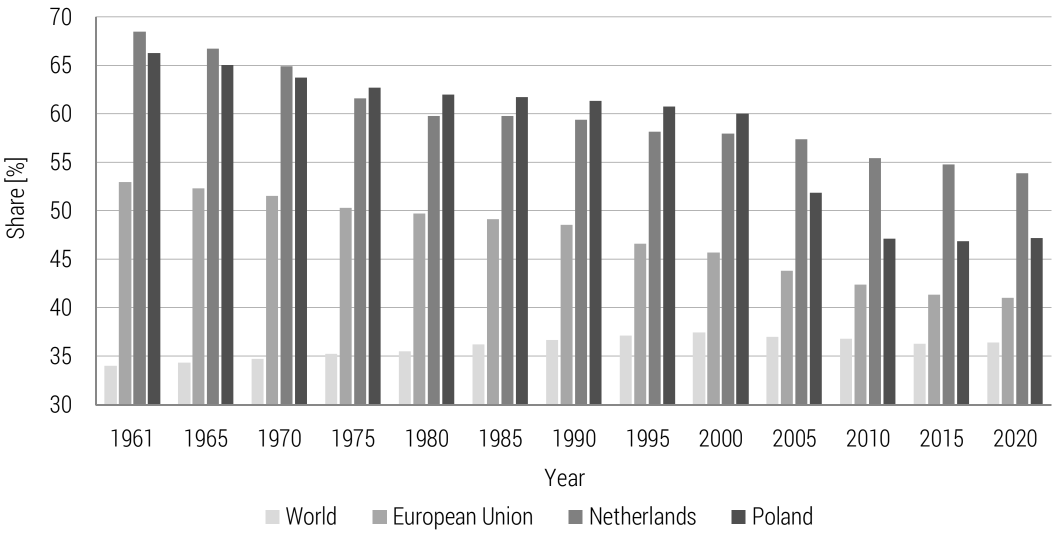

Figure 1. Changes in agricultural land (1961-2020) [%]
Source: authors' work based FAOSTAT (2022).

Despite the growing demand for food, Europe's farmland has shrunk. It was possible thanks to actions increasing the efficiency of crops, taking into account the specificity of the species of cultivated plants (and in the case of animal production – raised animals), taking into account the socio-economic and environmental conditions for sustainable and low-emission plant and animal production. Sustainable food production can provide sufficient protein and meet consumer expectations. However, this presents a challenge in the face of climate change and the need to reduce emissions (Henchion et al., 2021).

With forage grain farms currently dominating half of the crops in agriculture, there is a need to promote environmentally friendly farming systems that respect the principles of sustainable development. The statistical data in Table 1 show that the cultivation areas of rye (*Secale cereale*) and potatoes

DOI: 10.34659/eis.2022.83.4.535

(*Solanum tuberosum*) have significantly decreased. It is due to, among other things, the elimination of traditional pig farming, the transition to large-farm farming, and the abandonment of feeding with traditional feed prepared on the own farm. The feeding of farm animals with fodder from industrial production dominates. As a traditional crop, e.g., in Poland, the yield and rye prices did not increase despite significant progress in cultivation, so this plant was becoming less and less profitable for farmers. Rye is still grown on light soils in less favourable climates (mountain areas), and in Poland, it is the primary raw material for bread production. Recently, however, an increase in prices for cereals has been observed. In 2005-2020, the cultivation area of triticale (*Triticale*) and maize (*Zea mays*) for fodder increased. These species are the main energy components in industrial feed production for farm livestock production. The increase in maise cultivation in Poland is caused, among others, by climate change and negative water balance. This species needs less water to produce biomass (Kiryluk, 2009) and tolerates drought better during the growing season. There is a significant increase in rapeseed (*Brassica napus*) cultivation in the EU and Poland caused by the growing demand for biofuels and the increased profitability of this production. The expansion of intensively cultivated forage cereal areas is becoming a real threat to biodiversity and agricultural landscapes in the EU, including the Netherlands and Poland.

Table 1. Changes in the sown area of major crops in the EU, Netherlands, and Poland in 2005-2020

Feature	Year	European Union [thousand ha]	Netherlands [thousand ha]	Poland [thousand ha]
Agricultural land area	2005	192 006	1938	15 906
	2010	186 641	1872	14 449
	2015	182 406	1846	14 371
	2020	182 446	1817	14 253
Agricultural land (% of land area)	2005	43.9	57.4	51.9
	2010	42.5	55.5	47.2
	2015	41.4	54.8	46.9
	2020	40.9	54.1	47.4
Permanent grassland area	2005	51 117	795	2 592
	2010	50 742	813	2 508
	2015	48 508	766	2 628
	2020	48 231	768	2 478

DOI: 10.34659/eis.2022.83.4.535

Feature	Year	European Union [thousand ha]	Netherlands [thousand ha]	Poland [thousand ha]
Grassland (% of agricultural land)	2005	26.6	41.0	16.3
	2010	27.1	43.4	17.3
	2015	26.6	41.4	18.2
	2020	26.4	42.2	17.4
Rye	2005	2 479.2	2.5	1 415.3
	2010	2 248.9	2.3	1 059.6
	2015	1 982.4	1.6	725.3
	2020	2 073.7	1.8	843.6
Wheat	2005	24 720.9	136.7	2 218.1
	2010	24 172.5	153.7	2 124.2
	2015	24 902.0	142.5	2 395.5
	2020	22 876.3	108.9	2 373.3
Triticale	2005	2 580.2	4.1	1 194.6
	2010	2 698.6	2.7	1 324.8
	2015	3 065.7	1.4	1 516.2
	2020	2 751.8	1.2	1 388.9
Maize	2005	9 310.9	20.7	339.3
	2010	8 321.9	16.7	333.4
	2015	9 249	11.2	670.3
	2020	8 965	19.4	946.1
Potatoes	2005	2 178.1	156.0	588.2
	2010	1 803.4	156.9	400.7
	2015	1 555.7	155.6	300.4
	2020	1 536.4	164.5	225.7
Oilseed rape and agrimony	2005	4 297.1	2.0	550.2
	2010	6 444.8	2.6	945.5
	2015	5 825.8	2.3	947.1
	2020	5 324.3	1.7	980.9
Barley	2005	12 936.5	50.6	1 113.1
	2010	11 315.0	33.3	970.7
	2015	11 156.6	32.8	839.3
	2020	11 025.3	38.4	675.2

Source: authors' work based on FAOSTAT [26-05-2022].

DOI: 10.34659/eis.2022.83.4.535

Agriculture and the natural environment

Agricultural activities and factors influencing the environment

Mineral fertilisers can significantly disturb the natural environment if they are not carried out following pro-environmental technologies available in precision agriculture (Siebeneicher, 1997). Rockstrom et al. (2009) show that we are currently struggling with the destabilisation of biogeochemical cycles in the nitrogen and phosphorus cycle. The negative impact of fertilisation on the environment concerns mineral fertilisers (Arisha & Bardisi, 1999); therefore, organic fertilisers are gaining more and more supporters (Rahman, 2004).

Another urgent challenge for modern societies is slowing global biodiversity loss and extinction rate (Gołębiewska et al., 2016). There is overwhelming evidence that species extinction affects the functioning of ecosystems and that species provide many services; entire ecosystems have significant economic value. Much environmental research focuses on where biodiversity is lost most quickly and where biodiversity loss has the most immediate consequences. It is widely believed that converting land to monoculture and intensifying local farming practices such as using fertilisers and pesticides is the most harmful to biodiversity. The ecosystem services provided by pest control species involved in pollination and nutrient cycling benefit agricultural production and sustainable development (Gonthier et al., 2014).

The threat to the natural environment is also associated with chemical plant protection products, which, directed against specific pests, weeds, or diseases, are never indifferent to other representatives of biodiversity inhabiting the soil environment. Table 2 shows the amounts of applied mineral fertilisers and pesticides, and the amount of greenhouse gas emissions GHG (CH_4, N_2O, NH_3) converted into CO_2 equivalent in agricultural areas. The latest BP (*British Petroleum*) Statistical Review of World Energy report from 2019 shows that CO_2 emissions have been reduced by large EU countries and the USA, Russia, and Japan in the last decade. On the other hand, a significant increase in CO_2 emissions occurs in China, India, and Brazil, which creates a negative balance of emission reductions (Kacprzak, 2020).

The data in Table 2 show that Dutch agriculture uses almost three times more mineral nitrogen than Poland. It is related to introducing high-yielding wheat varieties to cultivation or increasing the number of vegetable crops requiring large doses of a strongly yield-generating factor, nitrogen. Nitrogen is a fertilising factor that threatens the quality of surface and groundwater – likewise, phosphorus is used in very high doses in Poland. The use of pesticides per hectare in the EU countries remains stable, and in Poland, it shows a slight upward trend.

DOI: 10.34659/eis.2022.83.4.535

Table 2. Fertilizers indicator, pesticides, and emissions on agricultural land (changes in the years 2005-2020)

Analyzed factor	Years	European Union	Netherlands	Poland
Nitrogen N [kg × ha-1]	2005	86.6	244.3	79.6
	2010	86.6	205.8	97.2
	2015	94.1	223.5	92.5
	2020	90.1	188.5	91.8
Phosphorus P2O5 [kg × ha-1]	2005	26.7	42.5	35.3
	2010	20.1	29.0	36.4
	2015	21.7	8.4	28.9
	2020	23.2	10.2	30.4
Potassium K_2O [kg × ha-1]	2005	28.6	41.5	42.2
	2010	23.4	48.4	40.6
	2015	24.4	25.5	46.7
	2020	26.3	51.3	49.9
Pesticide [use per cropland area kg × ha-1] FAOSTAT	2005	3.1	9.4	1.3
	2010	2.8	9.1	1.7
	2015	3.1	9.2	2.1
	2019	3.1	8.9	2.1
Emissions of carbon dioxide CO_2 [kilotons = thousand tons]* * GHG emissions converted to carbon dioxide equivalent	2005	2,124,510,728	113,589,394	288,617,151
	2010	2,041,562,763	112,539,696	273,098,557
	2015	1,782,141,930	96,897,942	252,571,675
	2019	1,746,081,409	90,595,091	274,861,565
Emissions of methane CH_4 [kilotons = thousand tons]	2005	91,169,153	4,614,733	6,159,323
	2010	88,960,686	4,874,800	6,146,479
	2015	88,005,595	5,233,143	5,919,083
	2019	85,055,332	4,661,738	6,081,571
Emissions of nitrous oxide N_2O [kilotons = thousand tons]	2005	6,096,656	242,474	600,079
	2010	5,937,252	237,398	608,626
	2015	6,128,161	251,705	587,185
	2019	5,983,277	229,431	621,704
Emissions of ammonia NH3 [tons]*	2005	3,471,000	135,210	318,030
	2010	3,270,480	117,643	296,820
	2015	3,295,770	116,013	285,730
	2019	3,284,470	107,063	299,880

Source: authors' work based on FAOSTAT [26-05-2022].

DOI: 10.34659/eis.2022.83.4.535

There is a need to reduce agricultural emissions from the cultivation of wheat intended for fuel (Jarosz & Faber, 2015). The amount of greenhouse gas emissions from Green House Gases (GHG) depends on crop rotation, cultivation method, the amount of mineral and natural fertilisers, plant protection products, and soil and microclimate. Increased doses of mineral fertilisers and plant protection products in intensive cultivation cause an increase in GHG emissions (Syp, 2017).

The cultivation of energy crops to produce first-generation biofuels, i.e., cereals and oilseeds, is also associated with increased GHG emissions, especially nitrous oxide (N_2O). These crops can sometimes cause even greater GHG emissions than petrol and diesel. It is estimated that N_2O emissions from agriculture, the leading share of direct crop emissions, cause about 60% of pollution (Czyżewski & Kryszak, 2017). Therefore, according to Directive (2009), it is necessary to estimate the emissions of agricultural and process greenhouse gases (CH_4, N_2O, NH_3) and compare them with the emissions generated using conventional fuels. The estimation of emissions of N_2O, the gas with the highest potential for warming the atmosphere, is of particular importance.

Methane emissions are associated with large-scale livestock production and the breakdown of agricultural waste. Part of this emission is used in the production of biogas. Limiting methane emissions from agriculture is difficult because meat remains a significant component of the European diet. The data from Table 2 show that in the period 2005-2020, there was a reduction of this gas emission in the EU by 6.7%. It was not recorded in the Netherlands, while the reduction in its emissions was slight in Poland. The high methane emissions in the Netherlands are due to the highly developed large-scale beef production. A similar cause of methane emissions occurs in Poland, a significant milk producer in the EU. The substrates to biogas production in anaerobic digestion, except plant materials, can also be animal faeces and manure. It should be highlighted that Poland is one of the leaders in the European Union in animal breeding (Kozłowski et al., 2019).

Direct nitrous oxide N_2O arise mainly from nitrogen fertilisers, while indirect emissions are influenced by ammonia (NH_3) emissions and nitrogen leaching (Jarosz & Faber, 2015).

The research and analysed statistics show that agriculture is responsible for 98% of ammonia emissions in the EU and Poland (Witkowska-Dąbrowska, 2018). Directive (2016) imposes an obligation to reduce: sulfur dioxide, nitrogen oxides, fine dust PM 2.5 and ammonia, the primary source of which is the production of animal. Poland was obliged to reduce ammonia by 1% in 2020-2029 and 17% after 2030 compared to 2005. In Poland, the problem of ammonia emissions is regulated by the Code of Good Agricultural Practice (Ministerstwo Rolnictwa i Rozwoju Wsi, 2019). The European Environment

DOI: 10.34659/eis.2022.83.4.535

Agency (EEA) compiled and published the agricultural ammonia emission factor under the Convention on Long-Range Transboundary Air Pollution (Nielsen, 2013). In 2005-2020, a decreasing trend of GHG emissions in the EU and the Netherlands was found. In Poland, however, a downward trend was recorded only from 2005-2015. Since 2015, a further increase in GHG emissions from agricultural areas in Poland has been observed. So it is a problem that should be solved as soon as possible. The ammonia emission rate from agricultural production analysis includes manure management, mineral nitrogen fertilisers, liquid manure, slurry, and droppings left by grazing animals. The emission also includes ammonia emitted from natural and mineral fertilisers at all stages of production and application to the soil. Ammonia emissions from agricultural sources cause negative changes in the environment. As a result of these emissions, there is the eutrophication of water, an increase in soil acidity, and a decrease in the absorption of nutrients by plants. Dry or wet ammonia precipitation threatens many crops and increases their susceptibility to physiological stresses. In the period up to 2005-2020, there was a slight decrease in the volume of ammonia emissions from agricultural sources in the EU and the Netherlands (Table 2). In the EU countries during this period, NH_3 emissions decreased by 9.2%, and in the Netherlands by 7.9%. The essential action of ammonia emission reduction is proper nitrogen balancing on the farm. The most significant ammonia emission occurs after applying mineral fertilisers containing nitrogen in the ammonium and amide form, which quickly transforms into ammoniacal nitrogen. Ammonia losses from nitrogen fertilisers such as ammonium phosphate, ammonium sulfate, urea, and urea solutions are estimated at 5-40%, depending on the conditions. Nitrogen losses in the form of ammonia at the stage of application of natural fertilisers on agricultural land range from about 25% to even 95%. It is crucial to cover the fertiliser with soil as soon as possible and soil application in the case of liquid fertilisers. Applying these practices and reducing emissions can improve the use of nitrogen in natural and mineral fertilisers and, thus, the farmer's environmental and financial benefits (Ministerstwo Rolnictwa i Rozwoju Wsi, 2019).

In livestock production, ammonia emissions can be reduced using appropriate feeding systems, storage, and application of manure and slurry. It is practical to use feed with a reduced total protein level, multiphase nutrition, protected protein, and feed additives, increasing protein digestibility in animal nutrition. It is also recommended to extend the grazing period, as the faeces excreted by grazing animals dry quickly, and urine is immediately absorbed into the soil. In livestock buildings, ammonia emissions mainly consist of reducing the area contaminated with faeces and their quick removal from livestock buildings. One should also pay attention to the proper storage of fertilisers; in the case of some, the loss of nitrogen compounds may even

DOI: 10.34659/eis.2022.83.4.535

reach 30% (Syp, 2017). The essential document concerning emissions from agricultural areas is the Intergovernmental Panel on Climate Change (IPPC) Directive, concerning integrated pollution prevention and control. The main pillars of the Directive are:

- an integrated approach to environmental protection and the granting of an integrated permit,
- using the best available techniques (BAT – Best Available Technique),
- control of technological activities,
- public access to information (Directive, 1996).

Activities for the protection of the environment in rural areas

Environmental protection of rural areas is all activities aimed at removing the negative consequences of anthropopressure and preventive measures preventing the depletion of ecosystem functions. These are also activities aimed at the rational use of natural resources, including measures to save matter and energy. Ecosystems are recreating thanks to biodiversity (COP, 2012; Europarc Federation, 2022).

Maintaining biodiversity and ecosystem services on a global scale depends on the adequate protection of approximately 30-50% of the Earth's surface (Wilson, 2016).

Ecosystems provide humans with food, fresh water, clean air, and shelter. They help mitigate the risk of natural disasters, reduce the occurrence of pests and diseases, and contribute to climate regulation. The transformation of traditional agricultural production technologies and the transition to the conventional (industrial) system were among the greatest threats to global biodiversity in the 21st century (Komorowska, 2014; Scherr & McNeely, 2008). Significant biodiversity at the gene, species, and ecosystem levels enables a smoother transition of extreme climatic and environmental phenomena in agricultural ecosystems, making them more resistant to abiotic and biotic stresses. Maintaining biodiversity is essential to sustaining ecological functions and processes that ensure soil fertility and the excellent productivity of agricultural ecosystems (Erisman et al., 2016). By maintaining high biodiversity, the farmer can obtain higher and more stable crops of higher quality and reduce or eliminate the use of pesticides (Feledyn-Szewczyk et al., 2016). Many species favour the pollination of arable crops (Radzikowski, 2018). Proper development and yielding of about 70% of cultivated species and about 35% of food produced in farmland depend on the presence of pollinating insects. Large numbers of bees and other pollinators in the rural landscape allow for obtaining high-quality crops. The bee population, in turn, depends on the diversity of the flora of the honey-bearing species. While food security is becoming more and more focused on and linked to biodiversity,

DOI: 10.34659/eis.2022.83.4.535

this is mainly true of above-ground biodiversities such as plants and animals. Far too little attention has been paid to biodiversity beneath the feet in the soil, yet it is what drives many of the processes of producing food or cleaning soil and water.

As already mentioned, greenhouse gas emissions are also associated with agricultural production. Limiting global warming to 1.5°C requires rapid and far-reaching social and economic changes in line with the dynamic development of societies and the economy. Transformations are necessary for all areas of socio-economic life, especially changes in the philosophy of approach, development, and management, and legal changes in the areas of energy, transport, infrastructure, industrial systems, economy, business, technology, health, safety, water and environmental management and politics, communication and social participation. Transformation of economic systems should rely on actions limiting and reducing emissions in all sectors, introducing adaptation measures, and increasing pro-environmental investments. In Polish rural areas, attempts have been made for many years to use innovative system solutions (Kostecka & Kostecki, 2016a).

Agri-environment-climate activities

The solution supporting environmental protection in rural areas is currently the second pillar of the Common Agricultural Policy (CAP) of the EU, enabling the practical application of many educational programs and projects. It consists of farmers' services for the environment (Bogactwo wsi, 2022). The benefits include adjusting agricultural (field and livestock) production to environmental protection requirements. These are the so-called agri-environment-climate measures. These programs aim to protect the existing natural ecosystems in rural areas, restore the values or maintain the condition of valuable agricultural habitats and preserve biodiversity by promoting a sustainable management system, appropriate use of soils and water protection, and protection of endangered local livestock breeds and local plant varieties of arable crops (Ministerstwo Rolnictwa I Rozwoju Wsi, 2011). The solutions used in the United States were the prototype of agri-environmental programs. They were based on voluntary agreements of environmental organisations and local authorities with farmers to protect natural and landscape values. Due to the monocultural and industrial nature of the agricultural economy, the American concept of agri-environmental programs was based on the assumption of a contradiction between this economy and the preservation of environmental values. The main task of the current agri-environment-climate programs is to restore agricultural land to a state of natural homeostasis. The use of industrial production methods in agriculture should consider the latest technical solutions in this area (Samborski, 2018).

DOI: 10.34659/eis.2022.83.4.535

As part of the Common Agricultural Policy, the so-called "agri-environmental packages" aim to protect biodiversity in agricultural areas (Kozłowska-Burdziak, 2020; Stalenga et al., 2016).

At the stage of declaration and implementation of the package, the farmer should cooperate with an agri-environmental advisor and, in the case of packages implemented on permanent grasslands, with a nature expert. Using a package or several packages on the farm may bring tangible financial benefits to the farmer.

Plant alternation (rotation)

The selection of the forecrop and the rotation (succession of plants) in the field plays a prominent role, among others, in the stable yielding of crops and the quality of the obtained crop. This issue was considered from the beginning of agricultural development (Chmielecki, 1956). Cultivating the same species in a given field (monoculture) for many years results in a decrease in yield, soil impoverishment, and accumulation of pathogenic factors (Feledyn-Szewczyk et al., 2016). These problems can be eliminated or minimised using crop rotation and a fixed and planned sequence of plants (Barbieri et al., 2017). The model crop rotation in agriculture is the Norfolk four-field crop. It began to be used in England in the 17th century. This cultivation system divided the farm acreage into four fields of similar size, where they have grown in the following years: root crops (potatoes), spring crops, legumes, and winter crops. As a very effective agricultural production system, the Norfolk four-field farm was quickly adopted all over Europe, where it was widely used until the second half of the 20th century. Unfortunately, at the end of the 20th century, the Norfolk crop rotation was replaced by intensive agriculture based on the achievements of the agricultural revolution (mineral fertilisers, pesticides, modern varieties). Currently, there is a belief that obtaining very high yields of the species grown in monoculture is possible. However, agricultural practice and climate change prove that modern pesticides do not destroy all plant pests and diseases. In monocultures, chemicals accumulate in the soil, and high doses of mineral fertilisers cause the depletion and depletion of organic matter in cultivated soils. These unfavourable processes begin to be minimised and eliminated in so-called sustainable agriculture, especially in organic farming. In small cultivated areas and the conditions of backyard farms, the phytosanitary effects of some plant species or the so-called positive allelopathy (secretion by one species into the environment of substances supporting the growth of the other species). Enrichment of the soil with nitrogen from atmospheric nitrogen-fixing legumes with nitrogenous bacteria (e.g., vetch, lupine, red clover, sunflower) is also included.

DOI: 10.34659/eis.2022.83.4.535

Ecological agriculture in balancing the environmental burden of rural areas

Organic farming is a pro-environmental method of agricultural production. The European Commission indicated it in both the biodiversity strategy and the *From Farm to Fork* strategy, where the goal of achieving 25% of crops in the European Union in the organic farming system by 2030 was set (EC, 2022). As can be seen from Table 3, this is an ambitious goal because the total area of ecological agricultural land in the EU in 2020 has reached 9%.

In 2015, 271,349 organic farms in the EU were operating in 11,935,317 ha (Table 3). The cultivation of cereals occupied the largest area of ecological agricultural land. Permanent grasslands were in second place. In 2019, in livestock production, the production of eggs and fish increased significantly, and the number of animals, especially poultry, increased. Moreover, the number of entities preparing organic products for direct consumption has significantly increased (FAOSTAT, 2022).

Table 3. Selected features of organic farms in 2005-2020 in the EU, the Netherlands, and Poland

Specification	Year	European Union	Netherlands	Poland
Number of organic farms	2005		1 377	7 182
	2010		1 462	20 582
	2015	271 349	1 475	23 015
	2020		1 937	20 274
Area of ecological agricultural land [ha]	2005	6 362 954	48 765	166 298
	2010	9 174 505	46 233	519 068
	2015	11 935 317	49 273	580 730
	2020	14 719 036	71 607	509 291
Percentage of the total agricultural area	2005	3.8	2.5	1.0
	2010	5.1	2.5	3.3
	2015	6.6	2.7	4.0
	2020	9.0	3.9	3.5

Source: author's work based on Eurostat. Area for organic farming.

Organic agricultural production places the most significant emphasis on environmental protection and animal production on animal welfare considerations. Gives up or drastically restricts synthetic chemicals such as fertilisers, pesticides, additives, and medicinal products. The production of genetically modified organisms (GMOs) and their use in animal feed are prohibited. It is part of a sustainable farming system and a viable alternative to more traditional approaches to agriculture. Organic farming requires regulated standards (production rules), critical control systems, and a specific labelling system, unlike other agricultural production methods.

The European Parliament and the European Commission have adopted the 2030 targets for organic farming. They assume limiting the use of the most dangerous chemical plant protection products by 50%, limiting mineral fertilisers by at least 20%, and limiting the loss of nutrients by at least 50% (Eurostat, 2022).

Organic farming is a system that positively influences the natural environment, contributing to achieving broadly understood agri-environmental benefits. It is also a response to the changing structure of market demand and growing consumer awareness. As part of the most extensive public consultation in the history of the European Union carried out to guide changes in the legislation on organic production, consumers indicated that they are ready to pay higher prices for products produced with respect for the environment and animal welfare (IJHARS, 2018).

Field plantings in the system of conventional agriculture

The farm forms a large functional whole with the possibly closed circulation of matter. Large monoculture farms in conventional agriculture impoverish the agricultural landscape and reduce the biodiversity of flora and fauna. Therefore, in shaping the value of the rural landscape, one should consider such elements as the size and distribution of fields and the surroundings: bushes, clumps or stripes of shrubs and trees, watercourses and reservoirs, the sequence of arable land and grasslands, and high woody vegetation – the so-called in the field. Trees are the allies of the farmer; their importance increases, especially in forestless spaces and areas with light soils, an insufficient amount of precipitation, and limited resources of ground and soil water. The measurable importance of tree stands is: the protection of fields against the harmful effects of winds, maintaining air humidity in the ground layer, limiting wind and water erosion on light soils, and increasing water retention in soil. They are also a habitat for many fauna species that help fight diseases and pests of crops.

Row, strip, or clump plantings should be introduced in a landscape with insufficient or improperly distributed woody vegetation. As their location can and should be adapted to the needs of agriculture, they should be considered the most crucial tree formation, especially in a lightly forested landscape (Ministerstwo Rolnictwa i Rozwoju Wsi, 2019).

DOI: 10.34659/eis.2022.83.4.535

Assessment of the case of Hajnówka county as a model of the organisation of harmonious development of agriculture

The Hajnówka county is located on the eastern edge of the Podlaskie Voivodeship in the Republic of Poland (52.733333 = 52° 43′ 59″ φ N; 23.566667 = 23° 34′ 0″ λ). It borders Belarus from the east, Siemiatycze county to the south, Bielsko county to the west, and Białystok county to the north. Agriculture is one of the most critical sectors of the economy of the Hajnówka county (Raport, 2019).

The forest area in the Hajnówka county covers 88,000 ha, and the forest cover index (forest area relating to the total area of the unit) amounts to 53.2%. It is higher than the national average by 24%. The large forest cover of the analysed area creates favourable conditions for the use of the remaining district area sustainably due to the favourable microclimate and reduced air pollution by forest communities. The forests occur in the dense complex of the Białowieża Primeval Forest and separate complexes. The most numerous are pine forests. Scots pine is the essential forest-forming species, and Norway spruce forms groups of low boreal spruce forests. As a result of climate change and the lowering of the groundwater level, spruce is disappearing, also under the influence of the bark beetle infestation.

Protected areas are on 95 415 ha (Sawicka & Tomaszewska, 2012). In the eastern part of the county, there is the Białowieża National Park (with an area of 10,517.3 ha), classified as a UNESCO biosphere reserve. In the county, the protected landscape areas of the Narew Valley and habitat areas under Natura 2000 have been separated. Two protected landscape areas are under protection: a forest complex around the Białowieża Forest and a part of the protected landscape of the Narew Valley, with a total area of 84,490.8 ha, and 23 nature reserves covering 12,340.3 ha of land. In the Hajnówka county, 701.9 ha of ecological land was also established (Sawicka & Tomaszewska, 2012). In total, protected areas cover about 59% of the district's area, which is close to Wilson's (2016) concept, postulating that half of the Earth should be allocated to strict nature reserves, which could help save biodiversity for its own sake and human well-being.

There are about 8,000 farms in Hajnówka county, 72% of which are family farms with an area of 1-2 ha. On the other hand, over 500 farms have an area of over 15 ha; there are also several hundred hectares of farm-type farms located in the communes of Narew, Hajnówka, and Czyże (Strategia, 2014; Roszkowska-Mądra, 2014). In communes with light soils, a significant part of the arable land is used extensively or periodically fallow, contributing to biodiversity protection (Kiryluk, 2009).

The soils of Hajnówka county arose and were shaped under the influence of glaciation and, in later periods, also under anthropogenic activities. They

DOI: 10.34659/eis.2022.83.4.535

are diversified, which is also a natural advantage of this county, which has podzolic, brown, fawn, rusty soils, various forms of glazed soils, and organogenic soils in river valleys and peat bogs: black earth, muck soils, and peat of transitional, low and high fens. River marshes also occupy relatively small areas. Large areas are fertile brown soils, stuck brown soils, and deer. According to IUNG data, the average index of the quality of agricultural production space in Hajnówka county is 52.6 points, with the average index for Poland being 66.6 points (Biesiacki et al., 2004). Most of the soils in this area are low in nutrients (nitrogen, phosphorus, potassium). It is estimated that the shortages of these components concern about 60% of the agricultural land, depending on the commune. Percentage share of soil valuation classes in the county: class I-0%, class II-0%, class III -9.6%, class IV-36.8%, class V-34.7%, class VI-18.9%. Nutrient deficiencies in soil are unfavourable for its fertility and the diversity of zooedaphone from the invertebrate group. These facts weaken the ecosystem services of soil ecosystems, and consequently, humans receive crops of incomplete nutritional value.

There are natural minerals in Hajnówka county: gravel, sands, as well as significant clay deposits near Lewkowo Stare, Trywieża, and Czyże, often surrounded by agricultural lands (PIG, 2022). It generates a great variety of habitats. Due to the legal status of this county in terms of nature protection, the exploitation of these minerals cannot be extended due to the threat to agricultural and valuable natural areas. Attempts were made to exploit peat for non-agricultural purposes from the Bagno Tyniewicze low peat bog; however, the project will not be implemented due to active and long-distance socio-ecological pressure.

In the last 20 years, the structure of crops on arable land has also changed in Hajnówka county (Table 4). It transforms complex companion biodiversity groups. The disappearing plants include potatoes, sugar beets, flax, and others.

Table 4. Changes in the sowing area of more essential crops in the Hajnówka county in 2005-2020 [ha]

Years	Agricultural land	Permanent grassland	Rye	Wheat	Triticale	Maize	Potatoes	Oilseed rape and agrimony	Barley
2005	67 588	27362	5587	4 227	1 049	983	200	97	862
2010	44 030	15 260					682	1433	
2015	44 493	16 690	1143	4034	2380	2476	87	1304	380
2020	46 992	16 473	2113	8408	3652	4805	163	3195	231

Source: authors' work based on GUS [19-05-2022].

DOI: 10.34659/eis.2022.83.4.535

Potato cultivation area of edible and fodder varieties decreased in Hajnowski county to about 200 ha. It was a plant with a long-standing cultivation tradition and high nutritional importance in the region. The reduction in the size of the cultivation of these plants is due to the high labour consumption, low profitability, and the introduction of industrial fodder in livestock production. The decrease in legume cultivation is disturbing. The lack of these plants in field crops reduces the abundance of organic matter in soils and the assimilation of atmospheric nitrogen. There is also a downward trend in winter rye cultivation (Kiryluk, 2009). The cultivation area of oats, triticale, and barley also decreased slightly. It is due to the lower demand for these grains. Wheat cultivation is systematically increasing, resulting from the profitability and the use of new high-yielding varieties. Industrial feed producers are increasingly using wheat in their feed production. On the other hand, the cultivation of oilseeds, especially winter rape, is increasing significantly and systematically. Oilseed rape is grown on farms that produce cereals as part of the crop rotation. There is an increase in maise cultivation in the district, both silage and grain. It is often grown as the only plant on arable land. Still, negative phenomena must be considered (erosion, decrease in the content of humus and nutrients in the soil, growing weed infestation, and infestation with diseases and pests). Several hundred-hectare corn plots have recently been contracted as a long-term raw material for the existing biogas plant. The fermented manure, slurry, maise silage, and other agricultural waste make it possible to provide the biogas plant in Stary Kornin with at least 1,373,000 m^3 of methane. It is the equivalent of approximately 13,689 MWh of energy (Strategia, 2014).

Relating to the EU countries and the Netherlands, the applied mineral fertilisation for crops in Hajnówka county is low (Table 5). The pesticide application here is 1.17 kg of active substance per hectare (Łozowicka & Konecki, 2011). The most significant pesticides are used here in horticulture and rape cultivation.

Table 5. Consumption of mineral fertilisers, applied pesticides and CO_2 emissions as greenhouse gas equivalent in agricultural areas of the Hajnówka county

Years	Nitrogen N [kg × ha^{-1}]	Phosphate P_2O_5 [kg × ha^{-1}]	Potassium K_2O [kg × ha^{-1}]	Pesticide – use per cropland area [kg × ha^{-1}]	Emission of CO_2 (calculated data) [kilotons]
2005	-	-		-	61
2010	63.3	23.4	29.1	1.17	89
2015	-	-		-	66
2020	63.1	27.4	33.4	-	54

Source: authors' work based on GUS [19-05-2022].

DOI: 10.34659/eis.2022.83.4.535

The development of conventional agriculture leads to the natural impoverishment of the agricultural production space of the Hajnówka district. Failure to adjust the intensity and forms of agriculture to the natural conditions of agricultural production results in the activation of water and wind erosion and groundwater contamination. Pig and poultry farms (some of them require integrated permits) are also a threat to the environment. Their number decreased due to failure to meet the requirements and certification criteria.

In the Hajnówka county, there are perfect conditions for creating ecological farms producing high-quality food: vegetables, fruit, cereals, and meat (Table 6). Organic farming, run by family farms, creates local, independent, and short supply chains, enhancing food security and positively influencing public health and the environment. The total agricultural land under organic farming in Hajnówka county is only about 1%.

Among the ecological crops in the fields in Hajnówka county, there is a lot of buckwheat *Fagopyrum esculentum* and the health-promoting plantain *Plantago lanceolata* (Figure 2).

Table 6. Organic producers and the area of ecological agricultural land in 2005-2020 in the Hajnówka county

Year	Number of organic farms	Area of organic agricultural land [ha]	Percentage of the total agricultural area
2005	164	208.6	0.3
2010	339	795.2	1.8
2015	155	476.1	1.0
2020	90	532.1	1.1

Source: authors' work based on GUS [19-05-2022].

Organic cultivation of common buckwheat *Fagopyrum esculentum*

Organic cultivation of plantain *Plantago lanceolata*

Figure 2. Ecological cultivation in the fields in the Hajnówka county

Great potential for reducing anthropopressure in rural areas is given by the production of renewable energy in livestock farms. This includes the use of manure and other waste to produce biogas. Hou et al. (2017) showed an emission reduction of around 17% by analysing 12 different technologies that have been tested in different countries of the European Union.

Anaerobic fermentation turned out to be the most advantageous technology for GHG reduction. Manure composting is also an excellent solution to reduce emissions and obtain valuable and safe organic fertiliser. The use of digestate from agricultural biogas plants for soil fertilisation can significantly reduce the use of energy-consuming synthetic fertilisers. Lyng et al. (2018) developed models for optimising manure management. They showed that biogas production in small domestic installations and centralised biogas plants is profitable and contributes significantly to reducing emissions. It also makes it possible to generate an alternative energy source in dairy farming, which can be converted into heat or electricity. This renewable energy can significantly cover the energy demand of farms.

Recently, large photovoltaic farms have been located in agricultural areas in the Hajnówka commune, e.g., in Nowoberezowo and Dubiny. They are an essential part of renewable energy sources in the pro-environmental energy balance of the district. They were located on land with low valuation classes and did not diminish the landscape values. For ecological and aesthetic reasons, large-scale cultivation of energy crops, mainly maise in monoculture on arable land of medium and reasonable valuation classes, is not desirable. Perennial cultivation of energy crops reduces landscape values and biodiversity in agroecosystems.

Organic and sustainable agriculture arising in micro-regions requires support and the removal of administrative barriers that inhibit this development today. The agri-environmental and climate packages introduced under the Rural Development Programs aim to protect the existing natural ecosystems, restore the values or maintain the condition of valuable agricultural habitats, and preserve biodiversity. As mentioned many times, a necessary action to maintain biodiversity in rural areas is popularising knowledge in a sustainable society and the multifunctional importance of these areas.

New transformation concepts are urgently needed, developed in cooperation with local government officials, scientists, and active activists for rural areas, cities, ecology, and social welfare (Dearing et al., 2010). Humanity cannot afford to expect excessive and infinitely increasing materialistic prosperity. We have long lived on credit for ecosystem services, which means we use too many resources. You need to focus on high-quality public services and satisfaction of basic social needs while approaching ecological barriers cautiously (loss of biodiversity, climate change, use of water resources, loss of the ozone layer, ocean acidification, air pollution, chemical pollution of the

DOI: 10.34659/eis.2022.83.4.535

planet, unsustainable use of the surface, disruption of the nitrogen and phosphorus cycle), which humanity – if it wants to avoid catastrophes – should not exceed (Rockström et al., 2009; Nordhaus et al., 2012).

It is necessary to start with the regeneration of ecosystems and consider that the consumption of materials and energy occurs within the ecosystem cycles and their boundaries (Balmford et al., 2011). Since climate and biodiversity protection are now more important than economic growth for the survival of people, we must strive to slow down the production chain of goods and services and minimise the transformation of ecosystems (Kostecka, 2019; Hardt, 2017). It should be organised within the framework of the new European Green Deal. However, we need new and good ideas. One of them may be *The Amsterdam City Donut* (Rawortht, 2020) project/program that reconciles the interests of people and the planet, caring for development and prosperity in society while protecting natural ecosystems and resources of the Earth.

The above assumptions and actions correspond to removing the negative consequences of anthropopression and preventive actions in large areas, in line with the sustainable development of the entire planet. The chances of success here are only a logical and practical combination of local spatial development strategies built into regional strategies and, finally, a global sustainable development strategy at all the abovementioned levels. The Hajnówka county has a chance while maintaining over 50% of the area as a protected space, to develop with care for soil biodiversity and the restoration of other habitats and ecosystems. To establish a different development strategy, the decision-makers of this socio-economic area should actively update the value of their natural environment resources and social and economic needs, and then, for example, using the possibility of using an integrated index method for determining the value of environmental resources to determine the direction of development of a rural commune (Majewska et al., 2017), take long-term strategic steps that give future generations a chance to live in broadly understood well-being. When determining the conditions for the development of the county and communes, apart from determining the strengths and weaknesses of the area, one should; develop indicators of sustainable development based on data from the Local Data Bank and own research and determine the state of the natural environment of the entire area along with the level of its sustainability. The opportunity for new development directions should also be considered by defining the possible functions of these areas and activities shaping the environment. The natural and agricultural environment components should be considered, such as the current structure of land use, the quality of agricultural production space, water resources, soil, air, biodiversity, and landscape. Still, it may turn out that it will be necessary to take actions supporting the sustainable development of

DOI: 10.34659/eis.2022.83.4.535

some of these areas, and this most often concerns landscape elements (Majewska et al., 2017; Kostecka & Kostecki, 2016a), the greatest strength of rural areas is usually their biodiversity. This component can be used not only for the productive function of the village but also for the ecological or recreational function. It makes it possible to diversify residents' earnings towards various forms of tourism.

It is worth organising for tourists to develop and improve sustainable tourism, broadly understood as "educational trips in rural areas". They should enable tourists to contact an interesting place, provide them with exciting experiences, and provide the knowledge that provokes them to search for new information, solutions, examples, and motivation to use positive patterns or situations in their lives. After completing a well-prepared "educational journey," a tourist is many issues while travelling can be viewed differently.

Organising "educational trips for sustainable development" can function with the participation of clusters, which allows cooperation of many elements and institutions, starting from the district self-government and communes. The concept of clusters interests scientists, politicians, and entrepreneurs. It would be good if as many people as possible were persuaded to take sustainable actions for the local, regional or national economy. The functioning of the cluster economic system supports the tightening of cooperation between enterprises, increasing the productivity of production factors, implementing new technological solutions, improving the quality and directions of staff education, creating a regional brand, and using external sources of financing. The benefits for the external environment include the increase in the availability of specialised business-related services, investments in infrastructure, reduction of unemployment, increase in professional activity and income of the population, and, consequently, sustainable local and regional development. There may be entities closely related to tourism in a tourism cluster, e.g., accommodation facilities, restaurants, travel agencies, tourist carriers, and tourism-related entities: banks, insurance agencies, consulting companies – mainly small and medium-sized enterprises, highly specialised, connected with trust but competing.

In the era of exhaustion with the increasing pace of life, "educational trips" have a chance to become, for example, an exciting and attractive place to implement various forms of slow tourism embedded in nature. In this case, many places with elements of the existing traditional infrastructure may start to function as a cluster, creating an organisational structure of great economic importance (Kostecka & Kostecki, 2016b).

We must solve these and other problems significant for human survival in the ongoing and starting Decade of Ecosystem Restitution (2021-2030).

DOI: 10.34659/eis.2022.83.4.535

Conclusions

In the 21st century, agriculture has evident pressure on the natural environment. It is mainly due to the marketisation of agriculture and the focus of this activity on production maximisation. Meanwhile, agroecosystems are the basis of life and many other human activities. They influence the circulation of matter and energy and fulfil many regulatory functions in terrestrial ecosystems. Excessive and uncontrolled development of agriculture, especially large-scale crop production and industrial livestock breeding, threatens biodiversity, reduces the population of many species, and, consequently, reduces ecosystem services in these areas. It is increasingly common to believe that agriculture is essential not only because it produces the most important food products for human existence but also fulfils many social, cultural, and ecological functions. In most European countries, more than half of the area is used for agriculture. The farmer protects one of society's most valuable resources: agricultural land and many natural goods. Maintaining these resources properly for present and future generations is of the utmost importance. Human functioning in 21st-century civilisation requires new patterns of behaviour. Slowing down the processes of the negative impact of agriculture on the environment is possible, among others, by introducing integrated and regenerative farming methods (recommended by the Common Agricultural Policy of the EU) and other pro-environmental activities. In the long term, reducing species biodiversity in agrocenoses and introducing monocultures in field crops will limit plant biomass production due to reducing the yielding capacity of the soil and the impact of zoocenoses on the functioning of ecosystems.

The analysed Hajnówka county is an excellent example of an attempt to combine pro-environmental farming and nature protection by covering a large fragment of space with forms of area protection. It is in line with the concept of allocating half of the Earth to strict nature reserves and the assumptions of the Decade of Ecosystem Restitution (2021-2030). Such activities can help save biodiversity and ecosystems and benefit people and their well-being.

The lack of an apparent increase in macroeconomic factors does not eliminate the chances of a good life. We only need consistent reduction of negative anthropopressure and implementation of possible solutions.

Effective measures to reduce anthropopressure in agriculture include inhibiting but also adapting to climate change, reducing biodiversity loss and restoring ecosystem services. This is a priority, although it must not come at the expense of other sustainable development goals, especially those related to efforts to reduce poverty and hunger by 2030.

DOI: 10.34659/eis.2022.83.4.535

Countries that are parties to the Paris Agreement take measures to reduce greenhouse gas emissions. Priorities that directly affect, e.g. livestock include: increasing the efficiency of livestock production and resource use, intensifying recycling efforts and minimising losses for a circular bioeconomy, and reaping the benefits of the solutions based on the natural resource in order to increase the reduction of CO_2 emissions. What is also important is a comprehensive approach related to the changes in the applicable European law.

In the future of sustainable plant and animal production, the achievements of genetics, genomics, bioinformatics, statistics, automation, robotics and computer science should be of great importance. All these should also be embedded in the local natural conditions and to the satisfaction of the producers.

Recycling efforts should be stepped up and waste minimised for the circular bioeconomy. Agri-food systems rely on natural resources as the primary means of production; some natural resources are used too quickly, jeopardising their recovery. Promoting a "circular bioeconomy" instead of a linear extraction, production, use and disposal process includes recycling resources at every possible stage of agri-food systems and optimising the functioning of existing systems to minimise waste. Increased circulation in food systems, where waste from one process becomes raw material for another, is a way to increase food production efficiency.

It is estimated that about 30% of all crops are grown to feed livestock, and some animals are kept in mixed farming and breeding systems, including agroforestry and forest-pasture systems. Agriculture is a direct cause of global deforestation. Stopping such activities for forage production and grazing can be one of the most effective ways of mitigating the climate change impact on farming systems.

Extensive and semi-intensive grassland can provide much-needed carbon dioxide absorption. Well-designed grazing systems can stimulate plant growth and capture carbon in the soil, especially in areas where degradation is not yet significantly present.

The research shows that grazing farm animals are essential for sustainable development and biodiversity protection. This is gaining popularity due to the benefits it brings to valuable natural ecosystems, helping to maintain soil fertility and organic fractions, regulating water, reducing the occurrence of pests and diseases, and maintaining biodiversity.

There is also scope for wider use of land and buildings associated with livestock farms for locating solar and wind farm installations. The economics of such compensation would have to be beneficial to livestock farmers, and appropriate mechanisms for accounting for carbon dioxide emissions should be introduced so that the resulting emission savings are compensated against those generated by livestock. Conservation and ecosystem restoration is

DOI: 10.34659/eis.2022.83.4.535

a global problem that requires well-integrated local, national and regional solutions.

The Hajnówka county may continue to undergo a favourable transformation and become a model of pro-environmental development with minor changes. It would be advisable to return to the traditional agricultural production methods and effectively protect the trees and vegetation that make up the ecological corridors. It is necessary to comprehensively support the development of organic farming for the local and national market and export. The existing area of organic farming should be considered minimal and not take advantage of the environmental conditions in the county.

When limiting the cultivation of maise for biogas instead of for food or fodder, a proper balance of municipal waste biofraction should also be made. Assuming that some of the best quality fractions will be composted and returned to the soil, the poorer-quality ones can be converted into energy without forgetting the necessary energy-saving strategy. One should also not forget about the aspect of social development, organising it to increase the profitability of pro-environmental farms.

We must solve these and other problems essential for human survival in the Decade of Ecosystem Restitution (2021-2030) that has just begun to build a sustainable human welfare strategy using wisely the resources of matter and energy recreated innately. It should also be emphasised with complete conviction that without a broad front of activities, including continuous education of the society, also through "educational trips", neither provisions in fundamental legal acts nor those announced by international bodies of the Decade (Decade of Education for Sustainable Development (2005-2014), The Decade of Biological Diversity (2011-2020), the International Decade of Soils (2015-2024) and the Decade of Ecosystem Restoration (2021-2030)).

The use of ecosystem services will be permanent and easier when the elements of the decade of ecosystem restitution are widely disseminated and rooted in the civic consciousness of the inhabitants of Poland and similar spaces in Europe. For this to happen, this decade of ecosystem restitution must be advertised as widely as possible, writing and talking about it in various contexts.

Acknowledgements

The research was funded by The Scientific Subvention of Bialystok University of Technology, Poland, as part of research project no. WZ/WB-IIŚ/2/2021

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Aleksander Kiryluk – 50%
Joanna Kostecka – 50%

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CHALLENGES FOR AGRICULTURE IN POLAND RESULTING FROM THE IMPLEMENTATION OF THE STRATEGIC OBJECTIVES OF THE EUROPEAN GREEN DEAL

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ABSTRACT: The aim of the paper is to indicate the most important challenges for agriculture in Poland in the context of the implementation of the European Green Deal and the Polish Strategic Plan for the Common Agricultural Policy for the years 2023-2027. The primary tool used in the study was a comparative analysis of legal EU and Polish documents. This comparison was supplemented by an analysis of statistical data on agriculture in Poland, mainly covering 2005-2020, obtained from the Agricultural Census 2020, Statistics Poland, the National Centre for Emissions Management, the Agricultural and Food Commercial Quality Inspection and the European Medicines Agency. The results show that the Polish national targets for 2030 are significantly lower than the European ones but have been set, taking into account the feasibility of their implementation, which means that meeting each of the primary national targets in the agricultural sector will be very challenging.

KEYWORDS: European Green Deal, agriculture, climate change, Common Agricultural Policy, Poland

 DOI: 10.34659/eis.2022.83.4.534 JEL: Q01, Q15, Q18

Introduction

Agriculture is an economic sector necessary for the proper functioning of society. Thanks to it, we are provided with a basic need, i.e. food security. The development of civilisation caused huge changes in the field of agricultural production, which ensured relatively easy availability of food and thus facilitated the rapid growth of the human population. As societies, we have become accustomed to this situation. At the same time, despite significant changes in agriculture, this sector is still dependent on the natural environment and climatic conditions. This dependence is often overlooked in business activities.

In the era of rapid changes taking place in the natural environment, the conditions for the functioning of agriculture are changing. This is mainly due to climate change, but agriculture, through its activities, affects the natural environment by changing agricultural production conditions. In this way, we are dealing with a feedback loop, i.e. the interaction of agriculture and the natural environment. Agriculture, as a result of intensive production, changes the atmosphere, leading, i.a., to the degradation of the soil, the reduction of biodiversity and changes in water relations and climate, which in turn affects the conditions of agricultural production. This situation means that after years of dynamic development, there are periods of lower harvest, which, combined with growing consumption, means that food is more expensive, and access to it may again be difficult. The trend of degradation of the natural environment under the influence of agriculture is likely to continue in the coming years.

For more than three decades, the need to implement the principles of sustainable development, including the agricultural sector, has been pointed out. The United Nations' latest project, the 2030 Agenda, contains 17 global goals that should be achieved by 2030. Of these, in agriculture, the second objective is important, i.e. "Eliminate hunger, achieve food security and better nutrition, and promote sustainable agriculture" (United Nations, 2015). The goal presented in this way shows the direction of changes in which global agriculture should go.

The European Union's actions are part of the global 2030 Agenda, which is reflected in the European Green Deal strategy (European Commission, 2019) announced in December 2019. This document determines the direction of changes taking place at the Community level. One of these directions is a group of goals aimed at increasing care for the natural environment in the agricultural sector. The objectives in this area are described in detail in two complementary strategies, i.e. Farm to Fork (is part of the global 2030 Agenda, which is reflected in the European Green Deal strategy (European Commission, 2020a) and the Biodiversity Strategy (are part of the global

DOI: 10.34659/eis.2022.83.4.534

2030 Agenda, which is reflected in the European Green Deal strategy (European Commission, 2020b). Important environmental objectives are linked to mitigating climate change, but new, more ambitious specific targets have not yet been introduced in this respect.

The adopted commitments are implemented into Polish national solutions in the field of agriculture and make it necessary to adapt to new requirements as far as possible. Such actions have been taken, and as a result, the European Commission approved Polish Strategic Plan for the Common Agricultural Policy for 2023-2027 in August 2022 (MRiRW, 2022). This document contains the goals that agriculture in Poland must achieve. The question, therefore, arises as to how different the national targets are, compared to those adopted by the European Union as a whole and why this difference arises. In addition, it is important to determine how large the gap is between the commitments made and the current situation in agriculture. Its indication will allow us to determine how much effort should be made from the perspective of 2030 and what the path of agriculture in Poland to sustainable development looks like.

This paper aims to indicate the most important challenges for agriculture in Poland in the context of the implementation of the strategic objectives of the European Green Deal and the Polish Strategic Plan for the Common Agricultural Policy for the years 2023-2027. The study was based on our empirical analysis and on a review of the available literature and documents of the European Union and Poland.

An overview of the literature

The European Green Deal is the European Union's fundamental development strategy for this decade. For this reason, this strategy is often described in the scientific literature (i.a., Siddi, 2020; Lapiere & McDougall, 2021), popular science (e.g. Sachs, 2019) and journalism (e.g. Harvey & Rankin, 2020). This document, although in its nature is a part of the current path of sustainable development of Europe, in fact, even more strongly accepts the need to protect the environment and climate in the broadly understood economy compared to previous strategic documents.

The basic assumptions of the European Green Deal strategy and its importance are extensively explained by the European Commission on its website (European Commission, 2022). The aim is to build a modern, resource-efficient and competitive economy in the perspective of 2050 characterised by: climate neutrality, separation of economic growth from the use of natural resources, and care for residents. Achieving such a goal requires changing the philosophy of thinking about the economy and development. The objectives

DOI: 10.34659/eis.2022.83.4.534

are to be achieved, i.a., through the circular economy and to cover a wide range of activities of EU residents. Revolutionary changes should lead to a reduction of pollutant emissions, creation of new jobs and economic growth, reduction of energy poverty, reduction of external energy dependence and improvement of health and quality of life. These objectives are to be achieved with the contribution of all member states of the European Union and various economic sectors. The assumed pro-environmental and pro-climate transformation of Europe, as planned, will be co-financed by the EU and supported by the scientific community. However, the noble strategic objectives enshrined in the European Green Deal concern only the area of the European Union, which assumes the ambitions of a leader in this area in terms of the whole globe (Communication, 2019; Wrzaszcz & Prandecki, 2020; Gradziuk et al., 2021).

Ambitious EU goals and the pace of achieving them are differently assessed in the literature. On the one hand, the European Green Deal is treated as a desirable and even necessary step (Bongart & Torres, 2021; Switch-2green, 2022; van Zeben, 2020), and on the other hand, heavily criticised, especially for the pace of change. The direction of change also meets with criticism (Tomson, 2021). The latter is particularly noticed in Polish journalism. This attitude of the Polish authorities is also noticed in the international press (The Economist, 2021). It results partly from national conditions, which make it very difficult for Poland to meet the requirements of the European Green Deal (Kancelaria Senatu, 2020). This is mainly due to the energy system, which is predominantly based on coal and causes high emissions of pollutants, including greenhouse gases. Difficulties with changing the energy mix mean Poland is treated as the main deceleration factor of change processes.

The European Green Deal strategy is a crucial document outlining the direction of economic development. At the same time, detailed strategic objectives for individual sectors are specified in subsequent strategic documents developed by the European Commission. One of the sectors that are particularly important in the context of the stabilisation of the natural environment and climate is agriculture. Its importance is determined by the use of agricultural land – its area and management method. Agricultural practices provided by farmers determine the state of the natural environment and climate, mainly due to the scale of emissions of gases of agricultural origin (Ahmed et al., 2020; Zegar, 2012).

The relations between agriculture and its surroundings – the environment and climate – are bidirectional. Agriculture absorbs components of the environment due to their productive importance, including water and soil. The quality of agricultural practices determines the environmental and climate pressures and further their importance in supra-local terms. A properly

DOI: 10.34659/eis.2022.83.4.534

conducted agricultural economy is an integral part of the ecosystem, while incorrect farming contributes to its destabilisation. Therefore, sustainable economic development is impossible without sustainable development of agriculture, which, in addition to its economic and social significance, is also assigned a particular environmental and climatic significance (Sadłowski et al., 2021; Wrzaszcz & Prandecki, 2020; Zegar, 2012).

The objectives for the agricultural sector are set out in the strategy and further described and justified in specific documents, i.e. in Farm to Fork (European Commission, 2020a) and the Biodiversity Strategy (European Commission, 2020b). In addition, many provisions on combating and adapting to climate change are linked to agriculture. Although the "Fit for 55" package has not entered into force (The Greens/EFA, 2022), its assumptions are still being processed (European Council of European Union, 2022), and the overall target for 2030 is to be achieved, although it seems less and less likely.

Those mentioned above European thematic strategies point to the problem areas of European agriculture, which should be included in the national strategic plans, clarifying agricultural practices and administrative activities adequate to the scale of the problem occurring in a given country. This approach results from the legitimacy of eliminating specific environmental and climate problems, as well as the need for administrative efficiency – both in terms of environment, climate, as well as production and economy (Czyżewski et al., 2020; Prandecki et al., 2021).

The changes in the agricultural sector brought about by the European Green Deal are being analysed in detail. In most cases, it is indicated that the direction of change is correct. It should be emphasised that considerations related to climate problems dominate (Rivas et al., 2021), but other issues are also addressed, i.a., the importance of soil condition (Montanarella & Panagos, 2021; Heuser, 2022; Fayet et al., 2022).

The implementation of the European Green Deal in agriculture is also criticised (Purnhagen et al., 2021) as contradictory or hindering the implementation of sustainable development. In this regard, criticism concerns the financing of the Common Agriculture Policy as an instrument supporting harmful, intensive agricultural practices and the lack of promotion of a healthy diet (EEB, 2022).

In Poland, the problem of the European Green Deal is also widely discussed in the context of agriculture. In many articles, there were concerns about the shape of the obligations that Poland would assume and the scale of burdens on farms resulting from it. The answers to these questions are given by the Polish Strategic Plan for the Common Agricultural Policy for the years 2023-2027. It is worth emphasising that it is one of the first seven plans approved by the European Commission. In addition to Poland, European Commission approved plans for Denmark, Ireland, Spain, France, Portugal

DOI: 10.34659/eis.2022.83.4.534

and Finland. In September 2022, Plans for Luxembourg and Austria were also approved. Polish comments after adopting the CAP Strategic Plan should be assessed as optimistic. They highlight the size of funds allocated to support agriculture and increase care for climate and environmental problems (Adamska, 2022; Molenda, 2022). However, these articles lack an assessment of the commitments negotiated and do not mention the anticipation of the effort that will have to be made by the agricultural sector to fulfil the commitments made.

Research methods

The primary tool used in the study was an analysis of the literature and legal documents, in particular, a comparative analysis of the European Green Deal and Polish Strategic Plan for the Common Agricultural Policy for the years 2023-2027. Such a comparison was necessary to assess the European and Polish strategic objectives in the agricultural sector and to determine how far the national targets are from the European ones.

The above research has been supplemented by an analysis of available statistical data showing the situation in agriculture in Poland, basically concerning the years 2005-2020. The latest data on the agricultural sector, collected from the Agricultural Census 2020, were used. Such an assessment made it possible to determine how much effort awaits agriculture in Poland to achieve the set goals. For this purpose, statistical data from Statistics Poland, the National Centre for Emissions Management, the Agricultural and Food Commercial Quality Inspection, and the European Medicines Agency were used.

In addition, literature and legal documents analysis helped to identify the research gap and assess the discussed documents.

Results of the research

Green strategic objectives for European agriculture were outlined in several strategy papers for the EU (European Commission, 2020a; European Commission, 2020b; European Commission, 2020c). The objectives for European agriculture relate to six main problem areas (European Commission, 2020; European Commission, 2020b). In each of these problem areas, several targets were established. According to the authors, the most important targets mentioned in the above-indicated documents are:

1. Fertilization management. The Commission will act to:
   – reduce nutrient losses by at least 50% while ensuring no deterioration in soil fertility,
   – reduce fertiliser use by at least 20% by 2030.

Short argumentation: The excess of nutrients in the environment is a major source of air, soil and water pollution, negatively impacting biodiversity and climate.

2. Pesticide management. The Commission will take actions to:
   – reduce by 50% the use and risk of chemical pesticides by 2030,
   – reduce by 50% the use of more hazardous pesticides by 2030.

Short argumentation: The use of pesticides in agriculture contributes to the pollution of soil, water and air.

3. Use of antimicrobials. The Commission will take action to:
   – reduce by 50% the sales of antimicrobials for farmed animals and aquaculture by 2030.

Short argumentation: Antimicrobial resistance linked to antimicrobials in animal and human health leads to an estimated 33,000 human deaths in the EU each year.

4. Development of organic farming. The Commission will:
   – boost the development of EU organic farming areas with the aim to achieve 25% of total farmland under organic farming by 2030.

Short argumentation: Organic farming is an environmentally-friendly practice that needs further development.

5. Protecting biodiversity in agricultural areas. The Commission underlines:
   – need to bring back at least 10% of agricultural area under high-diversity landscape features. These include, among other things, buffer strips, rotational or non-rotational fallow land, hedges, non-productive trees, terrace walls, and ponds.

Short argumentation: This help enhance carbon sequestration, prevent soil erosion and depletion, filter air and water, and support climate adaptation. In addition, more biodiversity often helps lead to more agricultural production.

6. Climate action. The Commission has not indicated a clear reduction target for agriculture in European Green Deal. Such a goal is to be indicated in the Fit for 55 packages, which have not yet been adopted. In the existing documents, the climate target is mentioned, but its description is not unambiguous. The actions are to be used to:
   – implement agricultural practices such as precision farming, organic farming, agroecology, agroforestry and stricter animal welfare standards.

Short argumentation: These practices will not only contribute to the achievement of the primary goal of reducing greenhouse gas emissions but

DOI: 10.34659/eis.2022.83.4.534

also to the implementation of sustainable methods of food production at all stages of its production.

These strategic objectives to be achieved by 2030 have been adopted for the entire European Union. This does not mean that the objectives are translated into the same dimension for each Member State. The involvement of individual member states in the implementation of EU objectives is indicated in the national strategic plans that are being developed for the years 2023-2027. "The strategic plans will need to reflect an increased level of ambition to reduce significantly the use and risk of chemical pesticides, as well as the use of fertilisers and antibiotics" (European Commission, 2019). The shape of the national strategic plans, including declarations on the contribution to the achievement of European objectives, results from many months of negotiations with the European Commission, based on the substantive justification of the proposed values to specific strategic objectives related to the European Green Deal. In accordance with the general principles adopted in the EU, adequate to the state of agriculture, its current direction of development and the possibility of involvement in the implementation of individual objectives, each member state has been obliged to determine its contribution to the EU objectives. For Poland, the Strategic Plan for the Common Agricultural Policy for 2023-2027 was approved by the European Commission on 31 August 2022, thus formalising the contribution of Poland to the common European interest in the agricultural sector (MRiRW, 2022) and thus in the individual strategic objectives.

The National Strategic Plan, in addition to the objectives to which we will aim, focuses on actions aimed at farmers, which should contribute to the achievement of environmental and climate goals, indicating specific indicators for measuring the achieved result, taking a specific time (year, period) as a starting point in measuring changes.

Fertilisation – the context of Polish Strategic Plan for Common Agricultural Policy 2023-2027 and current statistics

The contribution of Poland to the reduction of fertilisation in the perspective of 2030 in the EU will be determined by the changes planned for the years 2023-2027 in the values of the following indicators adopted by the European Commission, namely (MRiRW, 2022):

- gross nitrogen balance in kilograms per hectare of utilised agricultural area (in relation to the values from the reference period 2012-2014),
- gross phosphorus balance in kilograms per hectare of utilised agricultural area (in relation to the value from the reference period, i.e. 2012-2014),

DOI: 10.34659/eis.2022.83.4.534

- percentage of groundwater monitoring stations where nitrate concentrations exceed 50 mg/l (compared to the values from the reference period, i.e. 2012-2015).

Taking into account the previous research conducted by the Institute of Soil Science and Plant Cultivation State Research Institute and the planned launch of activities for farmers encouraging rationalisation of fertilisation of assumptions under the Strategic Plan for 2023-2027, in the perspective of 2030 compared to the reference period, it is expected:

- reduction of nitrogen doses in mineral fertilisers by approx. 10.1 kg N $\cdot$ ha^{-1} UR, i.e. 12.8%, to the level of 68.6 kg N $\cdot$ ha^{-1} UR,
- reduction of phosphorus doses in mineral fertilizers by 3.2 kg P2O5 $\cdot$ ha^{-1} UR, by 12.6%, to 22.2 kg P2O5 $\cdot$ ha^{-1} UR,
- increase in gross nitrogen consumption in natural fertilisers by 20% per ha UR, i.e. up to 43.2 kg $\cdot$ ha^{-1},
- increase in the consumption of phosphorus in natural fertilisers by 22.9%, to the level of 19.3 kg P2O5 $\cdot$ ha^{-1} UR,
- reduction of gross nitrogen balances by 0.7 kg $\cdot$ ha^{-1} (i.e. by 1.5%), which should be at the level of about 47.1 kg N $\cdot$ ha^{-1},
- reduction of the phosphorus balance below the level recorded in recent years, i.e. 2.5 kg P $\cdot$ ha^{-1} UR, by approx. 0.1 kg P $\cdot$ ha^{-1} UR, i.e. 1.5%.

Proposals for intervention under the strategic plan and regulatory frameworks should contribute to reducing nutrient losses and fertiliser consumption, namely:

- Eco-scheme – carbon agriculture and nutrient management in terms of practices:
  - development and adherence to a fertilisation plan,
  - mixing manure on arable land within 12 hours of application,
  - application of liquid natural fertilisers by methods other than splashing,
  - simplified cultivation systems,
  - winter intercrops/intracrop seedlings,
  - diversified crop structure.
- Ekoschemate – conducting plant production in the integrated plant production system,
- Organic farming,
- Investments in farms in the field of Renewable Energy Sources (RES) and improvement of energy efficiency,
- Creation of mid-field trees and establishment of agro-forest systems,
- Premiums for afforestation and tree cover and agroforestry systems,
- Agri-environment-climate commitments,
- Investments contributing to environmental and climate protection (places for storing natural fertilisers, equipment for processing natural fertil-

isers, equipment for precise application of fertilisers / mixing fertilisers with soil),
- Support for demonstration (model) farms (in the field of knowledge transfer on low-carbon storage techniques and the use of natural fertilisers),
- Agricultural Consulting,
- Implementations carried out outside the strategic plan resulting from the implementation of the nitrate programme (Rozporządzenie, 2020); act on fertilisers and fertilisation (Obwieszczenie, 2021); development of agricultural biogas plants.

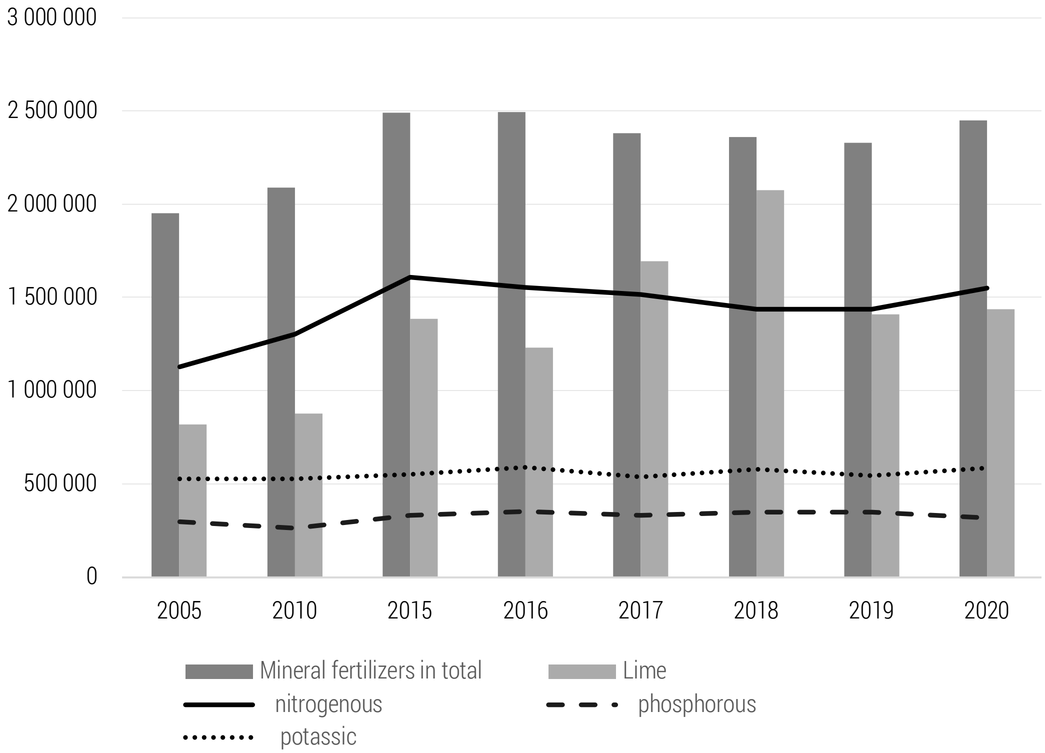

Figure 1. Sale of mineral fertilisers and lime in Poland [in terms of pure ingredients in tonnes]

Source: author's work based on GUS (2021b).

Taking into account the current statistics on fertiliser management in Poland, it is possible to outline the temporal intensity of fertilisation (Figure 1). Over the last dozen or so years, comparing extreme years, the turnover of

DOI: 10.34659/eis.2022.83.4.534

mineral and calcium fertilisers has increased significantly. At that time, the number of mineral fertilisers sold increased by 1/4, but the biggest changes concerned nitrogen fertilisers, containing the main yield factor, nitrogen (increase by 37%, 2020/2005). In the case of phosphorus and potassic fertilisers, positive changes were at the level of several per cent. Given the need to regulate soil reactions, a critical agricultural practice is the use of calcium fertilisation. In this case, sales increased by more than 2/3 (2020/2005). However, the illustrated period is not homogeneous. The last 2 years have unfortunately been a time to limit the sale of liming agents.

Considering the indicators of monitoring changes in fertiliser management, the balance results of nitrogen and phosphorus are significant. As indicated by research based on detailed periodic surveys of fertiliser management, only a part of farms produces balance surpluses in this area (Figure 2).

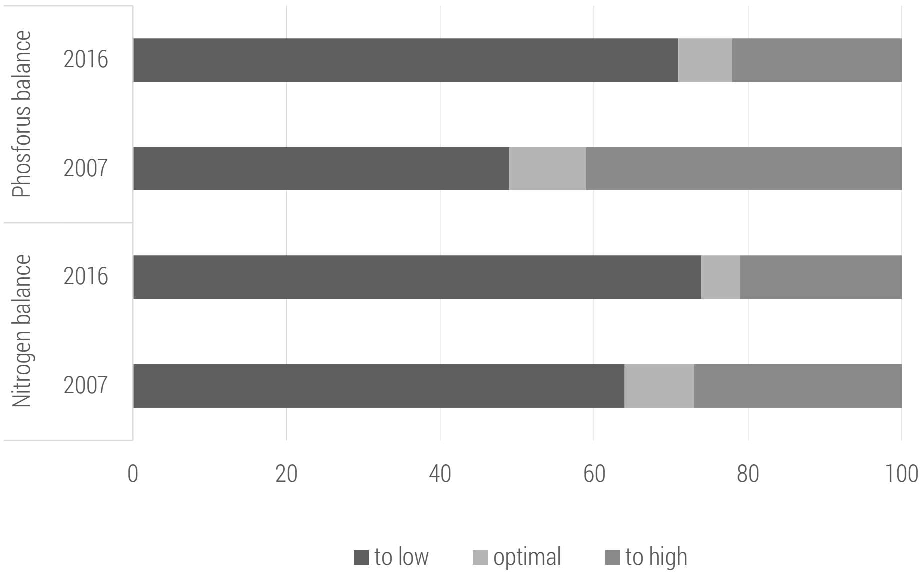

Figure 2. Individual farms structure based on the fertiliser balance [%]
Source: author's work based on Wrzaszcz and Kopiński (2019).

Pesticides – the context of Polish Strategic Plan for Common Agricultural Policy 2023-2027 and current statistics

In the case of plant protection products, the following indicators were adopted to assess changes in agriculture in Poland in the context of the adopted strategic objectives in European strategies in the perspective of 2030 (the base period is 2015-2017) (MRiRW, 2022):

DOI: 10.34659/eis.2022.83.4.534

- modified harmonised risk indicator HRI-1 – this indicator is based on data on sales of plant protection products,
- the rate of reduction of plant protection products containing active substances that are qualified for substitution.

The possibility of reducing the amount of plant protection products used (expressed in kg of active substance), as well as the scope of intervention planned in the strategic plan, is expected to limit it from approx. 3 to 9% by 2030. The recommended and possible level of plant protection products limitation was estimated by scientific institutions conducting research in this scope, e.g. The Institute of Agricultural and Food Economics – National Research Institute, The Institute of Plant Protection – National Research Institute, The Institute of Horticulture – National Research Institute (MRiRW, 2022). Taking into account the level of reduction of the HRI-1 index – that is the, one of the main indicators used to monitoring the progress in plant protection products – the aim of a decrease by 5 p.p. was assumed (comparing 2030/2019). The value of the HRI-1 index in 2019 was 85%, while the target value in the perspective of 2030 is 80%. However, the effectiveness of the HRI-1 index depends to a large extent on the withdrawal of acceptance of active substances used in plant protection products.

Key actions planned in the strategic plan contributing to the reduction in the use of plant protection products:

- eco-scheme – integrated agriculture,
- organic farming – the system eliminating chemical means of production in practice.

Based on the available, up-to-date statistics on the management of plant protection products in agriculture, a long-term upward trend in their sales is highlighted (Table 1). Comparing the years 2020/05, the total amount of plant protection products sold increased by more than 2/3. The peak took place in 2017, while recent years indicate a slight decrease in sales of selected ones. Depending on the type of these measures, the scale of changes varied. The key plant protection products are herbicides and fungicides.

The amount of active substance is a summary indicator informing about the activity of various plant protection products. In this respect, the last 5 years have been a period of stabilisation in the consumption of the active substance; however, comparing the values for extreme years, their use in the agricultural sector has increased by more than 50% (Figure 3).

DOI: 10.34659/eis.2022.83.4.534

Table 1. Sales of plant protection products[a] in Poland [in commodity mass in tonnes] by harmonised classification of substances

Plant Protection Products	2005	2010	2015	2016	2017	2018	2019	2020	2020/05 in %
Total	41.135	51.613	67.298	68.106	71.446	65.335	68.907	69.849	70
• insecticides	1.917	2.945	4.687	4.569	5.440	5.451	8.267	3.413	78
• fungicides	9.915	12.867	18.268	18.253	17.429	19.744	17.858	22.710	129
• herbicides	24.455	30.228	38.799	39.544	43.030	35.864	36.185	38.910	59
• plant growth regulators	2.483	3.014	4.293	4.251	4.261	3.406	4.737	2.954	19
• rodenticides	249	147	56	46	1	1	131	176	-29
• others	2.116	2.412	1.195	1.443	1.285	870	1.729	1.686	-20

[a] Deliveries on the domestic market by producers and importers; from 2018 by holders of the authorisation of the Minister of Agriculture and Rural Development for the marketing of plant protection products.

Source: author's work based on GUS (2021b).

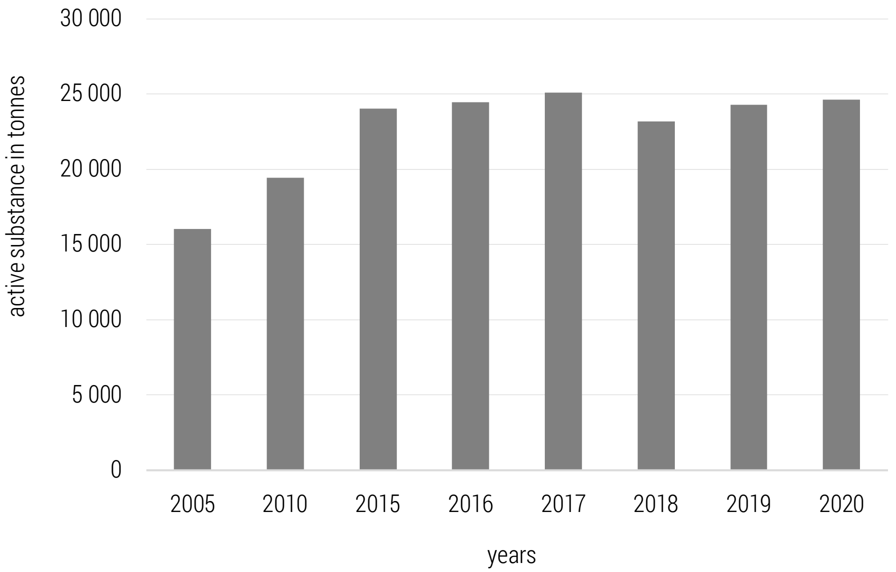

Figure 3. Sales of plant protection products in Poland [in active substance in tonnes]

Source: author's work based on GUS (2021a).

DOI: 10.34659/eis.2022.83.4.534

Use of antimicrobials – the context of Polish Strategic Plan for Common Agricultural Policy 2023-2027 and current statistics

A reduction in the use of antimicrobials in Poland is expected to be 10% up to 2030. This goal is to be achieved through a number of administrative actions aimed at ensuring animal welfare and broadly understood education of decision-makers in the agricultural sector. The actions positively assessed in the strategic plan by the European Commission, which are to contribute to reducing the use of antimicrobials, include (MRiRW, 2022):

- realization of the action: eco-scheme – animal welfare, which assumes the improvement of animal welfare, additionally translates into raising farmers' awareness of animal health,
- implementation of the action: investments – concerning the living conditions of animals, which concern m.in.:
  - the possibility of using paddocks or pasture (applies to cattle),
  - greater freedom of movement (in the case of pigs),
  - microclimate in livestock buildings, improving the health and comfort of animals.
- implementation of the action: investments to prevent the spread of African swine fever (ASF),
- introduction of higher standards in animal husbandry and breeding,
- development of cooperation between producers within the framework of food quality systems,
- conducting continuous training and advisory activities. Introduction of mandatory training for farmers on methods to reduce the use of antibiotics (intervention: occupational development of farmers) and on biosecurity methods and animal living conditions,
- national financial and legal tools implemented in three areas:
  - changes in the law – introduce a ban on the routine use of antibiotics,
  - introduction of digital solutions – electronic book of animal health (eBAH),
  - training for veterinarians.
- creating a website with a platform for knowledge and exchange of information for veterinarians and farmers,
- and the introduction of actions to increase consumers' knowledge of the products they buy,
- plan to introduce food passporting.

Statistics from the last few years indicate a positive trend in application veterinary antimicrobal agents (Figure 4). This tendency was accompanied by noticeable changes in the structure of antimicrobial use (Table 2). Microbials classified in the D category are in the majority, but the share of those antimicrobials decreased. Simultaneously, antimicrobials that act more

DOI: 10.34659/eis.2022.83.4.534

intensively are becoming more and more popular (particularly those classified into categories C and B)[1].

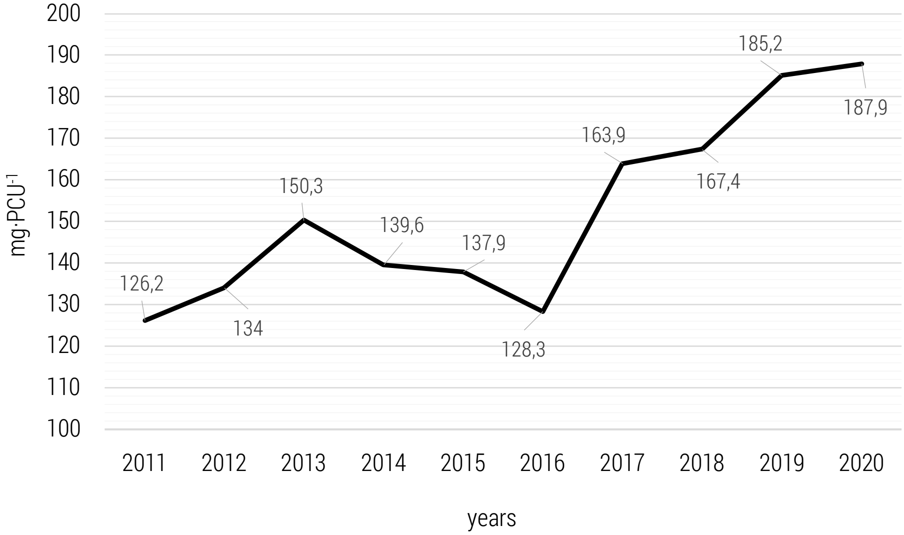

Figure 4. Annual sales of veterinary antimicrobial agents for food-producing species in Poland from 2011 to 2020 [in mg × PCU^{-1}]*

* Population correction unit (PCU) has been established as a denominator for the sales data (EMA, 2021).

Source: author's work based on EMA (2021).

Table 2. Veterinary antimicrobial use in Poland

Specification	2011	2018	2020
Estimated PCU (in thousand tonnes)	3.929	4.672	4.542
Sale of veterinary antimicrobial agents (mg × PCU^{-1})	126.2	167.4	187.9
Sale of 3rd- and 4th-generation cephalosporins (B category) (mg × PCU^{-1})	0.1	0.3	0.4
Sale of fluoroquinolones (B category) (mg × PCU^{-1})	7.1	10.9	12.9
Sale of polymyxins (B category) (mg × PCU^{-1})	4.1	7.4	9.1
Sales of the veterinary antimicrobial (% of mg/PCU in total):	**2011**	**2018**	**2020**
Tetracyclines (D category), (% of mg × PCU^{-1} in total)	38.1	28.3	24.1
Penicillins (D category), (% of mg × PCU^{-1} in total)	24.0	33.0	32.5
Sulfonamides (D category), (% of mg × PCU^{-1} in total)	11.4	3.9	4.3

1 According to antimicrobial classification, classes from A (meaning to avoid; they are contraindicated for use in food-producing animals) to D (to use wisely; if possible, these antibiotics should be used as a first-line treatment) were specified.

DOI: 10.34659/eis.2022.83.4.534

Macrolides (C category), (% of mg × PCU^{-1} in total)	5.4	12.1	13.2
Fluoroquinolones (B category), (% of mg × PCU^{-1})	6	6.5	6.9
Polymyxins (B category), (% of mg × PCU^{-1} in total)	3.5	4.4	4.8

Source: author's work based on Prandecki et al. (2021); EMA (2021).

Development of organic farming – the context of Polish Strategic Plan for Common Agricultural Policy 2023-2027 and current statistics

According to the EU strategic documents for the 2030 perspective, the development of organic farming in the EU will be measured by the area covered by the organic management system (taking into account both the area during the conversion to this production system and the certified area – after the conversion period). Exactly the measure of this development will be the share of organic agricultural land (mentioned above) in the total agricultural land used. In the case of Poland, the proposed instruments should ultimately contribute to an increase in farmers' interest in organic farming. The adopted target for Poland is 7% of organic agricultural land in 2030 (MRiRW, 2022).

Planned interventions in the strategic plan and additional actions intended to support the development of organic farming:

- organic farming,
- eco-scheme – animal welfare,
- supporting the fight against varroa with medicinal products,
- improvement of infrastructure for planning and organisation of production,
- information, promotion and marketing activities;
- investments in agricultural holdings increasing competitiveness,
- development of small farms,
- developed cooperation within the value chain,
- premiums for young farmers,
- establishment and development of producer organisations and agricultural producer groups,
- promotion, information and marketing of food produced under quality schemes,
- support for participants in EU and national food quality schemes,
- cooperation of EIP Operational Groups,
- agricultural Advisory interventions.

In addition: Program for schools on organic products as part of school classes.

DOI: 10.34659/eis.2022.83.4.534

These activities include support for the various stages of the organic food chain, i.e. agricultural production, processing, investment and education, and integration of decision-makers.

In the long term, there has indeed been an increase in organic agricultural area (Figure 5) – between 2020/2004, the total organic area increased by about six times. At that time, there were also periods of decline in organic agricultural land, primarily dictated by the change in the support rules for organic entities. Organic farming development in Poland is mainly determined by administrative support. The changes in subsidies to organic areas of agricultural land resulted in a decrease in farmers` interest in this production system, observed in the organic area fall after 2014 (Wrzaszcz, 2022).

Currently, the share of organic agricultural land area accounts for about 3.5% of the total agricultural land. In the structure of these areas, the most significant part currently falls on fodder crops and permanent grassland (Figure 6), although their production importance in the organic management system is decreasing.

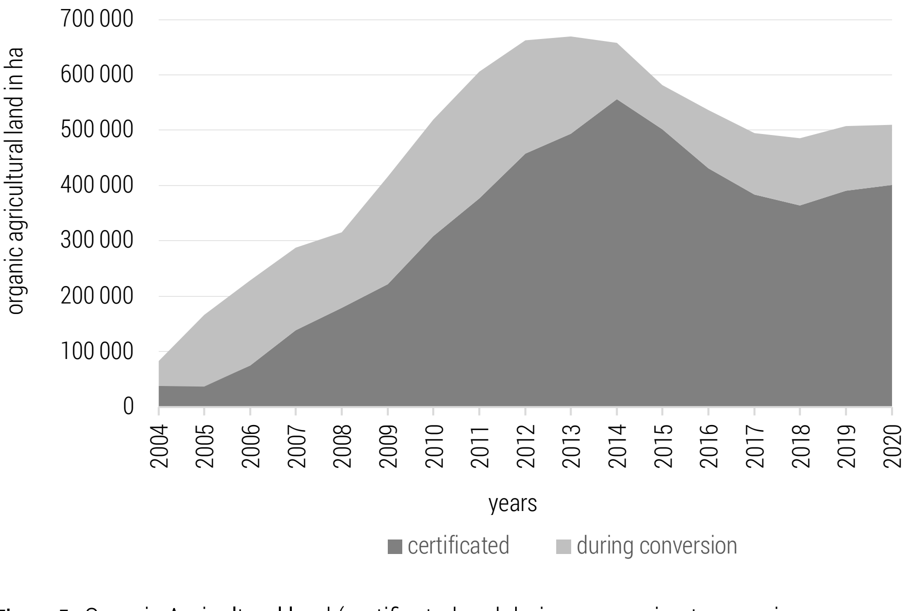

Figure 5. Organic Agricultural land (certificated and during conversion to organic production) in Poland in ha

Source: author's work based on GUS (2021b); IJHARS (2007); IJHARS (2009); IJHARS (2011); IJHARS (2013); IJHARS (2015); IJHARS (2017); IJHARS (2019); IJHARS (2021).

DOI: 10.34659/eis.2022.83.4.534

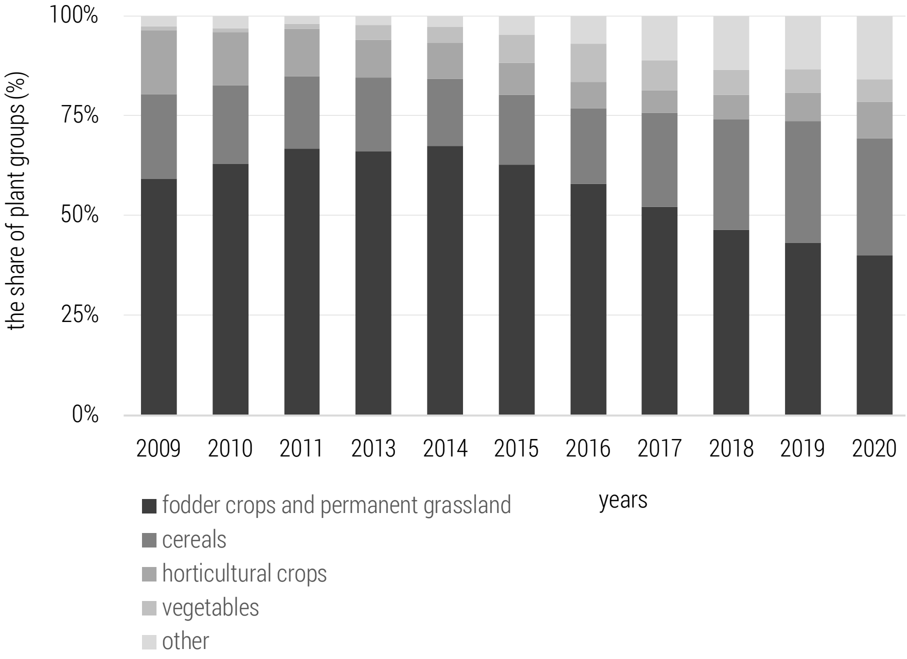

Figure 6. Structure of organic agricultural land use in Poland [%]

Source: author's work based on IJHARS (2007); IJHARS (2009); IJHARS (2011); IJHARS (2013); IJHARS (2015); IJHARS (2017); IJHARS (2019); IJHARS (2021).

Protecting biodiversity in the agricultural area – the context of Polish Strategic Plan for Common Agricultural Policy 2023-2027 and current statistics

The biodiversity protection on agricultural land amounts to using part of the land for non-productive purposes. In the case of Poland, the EC has accepted a level of 4% of the agricultural land area (MRiRW, 2022).

The strategic plan and general regulation propose actions to preserve biodiversity, including:

- introduction of at least 4 % of the arable area of the holding for non-productive areas and facilities in the primary set of land,
- action: preservation of orchards of traditional varieties of fruit trees,
- legal regulations concerning the protection of diversity on arable land,
- investment activity: mid-field trees, agroforestry systems and support for the nurturing of these landscape elements.

In Poland, according to EU data, 2.3% of the agricultural area is occupied by landscape elements. The Agency of Restructuring and Modernization of Agriculture (ARMA) data on all farms indicated that the total area of landscape features in these farms is 3% of the total agricultural area, so-called ecological focus areas (EFA): fallow land, linear trees, mid-field groves, hedges, single trees, ponds, ditches, buffer strips and strips of land on the edges of forests (MRiRW, 2022).

The fragmented area structure of farms is conducive to preserving landscape elements, which are also a reservoir of nature. Despite the observed changes in the decreasing number of farms, which is accompanied by the process of land concentration, small farms still dominate in terms of land used (Figure 7). Currently, over 80% of farms have an area of up to 15 ha, which use 1/3 of the area of used agricultural land.

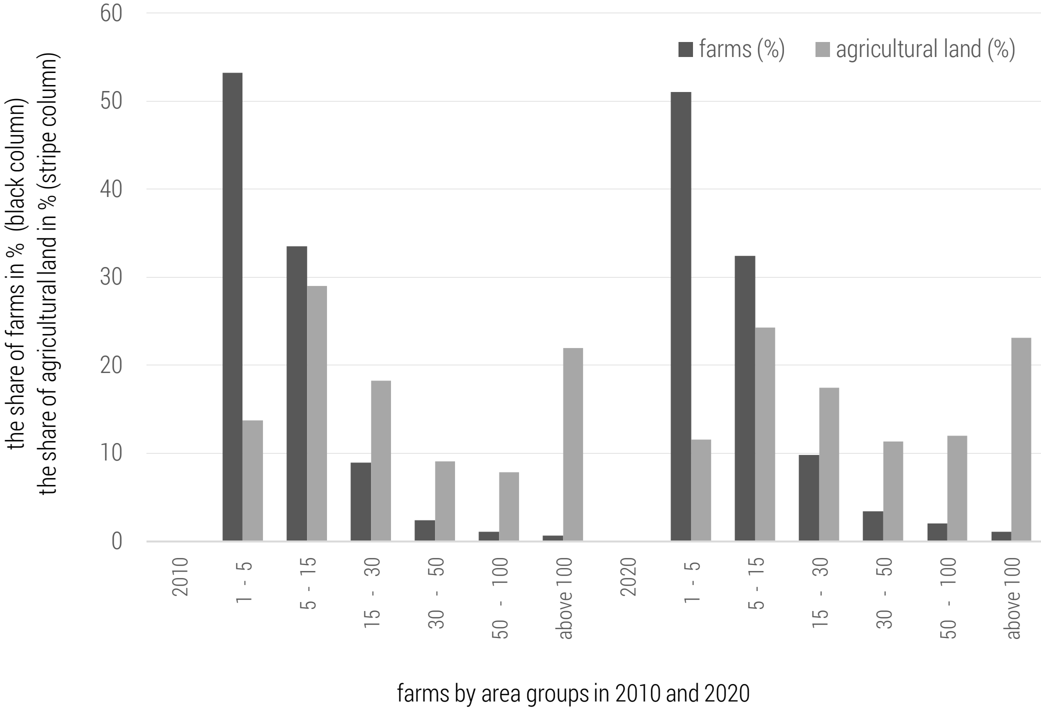

Figure 7. Structure of farms by agricultural land [%]

Source: author's work based on GUS (2022).

Climate action – the context of Polish Strategic Plan for Common Agricultural Policy and current statistics

In accordance with the provisions of the Paris Agreement (United Nations, 2015), the European Union has decided to achieve climate neutrality by 2050 (European Commission, 2018). This target is reaffirmed in the European Green Deal, which also sets a target of at least 50% and potentially a 55% reduction in emissions compared to 1990 in 2030. A 55% reduction in emissions was assumed to require emission reductions in non-ETS sectors, i.e. not covered by emissions trading, of 40% compared to 2005. Changes in this area were to be adopted in the summer of 2020, but in practice, the relevant package has not yet been adopted. This means that Member States are meeting their current targets, i.e. a 30% reduction in emissions compared to 2005. In the case of Poland, this means a reduction of 7%, but it is worth noting that by 2020, Poland was entitled to a 14% increase in emissions in non-ETS sectors. Poland has partially benefited from this privilege (Table 3), which means that in practice, the reduction effort is much more significant than it results from the documents. The goal for agriculture in Poland is to reduce emissions below the level of 29,702.4 kt eq CO_2. This means an actual reduction of 13.44% compared to 2020 emissions.

Table 3. Greenhouse gas emissions in Poland in 2005 and 2020 [GHG kilotonnes converted to CO_2 equivalent]

Specification	2005	2020	Change from 2005 in %
Polish GHG emission	405 202.26	376 038.46	-7.2%
Agriculture	31 938.07	34 314.52	+7.44%

Source: author's work based on (Ministry of Climate and Environment, 2022).

However, the reduction targets described above are not included in the strategies related to EGD and agriculture. The EGD assumes that at least 40% of CAP funding should be linked to climate change, and the Farm to Fork Strategy (European Commission, 2020a) identifies practices to implement sustainable climate-friendly solutions. In the context of climate, the aim is to ensure that the food chain has a neutral or positive impact on the environment, i.a., by helping to mitigate and adapt to climate change.

In this spirit, the Polish Strategic Plan for the Common Agricultural Policy for the years 2023-2027 has also been drawn up. It does not indicate specific reduction targets but only indicators concerning the use of specific practices. Six specific objectives have been set. These are:

1. Reduction of greenhouse gas emissions from agriculture.
2. Adaptation of agriculture and forestry to climate change – reduction of weather and disease risks.
3. Increasing the absorption and storage of coal, i.a., as a result of afforestation of the weakest agricultural land.
4. Development of sustainable energy based on non-food uses of agricultural and forestry biomass.
5. Exploiting and developing alternative energy production opportunities.
6. Raising awareness of climate change mitigation and adaptation.

Emission reduction is to be achieved through implementing mandatory requirements (the enhanced conditionality) and voluntary requirements included in the eco-schemes. The actions are taken to result from the requirements presented in the Farm to Fork Strategy (European Commission, 2020a) and are associated with reducing greenhouse gas emissions and maintaining carbon resources in the soil. Among the eco-schemas taking into account and admiring climate objectives, the most important should be considered Coal Agriculture and Nutrient Management, which implements such practices as winter catch crops/mid-crop seedlings, development and compliance with the fertilisation plan in the primary and liming variants, diversified crop structure, mixing manure on arable land within 12 hours of application, application of liquid natural fertilisers by methods other than splashing, simplified cultivation systems and mixing straw with soil.

An appropriate number of points has been assigned to each of the practices, and the condition for joining the eco-schemes is to obtain at least the number of points that corresponds to the equivalent of the points that the farmer would receive if at least 25% of the agricultural area of the highest-scoring practice were implemented.

In addition, in the context of climate, attention should be paid to eco-schemes:

- water retention on permanent grassland,
- actions for environmental protection and climate change mitigation (investment activities),
- protection of valuable habitats and endangered species in Natura 2000 sites,
- afforestation commitments from RDPs 2004-2006, RDPs 2007-2013, RDPs 2014-2020,
- organic farming,
- protection of valuable habitats and endangered species outside Natura 2000 sites,
- extensive use of meadows and pastures in Natura 2000 sites,
- preservation of orchards of traditional varieties of fruit trees,
- conservation of endangered plant genetic resources in agriculture,
- conservation of endangered animal genetic resources in agriculture,
- premiums for afforestation and trees and agroforestry systems,
- agri-environment-climate commitments implemented under the agri-environment-climate measure RDP 2014-2020. Package 4. Valuable habitats and endangered bird species in Natura 2000 sites,
- agri-environment-climate commitments implemented under the agri-environment-climate Measure of the Rural Development Programme for 2014-2020 (RDP 2014-2020). Package 5. Valuable habitats outside Natura 2000 sites,

DOI: 10.34659/eis.2022.83.4.534

- agri-environment-climate commitments implemented under the agri-environment-climate Measure of the Rural Development Programme for 2014-2020 (RDP 2014-2020). Package 1. Sustainable agriculture,
- creation of mid-field trees,
- establishment of agroforestry systems,
- enhancing the biodiversity of private forests,
- investments in agricultural holdings in the field of RES and improving energy efficiency,
- investments contributing to environmental and climate protection,
- development of agricultural and forestry services (Financial instruments).

The multiplicity of climate-related eco-schemes shows the growing importance of this problem in agricultural policy. At the same time, it should be noted that many of the above-mentioned activities are related to adaptation to changing conditions and not to the reduction of greenhouse gases.

Discussion – challenges for agriculture in Poland

The introduction of the European Green Deal at the end of 2019, and the core agricultural strategies, i.e. the Farm to Fork Strategy and the Biodiversity Strategy in mid-2020, triggered an international discussion on the legitimacy and feasibility of implementing these strategies in the EU and its countries (Wrzaszcz & Prandecki, 2020; Adamowicz, 2021; Prandecki et al., 2021; Ziętara & Mirkowska, 2021; Gargano et al., 2021; Blake, 2020; Matthews, 2021; Popescu et al., 2022). In view of the importance of agriculture in ensuring Europe's food security and its impact on the natural environment and climate, this discussion concerns the agricultural sector as well. While the legitimacy of the adopted strategic objectives for the EU is emphasised by many researchers, the scope and manner of involvement of Member States in achieving the EU objectives is a particularly difficult topic (Prandecki et al., 2021; Wrzaszcz, 2022).

For several months, negotiations between representatives of the Member States and the European Commission on the participation of individual countries in Community objectives have been ongoing. So far, in scientific studies, there has been information that EU objectives will be translated into national objectives in the same dimension (Adamowicz, 2021; Gradziuk et al., 2021; Ziętara & Mirkowska, 2021; Wrzaszcz & Prandecki, 2020). Since the end of August, when the first national strategic plans of selected Member States were accepted – including the plan for Poland and the other 6 Member States – documents informing about the strategic objectives adopted in a given country in the context of the European Green Deal have been in general circulation (MRiRW, 2022).

DOI: 10.34659/eis.2022.83.4.534

Taking into account the strategic objectives adopted for agriculture in Poland against the background of the objectives for the EU in the perspective of 2030, they can be considered significantly lower compared to the targets for the EU. However, the adopted objectives should not be assessed as unambitious or insufficient, but adapted to Poland's agriculture specificity. The adopted figures in the Polish strategic plan resulted from the specificity of agriculture in Poland, its current development path and the possibility of introducing the expected changes.

Based on the empirical and literature analyses carried out, the strategic objectives for agriculture set out in the European Green Deal are appropriate and justified. Taking into account the substantive scope of individual strategic objectives, these challenges for the agricultural sector in Poland can be grouped as follows:

- reduction in fertilisation:
  - determination of the scale/reduction needs of fertilisation on holdings generating excessive nitrogen and phosphorus balance surpluses,
  - the inclusion in the balance of the fertiliser balance of all sources of entry and exit of nutrients into the soil,
  - taking into account the state of soil acidification, which determines the efficiency of the use of nutrients by plants,
  - taking into account the abundance of soils in nutrients according to the location of a particular agricultural holding,
  - popularisation of tools and information on the rationalisation of fertilisation in order to raise the awareness of decision-makers and improve agricultural practices.
- reduction for plant protection products:
  - the establishment of the scale/reduction needs of plant protection products in the case of holdings abusing these chemical plant protection products,
  - popularisation of tools and information on the rationalisation of the use of plant protection products in order to raise awareness among decision-makers and improve agricultural practices.
- reduction in antimicrobials:
  - restricting the use, in particular in the case of farms abusing these measures,
  - dissemination of tools and information on the rationalisation of the use of antimicrobials in order to raise awareness among decision-makers and improve agricultural practices.
- development of organic farming:
  - taking into account the current state of organic farming, the relative area of the organic agricultural area should be doubled over the next few years,

DOI: 10.34659/eis.2022.83.4.534

  - stimulating, including through administrative bodies, the development of this production system in particularly predisposed areas, including those equal to landscape, tourist or natural values,
  - popularization of tools and information on the specifics of the organic production system in order to raise the awareness of decision-makers and improve agricultural practices,
  - the development of financially lucrative administrative tools to compensate and encourage conventional farmers to reorient their production towards sustainability.
- providing valuable elements in terms of landscape and biodiversity on agricultural land:
  - inventory of natural and landscape resources on agricultural land on various farms in terms of their size,
  - the maintenance of resources on holdings with areas of landscape and nature,
  - stimulating farmers who do not have valuable areas in their holding resources to separate part of the land for the development of nature.
- action to reduce climate change:
  - increasing the rationality of fertilisation,
  - increasing the use of carbon-retaining practices in soil,
  - reduction of emissions from agricultural sources.

In addition to the specific objectives, the achievement of which is a significant challenge, there are also general challenges related to the transformation of European agriculture towards further sustainable development (compare: Wrzaszcz & Prandecki, 2020):

- substantive – the adopted strategic objectives for the EU, as well as for Poland, are ambitious, thus increasing the risk of not achieving them,
- administrative and legal – it is necessary to adapt administrative institutions and other institutions functioning in the farmer's environment, as well as legal regulations at the European and national level, to develop internally coherent documents enabling monitoring of the results assumed in the adopted strategies and plans,
- social – encouraging the introduction of different practices for the sustainable development of agriculture, taking into account the different links of the food chain, by building awareness among consumers, producers, processors, and sellers, as well as the institutional environment of farmers, including advisers,
- financial – ambitious solutions involve adequate costs, both by public institutions and individual farmers,
- global – global challenges vs. European actions. The need to initiate global actions, including international cooperation, also taking into account the

DOI: 10.34659/eis.2022.83.4.534

principles of trade in agri-food products produced with different absorption of environmental and climate resources,
- geopolitical – the current geopolitical situation related to the ongoing war in Ukraine forces a correction of European actions for both budgetary and economic reasons.

Conclusions

The paper discusses the agricultural challenges in Poland in the context of strategic goals resulting from the European strategy – the European Green Deal. These objectives are located within the framework of the current documentation on the requirements faced by the agricultural sector in Poland. The presentation of selected common statistics relating to the main strategic areas made it possible to sketch the main trends and scale of key problems.

The study highlighted the need to transform agriculture towards further sustainability. This transformation has been ongoing in the EU since the beginning of the 90s of the XX century. Despite a number of EU policies and national programmes implemented over the past 30 years, environmental and climate pressures, including on agriculture, continue to increase. Due to the interconnected relations between the natural environment and human economic activity, it is necessary to continue the implementation of agricultural practices "at least" eliminating the negative impact of agricultural activity on the environment. The European Green Deal is another step towards the sustainable development of the European Union. In the coming years, further efforts to sustainable agriculture will be expected.

The contribution of Poland to the achievement of the objectives of the European Union is significantly lower than the values adopted for the entire EU, which results from the current development of agriculture in Poland and the possibility and legitimacy of the changes. Implementing most of the national strategic objectives adopted in the perspective of 2030 in the agricultural sector will involve a number of activities stimulating farmer activity (including administrative actions, compensating the economic effort undertaken, as well as legal actions – obliging to the basic scope of practices).

Further transformation of agriculture in Poland, although it is justified, is not easy. It is associated with a number of challenges of a general nature (including legal, organisational, social, financial, substantive, geopolitical, and global challenges) and specific challenges (challenges related to the management of chemical means of production in agriculture, as well as the preservation of valuable landscape elements, climate stabilisation and development of organic farming on agricultural land). With regard to the latter, the contribution to the achievement of the specific objectives of the European

DOI: 10.34659/eis.2022.83.4.534

Green Deal should result from the activity of different groups of agricultural holdings in line with their organisation and the appropriateness of introducing the indicated agricultural practices for the environment and climate. The critical issue in this respect is determining which farms should make the most significant reduction and development effort in the context of the adopted strategic goals.

To sum up, the scope of challenges related to the implementation of the European Union and specific Member States, including Poland, is a multifaceted range. The success of success will depend on actions on many levels by different decision-makers of the agri-food chain.

Acknowledgements

This research has been supported by the Institute of Agricultural and Food Economics – National Research Institute within the statutory funds.

The contribution of the authors

Both authors have equally participated in the preparation of this work. All aspects were discussed and shared between authors. Konrad Prandecki: conception – 50%, literature review – 50%, acquisition of data – 50%, analysis and interpretation of data – 50%. Wioletta Wrzaszcz: conception – 50%, literature review – 50%, acquisition of data – 50%, analysis and interpretation of data – 50%.

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STUDIES AND MATERIALS

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ANALYSIS OF THE POTENTIAL OF EFFECTIVE MICROORGANISMS IN PLANT PRODUCTION

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ABSTRACT: The natural environment is changing under the influence of human activity and the development of new technologies. One of the ways to restore the balance of the natural environment is to limit conventional agriculture in favour of organic farming based on the use of organic and natural fertilisers, excluding the use of chemical inputs. This action will go a long way in improving biodiversity and natural resource wealth. Fertilisation in modern agriculture is one of the most important agrotechnical procedures in deciding on the size and quality of the obtained crops. In organic farming, soil microorganisms play an important role because they influence the mineralisation of organic carbon and the humification of organic matter, thanks to which nutrients are more easily absorbed by plants. Organic fertilisers, which are Effective Microorganisms, are produced with the use of living microorganisms, which not only supply the soil with nutrients but also allow the inactive nutrients to be made available. Thanks to the better absorption of nutrients, plants develop and grow better, ensuring the best crops, the purchase prices of which from organic farming are very often much higher than in the case of traditional crops. The aim of this study was to present the possibility of using Effective Microorganisms as an ecological and economical alternative to conventional crop production systems using artificial fertilisers.

KEYWORDS: sustainable development, plants, Effective Microorganisms

No. 4(83) 2022 • pages: 180-195 DOI: 10.34659/eis.2022.83.4.485 JEL: Q01, Q18, Q50

Introduction

The natural environment can be considered an intrinsic good that has developed over millions of years of slow evolution. It is the basis for the existence of mankind. Due to the progress in the development of the economy, nature began to transform. The increase in birthrate resulted in more and more human interference in the changes taking place in the environment. In the 20th century, the dynamic economic development of the world, consisting in increasing the share of industry in national economies and urbanisation, led to a significant deterioration of the environment (Fiedler, 2018).

The changes that have taken place in the environment as a result of human activity have clearly marked the surrounding landscape. The branch of the economy with the most significant impact on the natural environment is agriculture. The large-scale use of artificial fertilisers contributes to environmental degradation. Modern agriculture is geared towards maximum production and maximum profit. As a result, environmental costs are neglected, which include impoverishment of landscape values, contamination of ground and surface waters, as well as soil degradation and erosion (Brdulak et al., 2021; Sobiesiak-Penszko et al., 2019).

Currently, great importance is attached to environmental protection and sustainable development. However, it should not be forgotten that sustainable production also aims to increase food production and reduce the incidence of diseases and pests without serious damage to crops. Organic production combines environmentally friendly management practices, supports a high degree of biodiversity, and utilises natural processes. Therefore, it is important to develop new methods to restore the mechanisms of the natural stability of microorganisms and agricultural communities (Hamid et al., 2021).

The deterioration of the natural environment contributes to the search for new, effective biological agents with a broad spectrum of activity. Microbiological preparations, which include properly selected, beneficial microorganisms that commonly occur in the natural environment, are highly effective (Panisson et al., 2021). In this aspect, liquid microbiological preparation Effective Microorganisms is gaining more and more popularity in Poland and in the world (Japan, Western Europe, USA, Brazil). Effective Microorganisms is the trade name for various products developed by Dr Teruo Higa, who is a professor of horticulture at Ryukyus University, a university located in Okinawa, Japan (Piotrowska & Boruszko, 2022; Pszczolkowski & Sawicka, 2018; Talaat et al., 2015).

Addressing human-induced pressure in the form of excessive chemical use in agriculture is made possible through the use of Effective Microorganisms. It is a group of microorganisms, including bacteria and fungi occurring

DOI: 10.34659/eis.2022.83.4.485

in nature, remaining in an undefined state of equilibrium with each other. Organic fertilisers in the form of EM are produced with the use of living microorganisms that can compete for space and/or food with pathogens (Feijoo, 2016; Morocho & Leiva-Mora, 2019).

Over the last several decades, there has been an increasing tendency to use biopreparations containing substances of natural origin. The use of biopreparations improves the health of plants and enables them to absorb nutrients better, resulting in increased yields. This action affects agricultural policy, which aims to shape the volume of agricultural production and maintain its profitability. The scope of action of EM preparations is wide due to their ability to increase the biological activity of the soil and thus prevent putrefactive processes. They can help improve soil structure and fertility by dissolving compounds unavailable to plants. EM improve the physicochemical properties of the soil, break down organic matter and synthesise nutrients needed for plant development (Ludwiczak et al., 2018).

A food policy adapted to the 21st century should take into account a number of criteria, among which are food quality, the environment, social and cultural values, and reasonable and competitive prices. The use of EM in crop production creates favourable habitat for plant growth. The presence of Effective Microorganisms in the soil accelerates the processes of decomposition of organic remains and facilitates the availability of micro- and macroelements to plants. Thanks to better assimilation of nutrients and protection against soil pathogens, plants develop and grow better, which ensures their better yield. The use of microbial preparations in crop production can contribute significantly to the production of high-quality food (Joshi et al., 2019; Nayak et al., 2020).

The aim of this study was to present the possibility of using Effective Microorganisms as an ecological and economical alternative to conventional crop production systems using artificial fertilisers.

According to Borowiak et al. (2021), the use of EM may have a positive effect on the microbial and enzymatic activity of the soil, as well as the intensity of plant photosynthesis, which in turn may result in a reduction in the use of mineral fertilisers and the promotion of sustainable agricultural production.

Olle and Williams (2013) studied the effect of EM preparation on plant growth, yield, quality and protection after application to soil. They found that 70% of the published studies on the subject showed that EM positively affected plant growth. Also, these authors, in another study, found that EM interacts with soil and plant ecosystems. This is to:

- suppression of plant pathogens and other pathogens,
- dissolving minerals,
- energy saving,

- maintaining the microbiological and ecological balance in the soil,
- increasing the efficiency of photosynthesis and biological nitrogen fixation.

Inoculation of the soil and plant ecosystem with Effective Microorganisms can improve soil quality, soil health, crop quality, growth, and yields. One of the reasons for these effects is that photosynthetic bacteria are the major component of EM. They act synergistically with other microorganisms. to meet the nutritional needs of plants and to reduce the proportion of disease-causing microorganisms. In addition to metabolizing organic compounds, EMs produce simple plant compounds that, when added to the soil, improve their use in agriculture and stabilise the natural ecosystem (Hidalgo et al., 2022; Rastogi et al., 2020).

According to Szewczuk et al. (2016), the EM preparation, which includes carefully selected strains of microorganisms, has a positive effect on the morphological features of plants, their physiological functions and the properties of the substrate. According to Yonghua et al. (2022), the use of EM for Asian ginseng cultivation improved soil fertility and Asian ginseng quality and revealed a connection between soil microbial diversity and physicochemical properties.

Research methods

The study used plant and soil material from the pot experiment in the form of plants and soil after two weeks of the experiment. The content of micro- and macroelements, as well as other elements in plants and four different types of soil available in a garden shop (universal top quality substrate, universal soil, gardening substrate for sowing and quilting and substrate with acid peat), were determined. 4 types of soil and 2 types of plants were selected, which were marked in the further part of the work in various combinations of G1 – G20 and R1 – R14. The soil pH varied from 3.5 to 6.8. They came from the orno-humus level (0-20 cm).

Two plants were selected for research on the potential of Effective Microorganisms: one from the monocotyledonous class, which is wheat (*Triticum aestivum L.*) and one from the dicotyledonous class, which is rapeseed (*Brassica napus L.*). The choice of plants was determined by their belonging to different systematic classes. The research samples were treated with the preparation EM Naturally Active. This preparation consists of lactic acid bacteria (*Lactobacillus casei, Streptococcus lactis*), yeasts (*Candidia utilis, Sacharomyces albus*), photosynthetic bacteria (*Rhodopseudomonas palustrus, Rhodobacter spae*), mold fungi (*Aspergillus oryzomae, Mucor hiemalis and actinomyces, Streptomyces albus*). The preparation EM Naturally Active was registered as organic fertiliser by the decision of the Minister of Agriculture and Rural

Development, Study No. 281/11 of March 31, 2011. The pot test was carried out at the Department of Environmental Technology, the Bialystok University of Technology, in 2021. The test was carried out in plastic containers with a volume of 150 ml (upper diameter 80 mm), 100 g of air-dry soil was placed and then moistened to 55% of full water capacity. When the soil was already moist, wheat and rapeseed seeds were sown in the amount of 10 seeds per one container. The previous evaluation showed a germination capacity of the test plants seeds of >95%. The tests were carried out in laboratory conditions, at room temperature (20-22°C), with natural lighting lasting 12-16 hours/day. The humidity level was checked daily by checking the weight of a number of selected containers of each combination. The grain of wheat and rapeseed in the test samples was watered with a 1% solution of Naturally Active EM, and the control samples with distilled water. The experiment was carried out for fourteen days (Klimkowicz-Pawlas, 2005).

The content of micro and macro elements and other elements was determined using the method of atomic absorption spectrometry (ASA) (Kornaś et al., 2019). This analytical technique allowed the determination of chemical elements such as B, Al, P, V, Cr, Mn, Co, Ni, Cu, Zn, As, Cd, La, Pb, K, Ca, Na, Mg in samples.

The content of metals in plants was determined after microwave mineralisation in nitric acid (V) and perhydrol. In the case of soil for microwave mineralisation, a mixture of nitric acid (V) with concentrated hydrochloric acid was used (Najduch et al., 2021). Before each series of determinations, at least five calibration solutions were prepared from the standard solution of the element, covering the concentration range to be determined. For each element, a calibration curve was plotted with readings of the concentrations of the calibration solutions. During the analysis of the samples, the blank solution and the test sample solution were sucked successively into the flame, and the absorbance value of a given element was measured. The element concentration corresponding to the absorbance values of the sample was read from the plotted calibration curve.

Experimental setup:

G1 – a control sample of the highest quality universal substrate, on which wheat grew for fourteen days watered with distilled water,

R1 – a control sample of 14-day-old wheat growing on the highest-quality substrate watered with distilled water,

G2 – a research trial of the highest quality universal substrate, on which wheat grew for fourteen days, watered with 1% Naturally Active EM solution,

R2 – a research trial of 14-day-old wheat growing on a top-quality substrate watered with 1% Naturally Active EM solution,

DOI: 10.34659/eis.2022.83.4.485

G3 – a control sample of universal soil, where wheat grew for fourteen days, watered with distilled water,
R3 – a control sample of 14-day-old wheat growing on universal soil watered with distilled water,
G4 – research trial of universal soil, where wheat grew for fourteen days, watered with 1% Naturally Active EM solution,
R4 – research trial of 14-day-old wheat growing on universal soil watered with 1% solution of Naturally Active EM,
G5 – control test of the potting soil for sowing and quilting, on which wheat grew for fourteen days watered with distilled water,
R5 – a control sample of 14-day-old wheat growing on a horticultural substrate for sowing and quilting watered with distilled water,
G6 – a research trial of a horticultural substrate for sowing and quilting, on which wheat grew for fourteen days, watered with 1% Naturally Active EM solution,
R6 – research trial of 14-day-old wheat growing on a horticultural substrate for sowing and quilting with 1% Naturally Active EM solution,
G7 – a control sample of acid peat, on which wheat grew for fourteen days watered with distilled water,
R7 – a control sample of 14-day-old wheat growing on acid peat watered with distilled water,
G8 – research trial of acid peat, on which wheat grew for fourteen days, watered with 1% solution of EM Naturally Active,
R8 – research trial of 14-day-old wheat growing on acid peat watered with 1% Naturally Active EM solution,
G9 – a control sample of the highest quality universal substrate, on which rapeseed grew for fourteen days watered with distilled water,
R9 – a control test of 14-day-old rapeseed growing on a universal substrate of the highest quality watered with distilled water,
G10 – a research trial of a universal top-quality substrate, on which rapeseed grew for fourteen days, watered with a 1% solution of EM Naturally Active,
R10 – research trial of 14-day-old rapeseed growing on a universal substrate of the highest quality watered with 1% solution of EM Naturally Active,
G11 – a control sample of universal soil, on which rapeseed watered with distilled water grew for fourteen days,
R11 – a control sample of 14-day-old rapeseed growing on universal soil watered with distilled water,
G12 – a research trial of universal soil where rapeseed grew for fourteen days, watered with 1% Naturally Active EM solution,
R12 – research trial of 14-day-old rapeseed growing on universal soil watered with 1% solution of EM Naturally Active,

DOI: 10.34659/eis.2022.83.4.485

G13 – control test of potting soil for sowing and quilting, on which rapeseed grew for fourteen days watered with distilled water,
R13 – a control test of 14-day-old rapeseed growing on a horticultural substrate for sowing and quilting watered with distilled water,
G14 – a research trial of a horticultural substrate for sowing and quilting, on which rapeseed grew for fourteen days, watered with 1% Naturally Active EM solution,
R14 – a research trial of 14-day-old rapeseed growing on a horticultural substrate for sowing and quilting with 1% Naturally Active EM solution,
G15 – a control sample of sour peat on which rapeseed grew for fourteen days watered with distilled water,
G16 – a research trial of sour peat, on which rapeseed grew for fourteen days, watered with 1% solution of EM Naturally Active.

Results of the research

The results of the determination of elements by atomic absorption spectrometry (ASA) are presented in Table 1, Table 2, Table 3, and Table 4. The content of heavy metals and other metals in soils was determined by the type of soil, EM watering and the type of plants that grew in a given soil.

The largest increase in the number of elements among the soils after wheat cultivation was recorded in the G2 object (universal substrate of the highest quality, on which wheat grew for fourteen days, watered with 1% EM solution), in which nine out of ten elements determined in relation to the control G1 (universal the highest quality substrate on which wheat grew for fourteen days, watered with distilled water). A significant increase in the content of elements was also observed in object G4 (universal soil, where wheat grew for fourteen days, watered with 1% EM solution), in which seven out of ten determined elements had a higher content, and two elements Cd and V out of ten had the same content with respect to the control object G3 (universal land on which wheat grew for fourteen days watered with distilled water). In the case of the substrate with acid peat and the horticultural substrate for sowing and quilting used for growing wheat, little or no effect on the increase in the metal content after the application of the EM preparation was observed.

In all types of soils used for the cultivation of rapeseed, in which the EM preparation was applied, a decrease in the content of seven to nine elements out of ten was observed. The observations also show that in all types of soils used for rapeseed cultivation, in 100% of the objects where the EM preparation was applied, the content of the elements As, Al and V decreased. The decrease in the content of Cd, La, Cr, and Ni was recorded in 75% of the

DOI: 10.34659/eis.2022.83.4.485

objects, for fourteen days, the rapeseed grew, watered with a 1% solution of EM Naturally Active. In 50% of the sites where rapeseed watered with 1% Naturally Active EM solution grew for fourteen days, a decrease in the content of Pb, Co and Na was noted.

Table 1. Metal content in the soil

Object	Element									
	As	Cd	La	Pb	Al	V	Cr	Co	Ni	Na
	µg/g dry weight									mg/g dry weight
G1	0.78	0.26	1.33	9.92	1315.38	11.14	10.59	0.68	4.91	0.42
G2	1.09	0.25	1.53	10.24	1484.48	12.34	10.61	0.78	5.35	0.46
G3	0.40	0.09	0.40	3.57	555.14	1.15	6,00	0.26	3.98	0.08
G4	0.57	0.09	0.43	3.22	570.94	1.15	6.03	0.58	4.72	0.11
G5	1.46	0.19	3.59	10.68	1209.82	2.99	7.27	0.68	5.13	0.17
G6	1.16	0.16	3.15	8.24	940.00	2.15	6.45	0.52	4.36	0.16
G7	0.79	0.09	1.22	8.16	771.49	1.78	6.23	0.45	4.00	0.13
G8	0.61	0.12	1.07	6.75	737.10	1.56	5.95	0.45	4.02	0.14
G9	0.83	0.24	1.59	10.84	1475.15	12.75	10.40	0.73	5.55	0.48
G10	0.80	0.30	1.49	11.67	1416.95	12.53	11.01	0.75	6.26	0.47
G11	0.47	0.08	0.42	3.36	600.80	1.18	6.10	0.25	3.88	0.09
G12	0.45	0.06	0.44	3.13	538.02	1.07	5.62	0.27	3.81	0.11
G13	1.88	0.25	6.13	19.16	1663.16	4.08	7.78	0.87	4.89	0.30
G14	1.19	0.19	3.97	10.04	993.14	2.38	6.53	0.53	4.41	0.18
G15	0.71	0.15	1.12	8.15	749.35	2.33	5.78	0.46	3.76	0.13
G16	0.47	0.11	0.90	6.59	597.76	1.36	5.57	0.41	3.64	0.15

It was observed that the content of aluminium was higher in all rapeseed seedlings, which were watered with the EM preparation in relation to rapeseed seedlings which were watered with water. The aluminum content in wheat in the control objects watered with water ranged from 176.46 to 442.31 µg/g dry weight, while in the objects watered with the EM prepara-

DOI: 10.34659/eis.2022.83.4.485

tion, it ranged from 189.75 to 632.84 µg/g dry weight. The aluminum content in rapeseed in the control objects watered with water ranged from 262.08 to 461.39 µg/g dry weight, while in the objects watered with the EM preparation, it ranged from 284.21 to 595.59 µg/g dry weight.

Diversified soils, which were used for the research, to a small extent, influenced the content of lanthanum in wheat and rapeseed. The lanthanum content in wheat in the control objects watered with water ranged from 0.09 to 0.34 µg/g dry weight, while in the objects watered with the EM preparation, it ranged from 0.15 to 0.33 µg/g dry weight. The lanthanum content in rapeseed in the control objects watered with water ranged from 0.20 to 0.28 µg/g dry weight, while in the objects watered with the EM preparation, it ranged from 0.15 to 0.49 µg/g dry weight.

Table 2. Metal content in plants

Object	Element									
	As	Cd	La	Pb	Al	V	Cr	Co	Ni	Na
	µg/g dry weight									mg/g dry weight
R1	0.54	0.27	0.32	8.29	442.31	0.79	49.55	0.40	32.26	0.19
R2	0.21	0.20	0.15	5.53	632.84	0.57	59.54	0.44	35.87	0.23
R3	0.13	0.19	0.09	4.51	233.15	0.24	28.16	0.22	16.61	0.20
R4	0.06	0.17	0.21	4.62	435.56	0.34	46.21	0.36	25.80	0.21
R5	0.80	0.26	0.19	6.21	197.25	0.32	52.73	0.41	33.28	0.23
R6	1.34	0.36	0.33	4.46	327.81	0.49	47.97	0.37	32.69	0.21
R7	0.24	0.54	0.20	13.67	176.46	0.81	215.57	1.55	132.71	0.62
R8	0.18	0.34	0.22	8.13	189.75	0.75	133.90	1.29	80.03	0.25
R9	0.17	0.36	0.28	7.76	461.39	0.88	110.44	1.02	65.10	3.37
R10	0.71	0.47	0.43	21.29	387.54	1.37	147.59	1.29	87.10	2.14
R11	0.10	0.52	0.20	9.62	262.08	0.81	159.42	1.25	95.20	2.04
R12	0.53	0.59	0.15	9.89	284.21	0.64	105.69	0.94	63.37	1.36
R13	0.47	1.45	0.26	17.64	439.79	0.84	115.91	0.96	68.84	1.93
R14	0.90	0.87	0.49	20.61	595.59	1.65	287.97	2.25	174.82	2.47

DOI: 10.34659/eis.2022.83.4.485

The study showed that the content of arsenic in the wheat watered with water was from 0.13 to 0.80 μg/g of dry weight, and thus it was higher than the content of arsenic in the rapeseed watered with water, which was from 0.10 to 0.47 μg/g of dry weight. A higher arsenic content was also noted in wheat watered with EM preparation, amounting to 0.06 to 1.34 μg/g dry weight, than the content of arsenic in the in EM-watered rapeseed, amounting to 0.53 to 90 μg/g of dry weight.

The use of EM preparation resulted in a decrease in nickel content in wheat in relation to objects watered with water, while in rapeseed, this action had the opposite effect. In wheat in the control objects watered with water, the content ranged from 16.61 to 132.71 μg/g of dry weight, while in the objects watered with the EM preparation, it ranged from 25.80 to 80.03 μg/g of dry weight. The nickel content in rapeseed in the control objects watered with water ranged from 65.10 to 95.84 μg/g of dry weight, while in the objects watered with the EM preparation, it ranged from 63.37 to 174.82 μg/g of dry weight.

In rapeseed objects watered with water, higher contents of cadmium, vanadium, lead, aluminum and sodium were observed than in wheat objects watered with water. In wheat objects watered with water, higher amounts of arsenic, chromium, lanthanum, nickel and cobalt were observed than in rapeseed objects watered with water. The rapeseed objects watered with the EM preparation were characterised by a higher content of arsenic, cadmium, vanadium, chromium, cobalt, lanthanum, lead, nickel and sodium than in wheat objects watered with the EM preparation.

It was observed that 87.5% of micro- and macroelements (potassium, calcium, phosphorus, zinc, boron, manganese and copper) increased in the G4 object (universal soil where wheat grew for fourteen days with 1% Naturally Active EM solution) in relation to the object G3 of the control unit. An increase of 75% of micro- and macroelements (magnesium, potassium, calcium, boron, manganese and copper) was observed in the G8 object (acid peat, where wheat grew for fourteen days, watered with 1% Naturally Active EM solution) in relation to the control G7 (acid peat, where wheat grew for fourteen days, watered with distilled water). Object G2 showed an increase of 62.5% of micro- and macroelements (magnesium, potassium, phosphorus, boron and manganese) in relation to the control object G1. On the horticultural substrate for sowing and quilting, on which wheat grew for fourteen days, watered with 1% EM Naturally Active solution, a 62.5% decrease of micro- and macronutrients (magnesium, potassium, calcium, phosphorus and manganese) was observed in relation to the horticultural substrate for sowing and picking, where wheat was grown for fourteen days and watered with distilled water.

DOI: 10.34659/eis.2022.83.4.485

Table 3. Contents of macro and micronutrients in soil

Object	Element							
	Mg	K	Ca	P	Zn	B	Mn	Cu
	mg/g dry weight				µg/g dry weight			
G1	1.47	1.05	35.88	0.90	33.52	0.53	122.14	20.46
G2	1.56	1.36	20.06	1.17	29.31	2.14	124.48	14.60
G3	1.05	0.14	17.85	0.48	12.51	2.27	22.63	9.37
G4	1.00	0.22	25.42	0.50	16.60	2.54	26.56	13.72
G5	1.82	0.56	28.37	0.59	26.16	0.53	65.53	5.94
G6	1.63	0.46	19.38	0.45	30.44	0.80	62.09	6.73
G7	0.94	0.23	3.35	0.27	19.44	0.40	24.71	5.48
G8	0.96	0.25	4.04	0.26	18.50	0.80	24.93	5.50
G9	1.61	1.68	22.40	1,00	49.72	3.74	140.17	21.20
G10	1.75	2.02	28.11	1.12	42.34	3.21	129.70	19.73
G11	1.12	0.44	18.02	0.54	20.04	3.07	21.48	21.76
G12	1.07	0.56	18.62	0.57	11.10	2.94	22.72	8.06
G13	1.04	1.23	29.42	1.56	84.39	1.47	100.59	14.03
G14	1.75	1.03	22.90	0.57	19.83	0.67	69.97	8.41
G15	1.08	0.24	4.42	0.26	22.30	0.27	23.92	7.23
G16	0.88	0.24	5.42	0.26	13.71	0.20	22.46	4.55

In the object G10 (the universal top-quality substrate, on which rapeseed watered with 1% Naturally Active EM solution grew for fourteen days), an increase in all macronutrients and a decrease in all tested microelements was observed in relation to the control object G9 (universal substrate of the highest quality, on which for fourteen days rapeseed grew watered with distilled water).

An increase in 75% of macronutrients (potassium, calcium, phosphorus) was observed in the object G12 (universal soil on which, for fourteen days, rapeseed watered with 1% Naturally Active EM solution grew), with a simultaneous decrease in microelements (zinc, boron, copper) in relation to the object control G11 (universal soil on which rapeseed watered with distilled water grew for fourteen days).

DOI: 10.34659/eis.2022.83.4.485

Object G14 (horticultural substrate for sowing and quilting, on which rapeseed watered with the Naturally Active EM solution grew for fourteen days) showed a decrease in all the tested microelements compared to the control object G13 (horticultural substrate for sowing and quilting, on which rapeseed watered with distilled water was growing for fourteen days). Moreover, object G16 (acid peat, on which rapeseed watered with 1% Naturally Active EM solution grew for fourteen days) showed a decrease in all micronutrients (zinc, boron, manganese and copper) compared to the control object G15.

When analysing the content of micro- and macroelements in the horticultural substrate for sowing and quilting after the cultivation of wheat and rapeseed watered with the Naturally Active EM solution, different trends in the changes of individual elements were observed. In object G6, where wheat was growing for fourteen days, the content of all tested macroelements decreased, while in the same substrate where rapeseed grew (object G14), a decrease in all tested microelements was observed.

A study by Iriti et al. (2019) reports that the application of EM in common bean cultivation increased the magnesium, manganese, phosphorus and sodium content of beans. According to Sawicka et al. (2021), the use of innovative technology of potato cultivation with the application of EM will allow us to obtain better quality products ennobled to potato processing.

According to Mohamed et al. (2021), the application of EM as an additive to sweet bell pepper cultivation through foliar applications enhanced sweet bell pepper development traits and biochemical components (mineral elements and some biocomponents).

Among the analysed micronutrients in plants, the most frequent increase in the objects watered with EM was recorded for copper. The highest copper content was observed in wheat growing on the highest quality substrate watered with 1% Naturally Active EM solution, the content of which was 201.53 μg/g of dry weight. In the same soil, the lower content of copper was found in rapeseed watered with water, which contained 46.01 μg/g of dry weight and watered with EM preparation, it contained 74.01 μg/g of dry weight.

Among the analysed macroelements, an increase in phosphorus in wheat and rapeseed was recorded in 71.43% of the objects watered with EM. Slightly lower growth in wheat and rapeseed was recorded for the content of calcium, magnesium and potassium, and it occurred in 57.14% of the objects watered with EM.

DOI: 10.34659/eis.2022.83.4.485

Table 4. The content of macro and micronutrients in plants

Object	Element							
	Mg	K	Ca	P	Zn	B	Mn	Cu
	mg/g dry weight				μg/g dry weight			
R1	2.27	103.10	3.51	23.68	247.53	3.83	186.16	131.31
R2	2.66	92.76	3.88	26.46	170.90	9.65	218.82	201.53
R3	2.56	72.84	4.57	24.73	157.89	1.65	147.92	51.61
R4	3.12	78.18	5.93	30.93	129.45	13.41	184.73	126.76
R5	2.82	99.35	5.40	24.95	212.21	1.35	105.71	73.63
R6	2.89	92.68	5.13	24.49	167.51	2.29	117.70	24.09
R7	2.63	10.69	0.79	13.96	332.39	0,00	65.68	64.26
R8	2.09	13.89	0.78	12.99	177.91	0,00	63.24	52.83
R9	7.46	121.89	16.24	15.79	151.84	21.20	304.35	46.01
R10	6.55	128.44	23.18	17.55	250.04	11.22	306.64	74.01
R11	6.46	107.52	26.79	17.62	186.68	53.34	214.64	58.64
R12	5.25	100.82	22.95	18.49	407.85	19.66	196.23	129.42
R13	6.54	104.35	21.70	17.35	146.56	27.5	111.16	20.47
R14	8.85	142.92	37.43	18.03	349.32	26.56	137.99	70.26

The objects R4 (fourteen-day-old wheat grown on universal soil watered with 1% Naturally Active EM solution) and R14 (fourteen-day-old rapeseed growing on a horticultural substrate for sowing and quilting watered with 1% Naturally Active EM solution) were distinguished by an increase in the content of seven out of eight micro- and macroelements. An increase in the content of 75% of micro- and macroelements was observed in the object R2 (fourteen-day-old wheat growing on the highest quality substrate watered with 1% Naturally Active EM solution) and R10 (fourteen-day-old rapeseed growing on the universal top quality substrate watered with 1% Naturally Active EM solution).

Conclusions

From the practical point of view in agricultural production, obtaining a high yield of good quality depends not only on supplying the crop with macronutrients but also on covering its demand for microelements. They determine the effective use of phosphorus and other macronutrients in the production of biomass. The obtained results indicate that the use of the Naturally Active EM preparation containing beneficial microorganisms influences the creation of habitat favourable to plant growth by facilitating the availability of micro- and macroelements to plants. The concentration of individual elements in the samples was determined by the type of soil, watering with EM preparation and the type of plant. Of the four types of soil on which wheat watered with EM preparation was grown, the greatest increase in the number of micro- and macroelements in wheat was recorded in the R4 object (research sample of 14-day-old wheat growing on all-purpose soil watered with a 1% solution of EM Naturally Active) in relation to the control object watered with water. The application of the EM preparation on the soils where wheat was grown had a significant impact on the content of micro- and macroelements, thanks to which plants have the opportunity to assimilate better nutrients, which can make the plant more valuable from the consumer's point of view. Studies have shown that EM as a representative of biopreparations can be an alternative to artificial fertilisers for not only ecological reasons consistent with the principles of sustainable development. The prices of synthetic fertilizers increased dramatically compared to previous years, making the use of EM economically advantageous as well.

Acknowledgements

The research was funded by The Scientific Subvention of Bialystok University of Technology, Poland, as part of research project no. WZ/WB-IIŚ/2/2021.

The contribution of the authors

The article was written in collaboration by all authors.

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THE ESSENCE OF THE POTENTIAL OF THE AGRICULTURAL BIOGAS MARKET IN POLAND – A CASE STUDY OF A BIOGAS PLANT PROJECT

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ABSTRACT: In recent years, the development of renewable energy sources has become one of the key demands in the European Union's policy. In Poland, the idea emerged that the energy potential of domestic agriculture may be an opportunity for broader use of the available agricultural biomass. Given that agricultural biogas has long been seen as one of the most promising directions for energy transition, the goal of the article was to assess the potential of the agricultural biogas market in Poland. The research methodology was based on statistical measures related to analysing the structure and changes over time in individual years. The structure analysis was carried out for selected Polish provinces, for which empirical distributions were built and selected descriptive parameters were calculated. A similar study was made in relation to selected EU countries. In addition, according to the National Action Plan for Renewable Energy, at least one agricultural biogas plant should be established in each Polish municipality. On this basis, the article assesses the ecological effect of the project on agricultural biogas in Marcinkowice, in the Zachodniopomorskie Voivodeship. The presented simulations allowed us to conclude that an agricultural biogas plant can be an ecological potential in the form of reducing the consumption of fossil fuels by reducing emissions of pollutants and greenhouse gases into the atmosphere while reducing fossil fuel consumption. It was important for the practice to confirm that investing in renewable energy sources, including the use of biogas, is part of the goals and directions of development related to the sustainable management of environmental resources and the development of renewable energy sources.

KEYWORDS: renewable energy sources, biogas market, analysis, agriculture, case study, ecological and energy effects

Introduction

The available literature emphasises that the biogas market in Poland is an interdisciplinary issue covering technical and organisational aspects of legal and even economic and social nature (Drożdż et al., 2021; Pietrzak et al., 2021; Tucki et al., 2019). Many researchers combine this subject with landfill, sewage or municipal biogas. The amendment to the Energy Law Act made by the legislator on 8 January 2010 introduced the definition of agricultural biogas referred to as gaseous fuel (ACT, 2010). Therefore, the huge energy potential of domestic agriculture may constitute an opportunity for the dynamic development of this energy sector in Poland (Bielski et al., 2021; Lipiński et al., 2018; Szyba et al., 2022; Janiszewska, 2019). Available reports and studies indicate that the theoretical raw material potential of the available biomass is estimated in the range of 5 billion m^3 of biogas (Energy Regulatory Office, 2021). This potential presupposes the use, as a priority, of agricultural by-products, liquid and solid livestock manure and by-products and residues from the agro-food industry. At the same time, together with their use, the possible use of crops is also planned, including those referred to as energy crops, as a substrate for biogas plants. It is estimated that this effect can be achieved in an area of approx. 700 thousand ha, which will allow for full coverage of national food needs and obtaining additional raw materials necessary for the production of agricultural biogas and biofuels (Czerwiakowska-Bojko & Zmuda, 2009).

On the other hand, the actual available raw material potential of biogas production, contained in agricultural by-products and residues of the agri-food industry, amounts to approx. 1.7 billion m^3 of biogas per year (Energy Regulatory Office, 2021). Available data indicate (Institute of Renewable Energy, 2021) that annually, approx. 14 billion m^3 of natural gas is consumed in Poland, including approx. 500 million m^3 of gas is consumed by individual consumers in rural areas. The estimated amount of biogas after purification could cover about 10% of the domestic gas demand or fully meet the needs of rural customers and provide an additional 125 thousand MWhe (electricity) and 200 000 MWhc (heat).

The essence of the potential of the biogas market was recognised by the Polish authorities in the document "Directions for the development of agricultural biogas plants in Poland in the years 2010-2020". This document highlights the importance of optimal conditions for the development of agricultural biogas installations to be used for electricity and heat production (Ministry of Economy, 2009). It is worth noting that, under Directive 2009/28/EC, Member States are required to ensure a certain share of energy from renewable sources in the final gross consumption of energy (Directive,

DOI: 10.34659/eis.2022.83.4.492

2009). Therefore, the issue of agricultural biogas becomes as topical as possible and worthy of a broader discussion in connection with the unfavourable legislative changes concerning photovoltaic or wind installations and the current high energy and heat prices (Lipiński et al., 2018; Augustyn & Mirowski, 2018).

In the extensive literature of the subject, descriptions regarding the possibility of achieving ecological effects related to the use of biogas can be found (Mamica et al., 2022; Korys et al., 2019; Kozłowski et al., 2019). However, the analysis of the available literature has shown that it is limited to considerations concerning agricultural biogas and individual case studies. In particular, there is a lack of publications in relation to the energy and economic impact assessment. Therefore, the presented study is an attempt to fill the gap in the literature by discussing the essence of the potential of the agricultural biogas market in Poland on the example of a selected case study of a biogas plant project, along with an estimation of the environmental effect of the project on agricultural biogas in a selected destination where the agricultural economy plays a dominant role.

In the presented form, this article has many important practical and theoretical implications in an interdisciplinary perspective. The considerations in the thesis were organised as follows. Chapter 2 contains a description of the research method used in response to the set purpose of the thesis. Chapter 3 presents the characteristics of the agricultural biogas production market in Poland in terms of individual voivodships and against the background of selected European Union countries. Chapter 4 presents the assessment of the ecological effect on the example of agricultural biogas. The thesis ends with conclusions in which current research limitations were indicated. Also, future directions of research in relation to the issues related to the assessment of both the potential of the biogas market in Poland and the economic and energy benefits related to its development were identified.

Materials and methods

Anaerobic digestion of biomass is a process that has been used for years. However, in the perspective of the current paradigm of sustainable development, it is gaining a new face, especially in the context of the carbon footprint issue. To outline the broader circumstances of the problem, the article is divided into two parts. In the first, the potential of the agricultural biogas market in Poland is characterised, and in the second, on the basis of an agricultural biogas plant project, it is shown that the provision of energy from a biogas plant makes it possible to reduce carbon dioxide emissions into the air. This is a significant environmental effect both locally and globally.

DOI: 10.34659/eis.2022.83.4.492

The article uses statistical data based on the reports of the Central Statistical Office and the report of the National Centre for Agricultural Support in Poland, thanks to which it was possible to assess the potential of the agricultural biogas market in Poland (Central Statistical Office, 2020; Central Statistical Office, 2021; Ministry of Economy, 2010). The research period covered the years 2016-2020, and due to the availability of data in some cases, it was extended until 2021. In the following part, the considerations in the article are also a case study. They focus on assessing the ecological effect on the example of the Marcinkowice agricultural biogas plant (Development study, 2019). The choice of this destination was not accidental but was dictated by the desire to evaluate the actual project. Detailed calculations of carbon dioxide emission savings resulting from the implementation of the project in renewable energy sources, i.e. an agricultural biogas plant, were made based on the methodology for calculating the carbon dioxide emission reduction coefficient for the Operational Programme Infrastructure and Environment 2014-2020 (sub-measure 1.6.1 POI & Ś). The research results are presented in tabular, graphic and descriptive form in individual chapters of the work. The effect represents the result of implementing projects in the field of atmospheric protection and prevention of climate change, and it determines the amount of reduced CO_2 emissions.

Reduced carbon dioxide (CO_2) emissions should be understood as the reduction in emissions achieved as a result of the implementation of projects that reduce or eliminate entirely the consumption of energy chemical energy contained in fossil fuels. In order to calculate the size of the effect (reduction or avoidance of carbon dioxide (CO_2) emissions), emissions should be calculated (before and after the implementation of the project) using the carbon dioxide (CO_2) emission factors (in kg/GJ) recommended for use for a given year by the National Centre for Balancing and Emission Management.

Biogas production in Poland

Biogas production in individual voivodeships

As indicated in the literature on the subject (Tomaszewski, 2020), frequent changes in the law, oligopolies of raw material suppliers, and difficulties in obtaining financing are factors inhibiting the development of biogas plants in Poland. Their total number by 2025 is estimated at 1500-2100 units. According to the available data, at the end of 2020 in Poland, there were 316 biogas plants, 116 of which were agricultural biogas plants, 100 were biogas plants located near wastewater treatment plants, and another 100 were biogas plants at landfills (Biogas Barometer, 2020; Institute of Renewable Energy, 2021).

DOI: 10.34659/eis.2022.83.4.492

Figure 1 shows the production of agricultural biogas in Poland in 2012-2020. Geographical analyses indicate that most agricultural biogas plants are located in the following voivodeships: Zachodniopomorskie, Wielkopolskie and Warmińsko-Mazurskie. These regions have the best conditions for growing energy crops (including the area they can devote to them), the most developed agri-food industry, and their farmers raise the largest number of animals (per farm). The last two factors are particularly important because they indicate the access to large quantities of free raw material for the production of biogas, i.e. manure and animal excrement, e.g. in the form of slurry. The smallest number of agricultural biogas plants operate in the Opole, Świętokrzyskie and Śląskie voivodeships (Report, 2021).

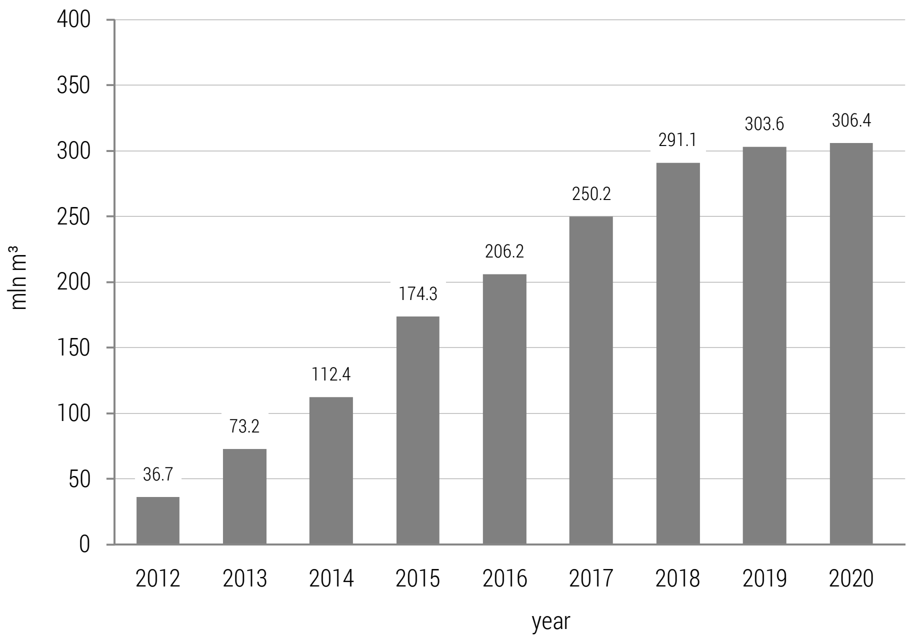

Figure 1. Production of agricultural biogas in Poland in 2012-2020 [in million m³]

Source: authors' work based on the Report (2021).

According to the reports (National Center for Agricultural Support, 2021) for 2020, over 3.96 million tonnes of raw materials were used to produce agricultural biogas, including decoction of the distillery (20.7% of the total raw materials used), followed by fruit and plant residues (19.5%), slurry (18.5%), maize silage (10.6%) and beetroot pulp (6.3%). Waste accounted for approx. 88% of raw materials are used for the production of agricultural biogas, and 12% – are cereals intended for purposes. The growth of biogas

DOI: 10.34659/eis.2022.83.4.492

production was mainly influenced by the well-developed food sector and agriculture, which ensured a constant supply of raw materials for biogas plants. The extraction of biogas from landfills in the years 2016-2020 is shown in Figure 2.

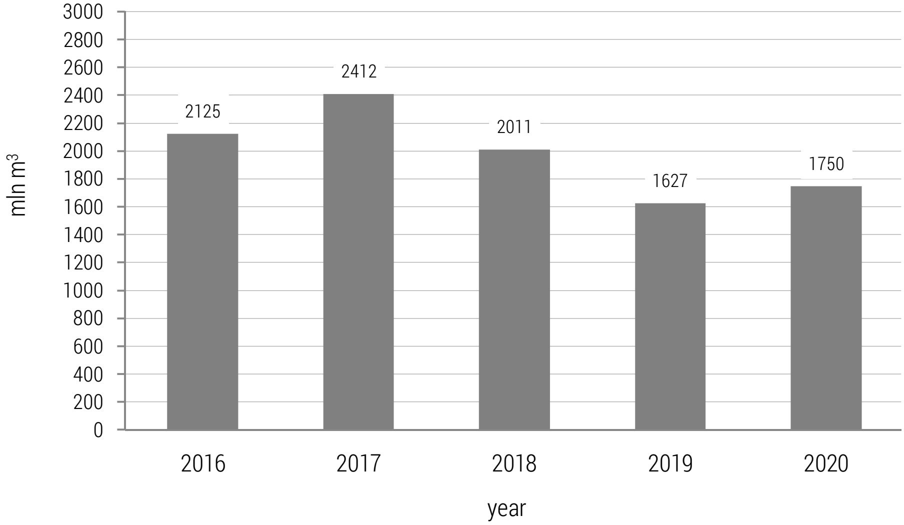

Figure 2. Obtaining biogas from landfills in 2016-2020 [in TJ]
Source: authors' work based on Central Statistical Office (2021).

As biogas plants producing energy from biogas from sewage treatment plants, they constituted 35% and were the dominant type of biogas plant (106 installations). In terms of the number of installations, the second place was occupied by power plants producing energy from biogas from landfills (33% – 100 biogas plants) (Central Statistical Office, 2021). The data contained in the above figure show that in 2016-2020, biogas extraction from landfills varied. Since 2017, a downward trend has been observed, followed in most cases by an increase in production in 2020 (Kwaśniewski et al., 2022).

The available data indicate that biogas plants producing energy from mixed biogas constituted 1% of all biogas plants and occurred individually in four voivodeships – Śląskie, Zachodniopomorskie, Lubelskie and Dolnośląskie. However, the dominant type of agricultural biogas plants are those that generate energy from biogas from sewage treatment plants. The data in this respect is shown in Figure 3.

The data analysis in Figure 3 shows that the production of biogas from sewage treatment plants in Poland in 2016-2020 was diverse. Biogas production increased in 2017, then decreased in 2018, and since 2019 there has been another increase.

DOI: 10.34659/eis.2022.83.4.492

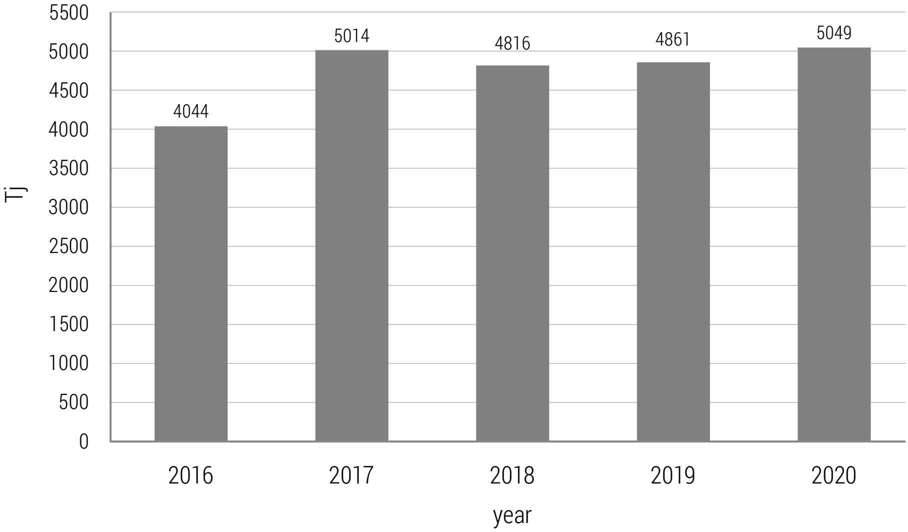

Figure 3. Obtaining biogas from sewage treatment plants in Poland in 2016-2020 [in TJ]
Source: authors' work based on Central Statistical Office (2021).

It should be emphasised that, for example, in the Silesian Voivodeship, biogas plants powered by raw material from sewage treatment plants had a large share. In turn, the smallest biogas plants operated in the Świętokrzyskie, Opolskie and Lubuskie voivodships, and their capacity was one of the smallest in the country (max. 4.3 MW in Lubuskie). The dominant type of biogas power plants in these voivodeships were installations using biogas from sewage treatment plants (Central Statistical Office, 2021).

To sum up, after analysing the share of individual types of biogas plants in Poland, it is possible to distinguish the regions in which the selected type of biogas plants was dominant. Agricultural biogas plants dominated in voivodeships in the western part of Poland (Lubuskie) through the northern part (West Pomeranian, Pomeranian and Warmian-Masurian) and in the eastern part (Podlaskie and Lubelskie).

The analysis of the available data indicates that the central part of Poland was dominated by power plants producing energy from landfill biogas. In turn, power plants producing energy from biogas from sewage treatment plants were located in the southern part of Poland (Opolskie, Śląskie, Małopolskie and Podkarpackie Voivodeships). Pomeranian Voivodeship stands out in terms of installation efficiency – 19 biogas plants were created there. 22.1 MW of energy (mainly agricultural biogas plants), while in the Silesian Voivodeship, almost twice as many installations (35) generated approx. 22.1 MW of energy. 21.4 MW. Most biogas plants in the Silesian Voivodeship generate energy from biogas from sewage treatment plants (Central Statistical Office, 2021).

The available data show that at the end of 2020 in Poland, the installed electricity capacity of 116 biogas plants reached 126.912 MW. All energy producers included in the central register of economic activities defined economic activity as concentrated exclusively in the production of electricity from agricultural biogas.

Biogas production in Poland against the background of selected European Union countries

According to the available reports and studies, biogas and biomethane are important elements of the energy system in countries with a well-developed agricultural sector (EBA, 2018; Alatzas et al., 2019; Niemczyk et al., 2022). The aim of the biogas industry is to manage those raw materials which are considered waste. However, the dynamic increase in the share of this industry depends mainly on the existence of sufficiently strong administrative and government support mechanisms.

The available data indicate that Germany is the largest European market for biogas, both in terms of the number of production units and the amount of fuel produced (European Commission, 2021). This raw material accounts for 14% of electricity production from renewable sources. Centres for the production and use of this fuel are relatively evenly distributed across all the Länder, although the highest concentration is found in the north of Germany.

The biogas sector also plays an important role in the German labour market. This industry offers employment of approx. 345 thousand employees (as of 2017). Legislation introducing favourable support schemes, including the EEG-Act (Erneuerbare-Energien-Gesetz), which entered into force in 2000, introducing, i.a. feed-in tariffs. Since 2017, the solutions offered by this document also include longer financing perspectives for existing units (until 2030), a package supporting the development of biogas-based energy and provisions making the existing regulations more flexible. As a result, at the end of 2019, 9527 biogas plants operated in Germany (EBA, 2018).

The biogas sector in Italy developed dynamically in 2008-2012, thanks to the feed-in tariff system (Murano et al., 2021). At that time, they were the highest in the European Union in terms of support offered to small biogas plants using slurry and energy crops. In just two years (2010-2012), the number of biogas plants in Italy has risen from 510 to 1264, and electricity generation from this raw material has risen from 1.6 to 7.4 TWh in five years (2008-2013). However, after a period of rapid growth, the Italian government has reduced its support for the sector to the development of small biogas plants (up to 600 kW). At that time, work began on installations for the

DOI: 10.34659/eis.2022.83.4.492

production of biomethane. However, these were not very effective, and at the end of 2017, there were only 8 such units in Italy. In 2018, the Italian government adopted the so-called Biomethane Decree – regulations that were to lead to faster development of the biomethane sector (EBA, 2018).

By comparison, the UK is one of three countries in Europe), alongside Sweden and Estonia, where sewage is the most important substrate for biogas production. In other cases, it is produced mainly from energy plants and agricultural and municipal waste. The cost-effectiveness of biogas production in the United Kingdom is based primarily on a properly constructed model for the certification of renewable energy sources. The first commercial installation for the production of this fuel was built in Great Britain in 1982. Currently, there are biogas production units in the British Isles with a total installed capacity of approximately 630 MW (Jinqi et al., 2022).

According to the statistical report of the European Biogas Society (EBA, 2018), a total of 18,202 biogas plants were operating in Europe in 2018, and the installed capacity across Europe amounted to 1,1082 MW. The largest number of biogas plants was in Germany (over 11 thousand installations), Poland with 304 installations ranked 8th. An interesting case was the Czech Republic, which at that time had 574 biogas plants, but per 1 million inhabitants (54 units), were in third place after Germany (138 units) and Switzerland (77 units). Poland had only 8 biogas plants per 1 million inhabitants, and in this ranking, it occupied 24th place in 2018.

Figure 4 shows the share of biogas energy in the acquisition of energy from renewable sources in 2018 and 2021 in Poland and selected for data availability in European Union countries.

The data presented in Figure 4 show that the share of biogas energy in the acquisition of energy from renewable sources in 2018 and 2021 in Poland and the European Union was very diverse. This state of affairs was influenced by many factors, including legal and administrative regulations.

In 2021, only Poland (0.6%), the Netherlands (0.2%), and Finland (0.6%) recorded an increase in the acquisition of energy from biogas compared to 2018. In the remaining countries, there was a decrease, the largest in Germany (1.2%). The largest share of biogas energy in the acquisition from renewable sources in 201-2018 was recorded in Germany and the Czech Republic. The smallest – are in Finland, Austria and Poland. The average European share of biogas in the production of energy from renewable sources was over 7%. Italy, Slovakia and Lithuania have a similar share to the European average (Eyl-Mazzegaand & Mathieu, 2019).

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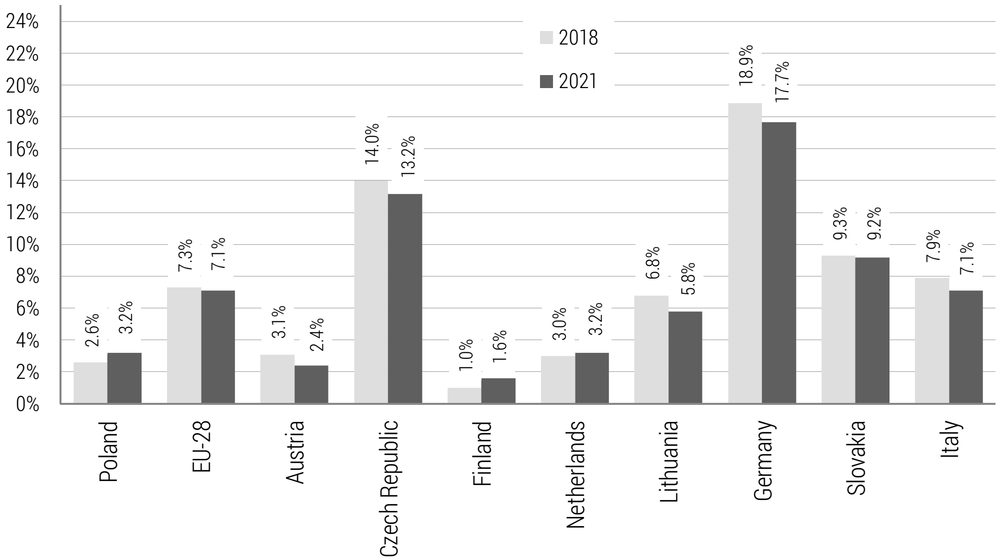

Figure 4. The share of biogas energy in the acquisition of energy from renewable sources in 2018 and 2021

Source: authors' work based on Central Statistical Office (2021).

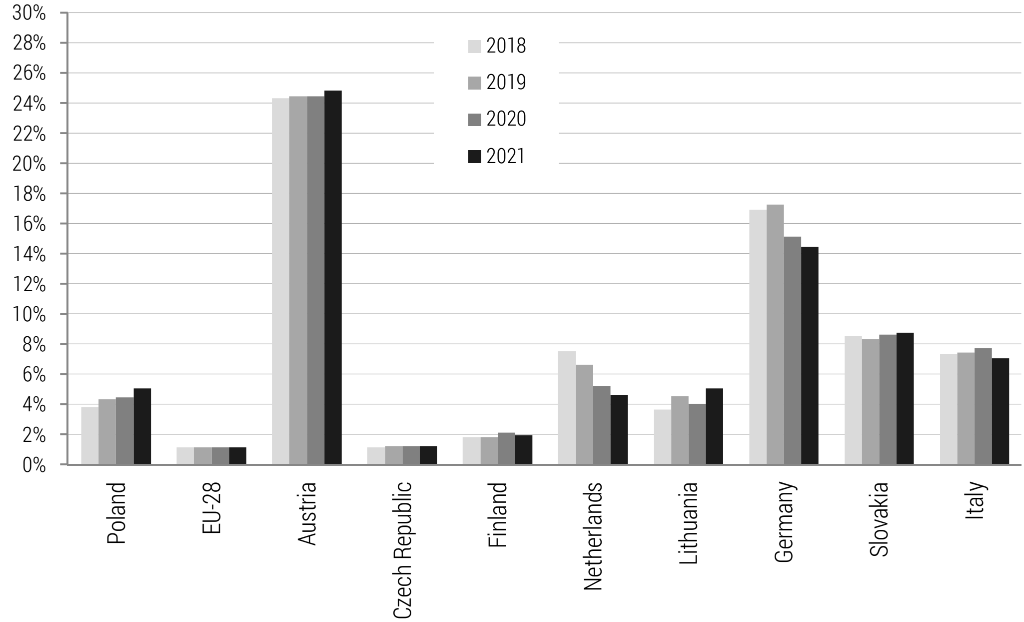

Figure 5. The share of biogas energy in the production of electricity from renewable sources in Poland and selected EU-28 countries in 2018 and 2021

Source: authors' work based on Central Statistical Office (2021).

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The potential of the biogas sector and the EU regulatory environment indicate that, in the opinion of the authors, the biogas sector may play an important role in the Polish energy mix. Meanwhile, currently, it is not sufficiently appreciated and used. Such a small use of biogas technology in the Polish energy system results, to a large extent, from the existence of regulatory and legal barriers, which either hinder the use of some of the available technological solutions or reduce the economic attractiveness of investments in the development of biogas installations (Pietrzak et al., 2021).

The share of energy from biogas in the production of electricity from renewable sources in Poland and selected EU-28 countries is shown in Figure 5.

The share of electricity obtained from biogas in 2018 and 2021 varied significantly across the EU. In Poland, Lithuania and the Czech Republic, there was a noticeable increase by 1.2, 1.5 and 0.5%. In the Netherlands and Germany, however, its share decreased by 2.9% and 2.5%, respectively. The largest share of energy from biogas in the production of electricity from renewable sources was recorded in Austria and then in Germany. Since 2006, the biogas market in Austria has been fully liberalised. In conclusion, the introduction of regulations limiting the use of food-type energy plants for the production of biogas has reduced the attractiveness of the conditions of payment for electricity from biogas. Nevertheless, some Member States have seen a positive increase in production due to their determination to promote both the production of biomethane and the recovery of energy from fermentation waste (ACT of 8 January, 2010).

Assessment of the ecological effect on the example of the Marcinkowice agricultural biogas plant

One example of renewable energy solutions is the planned Marcinkowice agricultural biogas plant. (Development study of the investment, 2019). The aim of the Marcinkowice investment is to generate electricity and heat from biogas obtained in the process of anaerobic fermentation of raw materials (corn silage) carried out using specialised strains of bacteria. It should be emphasised that Marcinkowice is an agricultural township with conditions conducive to the development of installations for the production of energy from renewable sources. There is currently one agricultural biogas plant, the capacity of which is fully used for the heat supply of the existing food production plant (confectionery production). Analysis of the needs of the local community indicates that the inhabitants are struggling with the growing demand for electricity. Therefore, it is necessary to expand the existing energy infrastructure with an additional element – a biogas plant.

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The project described here concerns the construction of an agricultural biogas plant with an electrical capacity of 1.1 MWe and thermal power of 1.04 MWt, together with the accompanying technical infrastructure.

The basic substrate in the planned installation, which constitutes energy fuel, is potato pulp, vegetable substrates (corn silage and other green biomass) and animal manure. The use of other products, such as post-boiler stock and bakery waste, is also allowed. Biogas production will occur using anaerobic methane fermentation.

The project assumes that substrate requirements will be: potato mash – 18,000 Mg/year, corn silage or other biomass – up to 8,000 Mg/year, manure – up to 4,000 Mg/year.

Biogas production will take place using anaerobic methane fermentation. In the technological process of the biogas plant in operation, energy recovery will be carried out from food waste and agricultural production or waste agrarian production. Accordingly, thermal energy and co-generated electricity will be generated. In the process of biogas production, post-fermentation will be created, which according to the law, can be treated as waste with the possibility of use in the process of fertilising agricultural fields. The digested product is separated into a liquid and solid phase. The liquid phase will be used to dilute plant matter, while the excess will be used to improve the quality of soils in agricultural areas. The plant in question uses a closed liquid circuit, which definitely minimises the need for water and the generation of liquid process wastewater. The planned installation will produce biogas, which will be used as fuel for power generation in cogeneration. This gas will power the cogeneration unit, and the electricity and heat produced will primarily cover the biogas plant's own needs, with surpluses being given away: heat to the supplier of the basic raw material company "Nowamyl", electricity to the local transmission grid.

The research aimed to determine the ecological effect of energy production in the Marcinkowice agricultural biogas plant by calculating the "emission reduction factor carbon dioxide CO_2." (Ministry of Economic Development, 2014). For this purpose, detailed calculations of carbon savings resulting from the implementation of the project in renewable energies sources were carried out based on the methodology of calculating the carbon dioxide emission reduction factor for the Operational Programme Infrastructure and Environment 2014-2020 (sub-measure 1.6.1 OPI and E). Table 1 presents the base data resulting from the project assumptions.

DOI: 10.34659/eis.2022.83.4.492

Table 1. Quantitative parameters for the implementation of the Marcinkowice biogas plant project

Description	Measurement units	Value
Biogas plant electrical power	MW	0.499
Thermal power of biogas plant	MW	0.54
Biogas plant operating time	H	8400
Gross amount of electricity produced (product of Biogas plant electrical power and Biogas plant operating time)	MWh	4192
Share of electricity for own needs	%	10.0
Including the amount of energy su%lied to the power system	MWh	3772.44
Conversion factor MWh to GJ	-	3.6
Amount of useful heat that can be generated (product of Biogas plant electrical power, Biogas plant operating time and Conversion factor MWh to GJ)	GJ	16329.6
Share of electricity consumed for own needs	%	15.0
Amount of heat consumed for own needs (Amount of useful heat that can be generated and Share of electricity consumed for own needs)	GJ	2449.44
Number of days per year on which the recipient can use the heat	Days	365
Amount of external heat that can be used by the recipient	GJ	13880.16
Reference efficiency for separate production of electricity (for biogas)	%	40
Reference efficiency for separate production of heat (biogas)	%	43
Limit efficiency (for a reciprocating internal combustion engine, points 1.2 and 1.3, Annex No. 1 to the Regulation Journal of Laws of 2017, item 834)	%	75
Correction multiplier for electricity other than own needs, e.g. introduced into the network (assumption: for voltage ≥ 12 – < 50 kV)	-	0.935
Correction multiplier for electricity consumed for own needs (assumption: for voltage from >=0.45kV to <12kV)	-	0.891
Calorific value of methane	MJ m^{-3}	35.73
Average CH4 (methane) share in biogas	%	60
Amount of biogas consumed	m^3	2 092 650

Source: authors' work based on data from the Development study Marcinkowice.

The calculations showed that the nominal heat output of the cogeneration source (the energy introduced in the fuel at the nominal load of the source) will be 1248 MW, including:

- electrical power of the biogas plant – 0.499 MWe,

- electrical power of the cogeneration source (lower consumption for own needs of the installation) 0.4491 MWe,
- heat output of the biogas plant – 0.540 MWt,
- heat output of the cogeneration source (lower consumption for the own needs of the installation) 0.459 MWt.

The electricity produced as a part of the investment is to be supplied to the local operator's power grid and the heat to an industrial customer (fish farming) located in the immediate vicinity of the investment. According to the calculations, the amount of energy transferred to the power system will be 3772.44 MWh, and the amount of useful heat that can be generated will be 16 329.6 GJ.

Table 2. Calculation of the direct result indicator 'Emission reduction CO_2'

Description	Measurement units	Value
Annual carbon dioxide emissions replaced (avoided) due to the project implementation		
CO_2 emission factor for electricity generation only, including transmission losses (former customer) – typical power plant supplying the National Power System (National Center for Balancing and Emission Management, 2020).	kg/GJ	267.6
CO_2 emission factor for heat production only (ex-producer) – typical coal-fired power plant (National Center for Balancing and Emission Management, 2020).	kg/GJ	126.5
Other assumptions: 1. The calculation does not include carbon dioxide emissions for energy produced for own needs. 2. Heat receiver – reports heat demand throughout the year. This is due to the fact that this heat is needed for production processes. Therefore, the calculations were made for the whole year, without division into the heating season and the period outside the heating season.		
CO_2 reduction – Electricity (Ete)	Mg	3 634.2
CO_2 reduction – thermal energy (etc.)	Mg	1 755.8
Total avoided CO_2 emissions (E1)	Mg	5 390.1
Annual emissions of carbon dioxide from the installation after project implementation		
Annual emissions of carbon dioxide from the installation after the implementation of the project (only biogas dispersed for energy production will be used, for which the emission factor, in accordance with Table 2 of the adopted methodology [3], is 0kg/GJ	Mg	0.00
Value of the CO_2 reduction indicator		
Value of the CO_2 reduction indicator	Mg	5 390.1

Source: authors' work based on data from Development study Marcinkowice.

DOI: 10.34659/eis.2022.83.4.492

The operation of the constructed installation will avoid the emission of CO_2 as a result of not connecting the energy consumers from the installation to the National Power Network and the Local Heating Network. The avoided carbon dioxide emissions related to the generated EEE electricity, in accordance with the adopted method, will amount to 3.634.2 Mg, while the avoided carbon dioxide emissions related to the limitation of heat generation Etc will amount to 1.755.8 Mg.

In order to calculate the carbon savings resulting from the implementation of the project, the following formula was used:

$$\Delta E = E1 - E2 \text{ [t/year]}, \tag{1}$$

where:
E1 – annual carbon dioxide emissions replaced (avoided) as a result of the project implementation [t/year],
E2 – annual emissions of carbon dioxide from the installation after project implementation [t/year].

For all renewable energy installations, the value of the carbon dioxide emission factors in relation to the generated energy is assumed to be zero, i.e. the carbon dioxide emission from these installations does not occur E2 = 0 [t/year]. The estimated annual reduction in greenhouse gas (CI) emissions is 5390.10 tonnes of CO_2 equivalent (Dictionary of environmental protection, 2022).

In conclusion, the presented simulations in the scope of all manufactured products (electricity, heat) constitute a key argument for promoting the development of this type of investment, which is a biogas plant. The functioning of the biogas plant will reduce the emission of harmful chemical compounds (including greenhouse gases) resulting from conventional processes of electricity and heat generation. Writing into the objectives and directions of development related to the sustainable management of environmental resources and the development of renewable energy sources in Poland.

Conclusions and summary

Undoubtedly, renewable energy sources will play an increasing role in global energy production (Ministry of Economy, 2009; European Commission, 2021). This process will be compounded by the deteriorating state of the natural environment and the growing energy intensity of many branches of modern industry (Sikora et al., 2020; Somers et al., 2018; Cesaro,2020). Higher energy consumption will also be driven by an increase in the world's population. However, the structure of energy consumption in Poland differs

DOI: 10.34659/eis.2022.83.4.492

from that in highly developed EU countries, mainly due to the dominant share of coal and the lack of nuclear energy. It is in recent years that changes aimed at diversification of the Polish energy sector have been noticed (Pietrzak et al., 2021).

The presented considerations in this article confirmed the increased interest in the production of biogas by domestic farms. In the period under review, the amount of biogas produced in Poland increased steadily. Many factors influenced this situation, including the well-developed food sector and agriculture, which ensured a constant supply of raw materials for biogas plants. In addition, the expected changes in legal regulations have contributed to the growth in the development of biogas plants. However, it should be mentioned that this increase is inadequate for Poland's potential (Mamica et al., 2022). The dominant type of biogas plants in the country in 2017-2021 were installations using biogas from sewage treatment plants and landfills. On the other hand, the number of renewable energy source installations using biogas in individual voivodships still varies. Agricultural biogas plants dominate in Lubuskie, Zachodniopomorskie, Pomorskie and Warmińsko-Mazurskie, Podlaskie and Lubelskie voivodships. In turn, power plants producing energy from biogas from sewage treatment plants are located in the following voivodships: Opolskie, Śląskie, Małopolskie and Podkarpackie. In the central part of Poland, most power plants produce energy from landfill biogas.

The presented case study shows that the building of an agricultural biogas plant reduces greenhouse gas emissions by reducing carbon dioxide emissions to the atmosphere. Furthermore, the production of agricultural biogas can contribute to improving the energy security of the region by increasing the energy supply using domestic raw materials. Thus, the fermentation of agricultural biomass, leading to the formation of biogas, may lead to achieving ecological and economic benefits, especially when we take into account the possibility of using large raw materials resources found in Polish agriculture. On this basis, the authors postulate that the production of agricultural biogas should be perceived as one of the most promising directions of energy use of biomass and the development of renewable energy sources in Poland. Especially in areas where agriculture is dominant.

Production of agricultural biogas in renewable energy source installations contributes to the achievement of objectives in the aspect:

- environmental: reduction of carbon dioxide emissions, reduction of exploitation and combustion of fossil non-renewable energy sources, prevention of environmental degradation, fulfilment of Poland's accession commitments to increase the share of energy from renewable sources,

DOI: 10.34659/eis.2022.83.4.492

- social: improving the quality of life by reducing the inconvenience associated with greenhouse gas emissions, increasing the environmental awareness of residents,
- economic: use of local energy resources, support of socio-economic development (construction of biogas plant gives the opportunity to create new jobs), an increase of investment attractiveness of the region (opening to new technologies), energy independence.

Summing up the presented research on the essence of the potential of the agricultural biogas market in Poland – the case study of the biogas project does not fully exhaust the essence of the issue. They are only an incentive for further research in this matter. Therefore, such analyses will be the subject of future work to define and identify the key factors for the implementation of an ambitious plan to develop renewable energy sources by increasing the importance of agricultural biogas in areas where the agricultural economy plays a dominant role.

The contribution of the authors

Agnieszka Brelik – conception, literature review, acquisition of data, analysis and interpretation of data – 25 %.

Wojciech Lewicki – conception, literature review, acquisition of data, analysis and interpretation of data – 25 %.

Milena Bera – conception, literature review, data acquisition, analysis and interpretation of data – 25%.

Monika Śpiewak-Szyjka – conception, literature review, acquisition of data, analysis and interpretation of data – 25%.

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Melania BĄK • Marzena STROJEK-FILUS

IMPRESSION MANAGEMENT IN REPORTING ENVIRONMENTAL INFORMATION IN GROUPS OF THE ENERGY, RAW MATERIALS AND FUEL SECTORS. EVIDENCE FROM POLAND

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ABSTRACT: Impression management is vital in disclosing non-financial information, including environmental information, in integrated reports. The purpose of the study is to identify and assess the effects of using the impression management strategies in presenting non-financial ecological knowledge in the integrated reports issued by capital groups from the energy, raw materials and fuel sectors, which have had a large share in the degradation of the natural environment for many years. The research was conducted based on two stages: the first stage – as part of the impression management strategy – focused on text analysis to identify the tools for thematic manipulation as well as visual and structural manipulation, and the second stage consisted in analysing the level of text readability using, i.a., FOG and Pisarek indices. The research findings regarding the selected business entities identified as the "polluters" of the natural environment confirm the application of various tools as part of the stakeholder impression management strategies, including manipulation using words, colour, pictures and text.

KEYWORDS: sustainability, green accounting, environmental information, integrated reports, impression management

Introduction

In light of the sustainable development goals, the problems related to protecting the natural environment represent an important area that requires swift and consistent action (General Assembly Resolution, 2015). Within the framework of these activities, appropriate legal regulations should be introduced, addressed to business entities and the general public aimed at encouraging, and in many cases also forcing, pro-environmental attitudes and behaviour. The effectiveness of such processes largely depends on proper communication between the economy, legislators, experts and society (Schriver, 2017). The following projects and initiatives on a global scale and within countries are a response to an accurate and up-to-date diagnosis related to the deterioration of the natural environment and its reasons. European Sustainability Reporting Standards (ESRS) proposal for a Corporate Sustainability Reporting Directive (CSRD) (ECN, 2022; EFRAG, 2022) are examples of such projects and initiatives.

One of the factors underlying such diagnosis is the reporting of environmental information by business entities whose activities are burdened with a significantly negative impact on the natural environment, such as climate, water condition, biodiversity, etc. Environmental information is highly diversified. It can be financial, quantitative, descriptive or mixed (Sobańska, 2007). The financial information presented in financial statements is subject to the rigour of balance sheet law. At the same time, specific regulations limit the discretion of the manner and scope of its reporting, e.g., IAS/IFRS or national regulations and the resulting accounting principles, in particular the accurate and fair view principle (e.g. Alexander & Archer, 2003; Mattessich, 2009; Boyle, 2010). The IFRS (International Financial Reporting Standards) Conceptual Framework states that the objective of financial statements is that they should be valuable, accurate, trustworthy, and fair. This concept means they must present a valid and unbiased view to be helpful. The essential requirement is "to achieve a fair presentation" (IFRS, 2022).

Non-financial reporting is much more flexible and discretionary regarding the scope and layout of the disclosed non-financial information than financial reporting. The research on this subject indicates numerous problems of a practical and legislative nature (e.g. Turzo et al., 2022; van der Lugt et al., 2020). In environmental problems issues, applying GRI (2016) standards makes it slightly limited (Diouf & Boiral, 2017). For this reason, non-financial information reflecting these issues may become the subject of narrative reporting to a greater extent, and primarily of impression management, which is directly focused on influencing the report user to create, e.g., a positive image of an eco-friendly enterprise, even though this particular enter-

DOI: 10.34659/eis.2022.83.4.500

prise may have a strongly negative impact on the natural environmental (e.g. Wang, 2016; Merkl-Davis & Brennan, 2013; Rämö, 2011; Cho et al., 2010; Rutherford, 2003). Taking intensive advantage of the impression management instruments may affect the quality of communication with the social partner and, as a result, also influence the diagnosis, e.g., regarding the scale and effectiveness of actions taken by these entities to eliminate or significantly reduce the negative impact on the environment (García-Sánchez & Araújo-Bernardo, 2019). As a consequence, it may, directly and indirectly, hinder the implementation of the sustainable development objectives, in particular the goals aimed at improving the natural environment (goals 7, 13, 14, 15) and the goal concerning the general public's right to be provided with relevant information (goal 12.8) (CZR, 2016).

To standardise the methods for reporting disclosures regarding sustainable development and to emphasise the consistency of financial statements and the sustainable development report, the European Commission (European Commission, 2021) published a draft of a new CSRD directive, which is to replace the existing directive on non-financial reporting (Directive, 2014). The reports will be prepared by the European reporting standards on the sustainable development of the ESRB, the purpose of which is to establish a uniform framework for non-financial reporting provided in the draft of the CSRD directive.

The research gap identified by the authors refers to the deficit in research studies addressing impression management strategies in non-financial reporting of environmental information related to the industry sectors exerting a strong negative impact on the natural environment in Central and Eastern Europe countries, including Poland. The purpose of the study is to identify and assess the effects of impression management strategies in presenting non-financial environmental information in the integrated reports issued by capital groups from Poland's energy, raw materials and fuel sectors. The sectors selected for the analysis have had a significant share in the degradation of the natural environment for many years. The study is focused on the most critical capital groups preparing integrated reports and listed on the Warsaw Stock Exchange (WSE). Within the framework of the research objective, additional analysis and assessment of the readability level referring to the selected fragments from the modules devoted to environmental problems were carried out in terms of their intentional impact on the report user. The analysis was also aimed at verifying the Jasnopis application as the software suitable to use in the texts addressing the area of green accounting.

As part of the two-stage research, the method of manual text analysis was used along with the study of the text readability level applying for the Jasnopis program within the framework of which, i.a., FOG and Pisarek indices were used. The structure of the article was adapted to the research purpose.

DOI: 10.34659/eis.2022.83.4.500

The first part presents the review of the basic and advanced tools used in impression management and the research carried out so far in this subject matter in terms of reporting environmental non-financial information. In this background, the research questions were formulated. The next part describes the research methodology, the obtained results, and their reference to other studies. The article's final part includes the conclusions from the research findings and their limitations.

An overview of the literature

Impression Management Strategies in disclosing non-financial – environmental information

Impression management refers to both financial and non-financial information (Cho et al., 2010; Merkl-Davies & Brennan, 2007), including social and environmental information. It is considered a strategy, a process (Leary & Kowalski, 1990) or a technique aimed at shaping and controlling stakeholder impressions. Impression management as a set of plans is used to co-create narration in reporting. It represents its instruments influencing the emotions and behaviour of stakeholders, frequently put together skillfully by biased managers. Impression management, taken from social psychology, refers to presenting oneself to others which results in being perceived positively (Hooghiemstra, 2000). Impression management is supposed to conceal the unfavourable adverse effects of the activities carried out by a business entity (Abrahamson & Park, 1994), magnify its achievements and emphasise its positive perception, e.g., by using a more significant number of positive keywords.

Beattie and Jones (2000) distinguish two types of impression management: accounting numbers management and presentation management. Leary and Kowalski (1990) propose a two-component model: impression motivation and impression construction. They believe that impression management is a rational process that helps entities bridge the gap between their actual situation and their desired status. Brennan et al. (2009) suggest conducting research on impression management in four areas included in the composite impression management score: thematic manipulation, selectivity, visual presentation, and comparing achievements. Merkl-Davies and Brennan (2011; 2013) distinguish seven strategies of impression management (including six classifieds in two main I-II strategies):

I) Strategies for obfuscation (concealing) unfavourable situations or results:

1) syntactic manipulation – using complicated language, which affects the degree of readability (e.g. Kohut & Segars, 1992),
2) rhetorical manipulation – using meaningful rhetoric, e.g., metaphors,

II) Strategies for emphasising positive situations or results:

3) thematic manipulation – highlighting good news and disregarding lousy information,
4) visual and structural manipulation – using appropriate graphic means, e.g., typeface, size and colour of letters, text arrangement,
5) comparison of achievements – selection of comparative periods presenting the entity's situation in the best possible light,
6) selectivity – focusing on selected information, ignoring specific indicators, and strategy,

and strategy

7) achievement attribution – assigning positive achievements to the entity (and managers), whereas the negative ones to independent external factors (e.g. Hooghiemstra, 2010).

In the case of each of these strategies, it is required to apply the appropriate method for detecting impression management (Merkl-Davies & Brennan, 2011), e.g., syntactic manipulation – readability indices (Gunning, 1952), thematic manipulation – encoding positive and negative keywords, visual manipulation – using fonts and colours, selection of charts, selectivity – the analysis of information arrangement, selecting the level of operating profit or net profit.

The main goals of using the impression management strategy in non-financial reports include creating the image and reputation of an entity and legitimising actions (Duchon & Drake, 2009; Hopwood, 2009). The obfuscation strategies constitute deliberate distracting messages which can confuse stakeholders, making them puzzled or disoriented (Diouf & Boiral, 2017). Rutherford (2003) defines obfuscation as regulated narrative disclosure of accounting in corporate governance, pointing out that poorly performing companies do not always obfuscate their image using text complexity.

The specificity of non-financial information (narrative form, voluntariness, creativity, individualism) makes it particularly susceptible to the influence of stakeholder impression management strategies (Wang, 2016). Numerous studies have already analysed impression management based on the narratives in non-financial reports. They cover both the revealed content and visual effects. Rämö (2011) claims that the photos presented in these reports (in corporate social responsibility reports) along with the text stimulate, to a greater extent, the impressions related to the reception of informa-

DOI: 10.34659/eis.2022.83.4.500

tion. In turn, the words providing inconsistent visualisations may distract stakeholders and disrupt the messages dedicated to them. Breitbarth et al. (2010) believe that visual communication is just as important as the words and numbers disclosed in non-financial reports.

Cho et al. (2010) contributed significantly to the research on environmental information disclosure. They analysed texts of the reports issued by American companies and observed an egoistic approach to the disclosed ecological knowledge as well as text and overtone manipulation, including the disclosure of slightly less optimistic narratives relating to worse environmental accomplishments of the entity. Breitbarth et al. (2010) found, based on the study of British and German companies, that visual communication (image creation) in the areas of social responsibility and sustainable development presented in non-financial reporting is as important as words and numbers in creating meaning and evaluating non-financial results. García-Sánchez and Araújo-Bernardo (2019) confirm the disclosure of social and environmental information in the reports of Spanish companies using impression management strategies based on visual and structural manipulation, which is manifested through using the right size of graphics and photography and the selection of proper colour. The psychology of colours in the conducted activity (business) plays a significant role in impression management, influencing the senses and emotions of stakeholders, e.g., green refers to hope, nature and ecology (ecological aspects of the business), and blue evokes trust, safety and responsibility. In contrast, red stimulates action and creativity and has an energising effect. However, different interpretations of colours in different cultures should be considered, e.g., green is the sacred colour of Islam (Bartosik-Purgat, 2004).

Applying the GRI (2016) standards and the accurate and fair view principle should prevent or reduce using the impression management strategy. However, the studies of sustainable development reports confirm their use, as evidenced by their optimistic and unsustainable nature, according to Diouf and Boiral (2017). Their research covered interviews with stakeholders and experts in corporate social responsibility investments in Canada, which confirm the flexible application of the GRI standards and the use of impression management to highlight the positive aspects of sustainability and obfuscate negative results.

Practice shows that the environmental information disclosed by the GRI 300 (Environmental Disclosures), which defines the exact scope of disclosures (Materials, Energy, Water, Biodiversity, Emissions, Effluents and Waste, Environmental Compliance, Supplier Environmental, Assessment), is also subject to impression management, e.g., manipulation of accomplishments regarding the selection of comparative periods (in some cases their absence) when disclosing non-financial information on biodiversity GRI 304, in par-

DOI: 10.34659/eis.2022.83.4.500

ticular GRI 304-3 Habitats protected or restored. It also happens that inconsistent environmental information is provided, e.g., different measurement units for energy consumption.

Impression management can result in lower quality of reporting, as confirmed by critical opinions about sustainable development reports, describing them as a form of a spectacle or myths about social and environmental responsibility (Solomon et al., 2013). In the opinion of Merkl-Davies and Brennan (2007), the voluntary nature of sustainability reporting and the absence of regulations in this area facilitate the development and the scale of an impression management strategy usage. Disclosing non-financial information in the corporate social responsibility reports is primarily aimed at making a positive impression on the stakeholders of the entity, which is related to (Wang, 2016): the company's mature approach to the practice of social responsibility, openness and honesty of the entities extending the disclosed information with narratives. The problem is that not every stakeholder has the appropriate competencies, knowledge, and tools to accurately assess the entity's intentions and the integrity of the submitted non-financial information.

The research confirms the biased nature of the provided environmental information, which frequently results from the harmful activity performed by entities, e.g., pollution and degradation of the natural environment. To maintain legitimacy and correct social relations, in such a situation, many entities decide to prepare non-financial reports dedicated to environmental information, supported by an appropriate narrative using impression management strategies. An increase in ecological information disclosures has been observed, e.g., in the reports issued by the US oil companies and also Canadian companies operating in the mining, oil and gas sectors, when an oil spill and negative public perceptions about environmental damage were recorded (Patten, 1992; Neu et al., 1998).

In this context, the authors formulated two research questions regarding the impression management strategy used by capital groups from the selected industry sectors in Poland about non-financial information addressing environmental issues:

Q1: What impression management strategies are used in integrated reports on environmental issues?

Q2: To what extent does the difficulty level of environmental text in integrated reports translate into its readability?

DOI: 10.34659/eis.2022.83.4.500

Research method

The research addresses the scope and strategies of impression management used in integrated reports of capital groups from the energy, raw materials and fuel industry sectors listed on the WSE, included in the WIG Energy, WIG Raw Materials and WIG Fuel indices. The groups listed in the abovementioned index represent Poland's most significant capital groups. At the same time, the entities exert a substantial negative impact on the natural environment due to their use of coal, crude oil and natural gas as the primary raw material. The groups covered by the study submitted their reports to the competition for the best sustainable development reports, edition 2021, including integrated reports (the National Competition Sustainable Development Reports, formerly the Competition Social Reports) organised by the Responsible Business Forum and DELOITTE (KRZR, 2022). It is essential information because participation in this competition aims at, i.a., building both image and reputation and legitimising the company operations. The analysis covered 2020. The Energa Group and the Jastrzębska Spółka Węglowa (JSW) Group did not participate in the competition in its 2020 edition. Only the report issued by the Energa Group covers 2019. Still, it was included in the research because the company is one of Poland's energy industry's largest capital groups and participated in the 2019 edition of the competition. The study also covered an integrated report by JSW, one of the largest capital groups in Poland operating in the raw materials industry, prepared for 2020. Ultimately, the following capital groups were accepted for the research:

- **Energy sector:**
  - ENEA,
  - TAURON,
  - ENERGA,
  - POLENERGIA,
  - PKP ENERGETKA.

- **Raw materials and fuel sector:**
  - KGHM POLSKA MIEDŹ,
  - LUBELSKI WĘGIEL "BOGDANKA",
  - JASTRZĘBSKA SPÓŁKA WĘGLOWA,
  - LOTOS,
  - PKN ORLEN.

DOI: 10.34659/eis.2022.83.4.500

The study was conducted based on two stages. In the first stage, the methods and scope of the environmental information presentation were compared, and the impression management techniques used in integrated reports for the texts on ecological problems were identified. The method of qualitative analysis was used, which consisted in reading the text and analysing it manually. The study's goal was to identify and indicate the potential differences in the applied narrative strategies, primarily the use of impression management between sectors and entities representing the same sector.

In the second stage of the research, selected fragments of the text presenting the modules on environmental problems were analysed using the Jasnopis program adapted to the specificity of the Polish language in the version available at www.jasnopis.pl. This application was developed as part of the research project on "Measuring the level of readability of Polish functional texts" (Gruszczyński et al., 2015; Gruszczyński & Ogrodniczuk, 2015). This program is the Polish equivalent of the programs used in other countries, e.g., the English-language program of the Hemingway Editor application (Hemingway-editor-review). A more advanced tool is Coh-Metrix9, which is an interactive system adapted to, i.a., English-language texts (Graesser et al., 2004; Gruszczyński et al., 2011; McNamara & Graesser, 2011).

The research conducted by the authors is a continuation and extension of the study initiated by Krasodomska (2016) and Czajkowska (2020), covering the selected individual entities listed on the Warsaw Stock Exchange. The research aimed at assessing the possibility of using the Jasnopis program for the texts included in non-financial statements. As part of our research, the results of the Jasnopis program application were analysed, including the calculated FOG Index and Pisarek Index. Also, the number and percentage of complex words were used. The study covered thematically compact fragments, including between 170 and 200 words.

Results and discussion

In the first stage of the research, the impression management strategies used in the integrated reports of the studied groups in the section on environmental information were identified: thematic manipulation, visual and structural manipulation, and syntactic manipulation. Table 1 presents the results referring to the thematic manipulation of ecological aspects in terms of words and phrases divided into general, i.e. concerning the entire report and the environmental ones. The mottos of information as the whole were also taken into account.

DOI: 10.34659/eis.2022.83.4.500

Table 1. Thematic manipulation related to environmental aspects in the analysed companies

Keywords and key phrases – selected	
General	Environmental
Company / Motto	
KGHM Polska Miedź / Future is made of copper	
stability, future, efficiency, flexibility, ecology, security, cooperation, dialogue, interaction, responsibility, good practices, public confidence, optimization, reliable producer, trusted contracting party, leader of sustainable development	**green order, green energy, pro-ecological investments**, climate and air protection, **renewable energy, reduction** of emissions, biodiversity conservation, afforestation, reclamation of mines, **counteracting environmental** threats, **ecological** production, **pro-ecological** regulations, man and the **environment**, photovoltaic power plants, responsible land and forest management
Lubelski Węgiel "Bogdanka" / Stable development in uneasy environment. Challenges in a time of pandemic	
stable development, responsibility, safety, mine of the future, smart mine, efficiency, dialogue with stakeholders, cooperation, innovative projects, social initiatives, support, partner	effective mine, land reclamation, increasing natural attractiveness, **green order, energy transition**, land revitalization, climate protection, **renewable energy**, protection of biodiversity, education for **environmental** protection, efficiency of electricity use, **environmental investments**, reduction resources, materials and energy consumption
Jastrzębska Spółka Węglowa / We mine coal that changes the world	
stable development, digitization, employee satisfaction, stable work, supporting partner, implementation of innovative technologies, increasing security, minimizing risks, counteracting corruption, compliance with the principles of ethics, human rights, support, training, commitment	reclamation, carbon footprint **reduction**, energy efficiency, revitalization, **environmental** awareness, sustainable development of mining and post-mining areas, **environmental** standards, **environmental** management system, biodiversity, **environmental** protection expenditure, **pro-environmental** investments, management of space and **natural environment** resources, **reduction of greenhouse gas emissions**, reduction of energy consumption by machines and devices, **reduction of CO_2** emissions, **environmental** strategy
LOTOS / Stabilization and safe development	
stabilization, safe development, stable position, modernity, development, modernization, flexibility, efficiency, process optimization, innovation, quality, social responsibility, business responsibility, cooperation, new generation fuel leader, supporting diversity, socially responsible company, sustainable development, multi-energy concern	responsibility for the **natural environment**, reduction of CO_2 emissions, care for biodiversity, **green** hydrogen, strategy for climate change, control of air pollutant emissions, hydrogen strategy, improvement of energy efficiency, **environmental** standards
PKN Orlen / We fuel the future. Sustainably	
leading player in Europe, energy transition leader in the region, socially responsible concern, retail sales leader, social dialogue, good practices, confidence, future, responsibility, development, sustainable, integrated, innovation, competitiveness, modernity, security, professionalism, cooperation, multi-energy concern, recognition, interaction, sustainable development	**counteracting the negative effects** of climate change, renewable energy sources, new mobility, recycling and biofuels, hydrogen, wind energy, photovoltaic farms, **environmental trends**, bioproducts, developing **ecological** sensitivity, renewable energy, circular economy, **green** financing, **green** bonds, CO_2 **emission reduction**, zero-emission and low-carbon energy sources, hydrogen technologies, climate neutrality by 2050, energy transition

DOI: 10.34659/eis.2022.83.4.500

ENEA / We invest in a green future	
safe/security, responsibility, green, respect, reliable, sustainable, leader, values, we care, protection, friendly, innovation ecosystem, socially responsible entity, counteracting communication exclusion, common values, mutual respect and acceptance of values, friendly atmosphere, lasting relationships, we do listen carefully	**ecological** awareness, ensuring proper **environmental** protection, caring for the **environment**, **pro-ecological values**, due diligence, **environmentally friendly activities**, rational use of natural resources, steady progress, CO2 reduction
TAURON / Our values Partnership, Development, Boldness. The power of team	
values, modern, potential, responsible, courageous, sustainable, future, value leverage, Tauron's green turn, responsible communication, environmentally friendly, values and vision, value system	**environmentally friendly**, **environmental** protection, **green transformation**, emission significantly below the levels defined as the maximum allowable annual loads of substances released into the air, activities resulting in **environmental** effects, caring for the natural **environment**, **minimizing negative impacts**, **counteracting** climate change
ENERGA / Our responsibility	
accountability, confidence, pioneer, leader, innovative, protection, modern, stabilizing, ethics, values, courage, reliability, ecological, partnership, respect, inspiration; reliability, commitment, recommendable employer, our responsibility, responsible development, the group is a pioneer, high quality of services, sustainable manner, lasting relationships, courage and innovation, puts great emphasis on ..., special efforts, social interests, improvement of activities, social commitment	**readiness to reduce**, **pro-ecological activities**, ecological solutions, active participation, modernization, key investments, **counteracting negative impacts**
POLENERGIA / Go green	
green, self-improvement, relations, partnership, standards, innovation, modern, leader, pioneer, success, value transformation, green side of power, active support, dispersed sources, new standards, we change our environment, setting new standards, new directions, future generations, renewable energy sources, the entity of the future	ecosystem, **energy from the future**, clean and green energy, climate change, **environmental impact**, the **green** side of power
PKP Energetyka / Supporting the development of Polish railways	
reliable, dependable, friendly, commitment, philanthropy, transparency, green, modernization, cooperation, reliable partner, solid infrastructure, ambitious plans	**environmental** awareness, **green** transport sector development, good practice, project name "Polish **Green** Railway", **nature-friendly**, **green**

Source: authors' work based on KRZR (2022).

The analysis shows that the keywords and crucial phrases presenting environmental-pro-ecological content are frequently included in the motto of the entire report, which may leave the user with the impression that the whole piece, and thus the group's activity, is determined by ecological goals and care for the natural environment (e.g. ENEA). The words and phrases bearing a general meaning can be correlated with those signifying the environmental area (e.g. KGHM: sustainable development – man and the environment, POLENERGIA: future generations – environmental impact). Among the repeating keywords and phrases of general nature for the analysed companies, the following were indicated: stability, development, future, security, responsibility, trust, and green. It is more difficult to determine the repeatability of environmental keywords and phrases because the companies most often wish to stand out in creativity and individuality in these parts of their reports and frequently introduce environmental keywords into other thematic modules, an example of which is the word "green". The authors selected the following repetitive environmental words and phrases: green, green order (energy, transformation), friendly, renewable energy, limiting/reducing/preventing/minimising emissions (negative impacts), energy efficiency, ecological investments, ecological/pro-ecological performance, environment /natural environment/environmental. In Table 1, the authors have bolded keywords and phrases with ecological overtones.

Table 2. Visual and structural manipulation regarding environmental aspects in the analysed companies

Company	Colours	Text arrangement
KGHM POLSKA MIEDŹ	Grey Brown Teal	**Module:** ***Natural environment*** **Photos**: forest, meadows, wildflowers as a background for the presentation of emission reduction **Charts and drawings:** with additional explanatory comments in gray, brown, and teal colours **Text**: small text font, titles of short text fragments in bold gray, teal colours, fragments of the text in teal and pastel brown colours, short texts with attached pictograms, the text fragment on teal background in white font
LUBELSKI WĘGIEL "BOGDANKA"	Green-blue	**Module:** ***Environmentally efficient mine*** **Photos**: mine (e.g. mine shaft) among meadows and wildflowers, mine at the background of nature (title page of the report) **Tables:** in green-blue and gray **Text:** fragments using green-blue font and presented at the green-blue background in white font, green-blue pictograms
JASTRZĘBSKA SPÓŁKA WĘGLOWA	Black Orange	Environmental aspects included in the **module:** ***Sustainable development***: ***Environmental protection. Caring for climate*** **Photos**: mine at the background of landscape and meadows, fragment of a forest **Drawings**: orange-coloured, tricolour tables and (pie, bar) charts: orange (dominant), gray, navy blue **Text**: short texts highlighted in orange, slogans, words in bold
LOTOS	Red Blue	**Module:** ***Environment*** **Photos**: a refinery or its fragment amongst green meadows, a butterfly at the background of the refinery, each part of the module starts with the same photo: two flying white birds at the blue background and a title in blue **Tables**: the text in tables in gray and red (table head) colours, bar charts in different colours (light blue and dark blue, red) **Text**: titles of the text fragments in bold blue, relevant text fragments highlighted at the blue background, blue pictograms

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Company	Colours	Text arrangement
PKN ORLEN	Red White	Included in the **module:** ***Our strategy in the ESG part: Climate. Environment*** **Photos**: refinery and petrochemistry or their buildings against the background of nature (forests, meadows, blooming poppies), falcon chicks at the background of the concern, wind and photovoltaic farms amongst meadows and installations. **Drawings and** (pie) **charts:** in gray-white, gray and red colours. **Text**: black, gray and red font, highlighted words, slogans, different font size, pictograms in red, short fragments of the text, grouped thematically
ENEA	Blue Royal-blue	**Module:** *Environment* **Photos**: trees and fields (exposed intense greenery), information on the level of CO_2 emissions at the background of photos showing windmills **Text**: short message-like texts, many charts, zoomed charts, highlighting information about the increase in energy production from renewable sources (although it was only 5%)
TAURON	Green Intense pink	No separate main **module** presenting environmental information. Information is separated in two modules as subsections: ***Environmental policy. Climate policy*** **Photos**: windmills at the background of clear skies and greenery, photovoltaic installations at the background of sunlight (even though the share of these sources is minimal on the list presenting the types of produced energy) **Text**: green and yellow letters at the black background (uncomfortable to read), displaying two documents: Environmental policy and Climate policy, no information about the unit of emission measurement in the tables presenting the emission scale
ENERGA	Green	**Module** ***Ecological solutions*** **Photos**: fragments of plants, leaves and sky, photos of employees. **Text**: small letters (text difficult to read), several columns on one page that make reading difficult, green font colour, numerous small drawings unnecessary from the content perspective, green background for the text
POLENERGIA	White Green	**Module:** *Environment* **Photos**: videos of windmills and investments in progress, numerous, large photos of windmills at the background of greenery, photos of nature **Tables:** presenting data on CO_2 emissions are not sufficiently described (e.g. no measurement units), presentation of information about gas emissions along with the information about avoided emissions highlighting quantitative information about the latter **Text**: short, including slogans, disproportionately large letters of the subheadings, highlighting the text on renewable energy sources in colour, colourful drawings to emphasize the text
PKP ENERGETYKA	Dark green	No clearly separated **module** devoted to environmental problems. The section ***We power energy transition*** presents environmental information **Photos**: mostly showing photovoltaic installations **Text**: very small letters used, text arranged in four parallel columns which make reading difficult, no orderly arrangement of the subheadings, information about the changed methodology of calculating own energy consumption without providing any substantive explanations, highlighted information about plans and intentions with reference to good practices, e.g., from other companies

Source: authors' work based on KRZR (2022).

To analyse impression management in visual and structural manipulation, the authors selected the used colours and text arrangement, considering the module on environmental issues, photos, tables and charts, and the font colour and size. The findings have been summarised in Table 2.

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The collected findings provide the answer to question Q1. The compilation shows various impression management instruments (e.g. font: size, colour) applied within a visual and structural manipulation framework. It is worth paying attention to the highlighted motto, which in all analysed groups includes keywords with the most positive overtones. The intense use of such words applies to all environmental modules. In most cases, the photos evoke clearing associations, e.g., green forests and meadows, windmills and photovoltaic installations, even in groups with negligible energy. In a few cases, additional drawings with a simple and positive message were introduced. Another intensely used tool is the colour of letters or the background, primarily about texts which highlight the ambitious plans and intentions of the groups rather than their specific achievements in the area of pro-ecological activities. The green colour is most intensely used in these parts of the text, which relate to environmental aspects. The information on the current environmental pollution is not provided. The quantitative data presented in the tables are lacking, e.g., appropriate explanations or interpretations. In one case, ecological information is scattered, making analysing and evaluating specific activities difficult. There are also significant differences in detail regarding the presented information. Overusing large charts dominated the entire environmental section and was noticed in one of the analysed companies. The remaining data was provided in the form of slogans or short messages based on which it is difficult to assess the activities performed by the business entity.

The results of our research are broadly in line with the findings obtained by Rämö (2011), who emphasises that a large number of photos or drawings may bring about the effect of concentration or, quite the reverse, distraction experienced by the report user. The author indicates that a descriptive text is more susceptible to impression management strategies. In the opinion of Breitbarth et al. (2010), the image can make as strong an impression on the report user as specific quantitative and evaluative data. In light of these conclusions, an intense application of visual strategy instruments by the analysed groups is justified. The researchers focused on the effects of the applied impression management strategies. The research conducted by Dembowska (2021) points out the need for introducing further legal regulations in the field of non-financial reporting. The study conducted by the author, covering companies listed on WSE and included on the WIG 20, 30 and 40 index list, indicates an improvement in its quality after the introduction of Directive 2014/95/EU. The application of impression management strategy in reporting environmental information, demonstrated in our research, confirms that such a need does exist. Expanding the regulatory sphere in non-financial reporting may also contribute to the intensification of green accounting

DOI: 10.34659/eis.2022.83.4.500

development, which, in practice, often responds to specific problems (e.g. Czaja & Becla, 2022).

In the second part of the research, the authors referred to another impression management strategy – syntactic manipulation based on the analysis of selected text fragments from the section devoted to environmental issues in integrated reports using the Jasnopis program (Table 3).

Table 3. The analysis results of the selected text fragments on environmental issues regarding syntactic manipulation

Title of the analysed text fragment	Text difficulty class	FOG Index Password / Text*	Pisarek Index Text**	Difficult words	
				Number	%
KGHM POLSKA MIEDŹ					
Climate and air protection	7	17,75 / 20,67	17,14	17	8
Water and sewage management	6	12,69 / 15,60	14,03	16	8
Energy policy	7	15,15 / 19,17	15,91	8	4
Environmental actions	7	17,53 / 20,84	18,21	12	6
LUBELSKI WĘGIEL "BOGDANKA"					
Environmentally safe actions	7	13,92 / 17,04	14,55	19	9
Energy consumption	6	13,38 / 14,69	12,99	10	5
Reduction of emissions	7	10,10 / 11,12	9,82	8	7
Effective land reclamation	7	16,80 / 20,08	17,56	19	10
Increasing natural and recreational attractiveness of the region	6	13,95 / 16,40	14,34	12	6
JASTRZĘBSKA SPÓŁKA WĘGLOWA					
Environmental Protection	7	16,28 / 19,30	16,93	12	6
Caring for climate	7	16,16 / 19,04	16,90	17	9
Gas and dust emissions	7	17,76 / 21,11	17,61	10	5
Efficient use of non-renewable resources	7	17,73 / 21,48	18,39	15	8
Energy efficiency	7	17,62 / 19,92	17,18	13	7
LOTOS					
Our approach to sustainable development – environment	6	13,86 / 16,21	14,02	12	6
Climate change strategy	7	12.64 / 14.41	11,05	18	9
Airborne emissions	7	15,19 / 18,33	15,06	10	5

Title of the analysed text fragment	Text difficulty class	FOG Index Password / Text*	Pisarek Index Text**	Difficult words	
				Number	%
Energy production and consumption	6	13,69 / 15,77	13,60	7	4
Biodiversity	6	11,96 / 16,00	13,00	7	4
PKN ORLEN					
Responsibility for the climate	7	16,69 / 19,09	15,74	12	6
Airborne emissions	7	14,05 / 15,13	13,21	11	6
Investment outlays	7	14,77 / 17,20	14,51	20	10
Protection of biodiversity	6	11,87 / 15,87	14,13	12	6
Energy management	7	1367 / 1522	1272	8	4
ENEA					
General principles of environmental impact management	7	19,71 / 23,33	20,05	5	4
Management of resources and materials	7	13,91 / 17,44	15,34	9	5
Management of other gas and dust pollutants	7	16,67/19,60	15,47	7	5
Protection of biodiversity and landscape	7	11,38 / 13,91	1,05	9	5
ENEA Group activities for the environment in 2020	7	20,30 / 22,80	18,41	11	6
TAURON					
Environmental policy	7	20,80/ 22,42	18,29	10	5
Climate policy	6	15,55 / 17,83	13,77	11	6
ENERGA					
Approach to managing the environmental impact	6	8,54 / 9,77	8,87	14	7
Goals for 2019	7	7,68 / 10,92	9,93	7	4
Key investments	7	9,36 / 11,60	10,91	17	9
Energy efficiency	6	9,64 / 10,58	9,42	13	8
POLENERGIA					
Climate impact management	7	10,85 / 12,10	9,58	9	5
Environmental impact	6	13,65 / 15,56	13,53	10	5
Biodiversity	6	14,16 / 1,42	14,68	21	11
Go green	5	11,55 / 13,65	1,02	5	3
PKP ENERGETYKA					

Title of the analysed text fragment	Text difficulty class	FOG Index Password / Text*	Pisarek Index Text**	Difficult words	
				Number	%
A part devoted to the "green railways" program – the fragment from section 03 "We power energy transition"	6	13,02 / 15,39	13,75	16	8

Value ranges – text difficulty:
* 7-9 easy, 10-12 fairly easy, 13-15 standard, 16-17 quite difficult, 18-21 difficult, above 22 tough (Gunning, 1952),
** 4-7 very easy; 7,1-10 easy; 10,1-13 medium difficult; 13, 1-16 difficult; 16,1-20 very difficult (Pisarek, 1969).
Source: authors' work based on KRZR (2022).

The indicators presented in Table 3 are part of the algorithm on which the Jasnopois program is based. To make the results more specific, the authors chose from the program report the two most common indicators, i.e. FOG and Pisarek, which cannot be assessed separately but as mutually complementary elements.

The analysis of the text showed the environmental module differentiation in terms of readability and allowed for the formulation of conclusions providing the answer to question Q2. POLENERGIA Group may serve as an example, where the classes of text difficulty range from 5 to 7. It has been noted that in the case of class 7, there is a relatively small percentage of complex words (5%) compared to the text graded in class 6 (11%). The fragments characterised by the difficulty graded as class 7 contain the most relevant and specific information addressing, e.g., greenhouse gas emissions and the already implemented strategies. The lowest difficulty class was detected in the text discussing the Group's activities focused on education and raising environmental awareness among children. The most melancholic FOG and Pisarek indices were noted in the text presenting difficulty graded as class 7, whereas the highest for the class graded as 6. It has been observed that in some of the analysed companies (e.g. ENEA group), the highest text difficulty (class 7) is characterised by the FOG and Pisarek indices that most often are close and relatively low, which can be interpreted as a highly readable text, despite the percentage of complex words higher than in the case of other companies. The texts related to increasing the natural and recreational attractiveness of the area (e.g. Lubelski Węgiel "Bogdanka") and biodiversity (e.g. LOTOS group, PKN Orlen) reveal a lower level of difficulty (class 6). The texts with assigned class 7 are considered extensively complex and professional, hence may require specialist knowledge and a university degree in the relevant field to understand them. Therefore, not every stakeholder has the opportunity to read the text with comprehension and make the right decision based on the information provided in the reports. It was observed that the percentage of difficult words in the analysed text does not always translate

DOI: 10.34659/eis.2022.83.4.500

into the text difficulty class, e.g., in the texts classified as the difficulty class 7, the percentage of complex words was at the level of 4-5%. The information presented in such fragments would require additional interpretation and description to facilitate their comprehension by users, which, in most cases, is not provided.

The results of text analysis using the Jasnopis program are consistent with the research findings collected by Krasodomska (2016) and Czajkowska (2020). These authors analysed in detail the entire report of one entity only. Our research addresses a broader subjective scope covering the cross-section of the selected industry sectors and is focused on environmental problems. Our research shows that the scale of text difficulty is diversified. It ranges between 5 and 7 difficulty levels, with the dominating class 7. The fragments with assigned problems graded as classes 5 and 6 are generally descriptive and express the entity's concern for the natural environment or present general objectives within the framework of pro-ecological activities. The fragments assigned to class 7 refer to specific ongoing activities that the entity is required to report by the GRI. It is worth paying attention to the following correlation: the number of complex words does not translate into the level of text readability. This may imply that the information which is difficult, inconvenient and measurable for the entity is intentionally presented in an unclear and incomprehensible manner, thus remaining challenging to interpret and evaluate for the user of the report.

Conclusions

The analysis of the selected integrated reports showed that impression management strategies were used in all cases, although to a different extent. Some of them can be indicated as the ones most frequently used. Among them, the authors included the following: intensive use of words with positive overtones, colour manipulation of the text and background, overusing photos presenting nature, windmills, photovoltaics or additional graphics. The less frequently applied techniques included reducing the font and introducing several columns, which make reading more difficult, presenting quantitative data in accordance with GRI standards lacking data description or units of measurement, making the report interpretation and evaluation difficult for the user, and giving environmental problems in a scattered way. The majority of applied solutions aimed at constructing the appropriate image of groups as entities evoking confidence and acceptance in terms of their past, current and future pro-ecological activities.

The applied impression management strategies raise questions about the compliance of such a message with the accurate and fair view principle in

DOI: 10.34659/eis.2022.83.4.500

financial and non-financial reporting. It is also worth highlighting that the analysed groups used the GRI standards, which proves they are not affecting either elimination or significant reduction of such practices.

The research has also confirmed that the Jasnopis application can analyse Polish texts in green accounting regarding their readability for the user. The analysis also showed that the text difficulty level is not determined by the number of difficult words. Environmental information as a specialist text can be reported transparently or complicatedly, which can remain yet another area of intentional actions carried out by business entities as part of their impression management strategy.

A small number of sectors covered by the study, classified as "polluters" and "destroyers" of the natural environment, was a limitation of the research. For this reason, the sector oriented analysis was limited. In the second stage of the research, the authors intend to consider more industry sectors and conduct a comparative analysis covering other European Union countries.

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Piotr **BOŁTRYK**

THE IMPACT OF THE AGREEMENT BY THE REGIONAL DIRECTOR OF ENVIRONMENTAL PROTECTION ON THE DECISION ON ENVIRONMENTAL DEPENDENCIES FOR THE IMPLEMENTATION OF INVESTMENT IN POLAND

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ABSTRACT: The purpose of this study is to attempt answering a question about the impact that the agreement reached by the Regional Director for Environmental Protection has on decisions regarding environmental dependencies in Poland. So far, two positions have been expressed in the literature on the subject. According to the first one, such an agreement is binding for the authority issuing the decision. The opponents of such an approach, on the other hand, argue that the administrative body is independent in that respect. The author, although attempting an in-depth analysis of both approaches, is in favor of the first one, additionally taking into account arguments of a juridical, functional and teleological nature. The case study concerned the construction of five buildings for breeding chicken broilers or turkeys along with the accompanying infrastructure on a property located within Solniki, municipality of Zabłudów.

KEYWORDS: decision, the environment, agreement, evaluation

 DOI: 10.34659/eis.2022.83.4.549 JEL: K23, K32, K40

Introduction

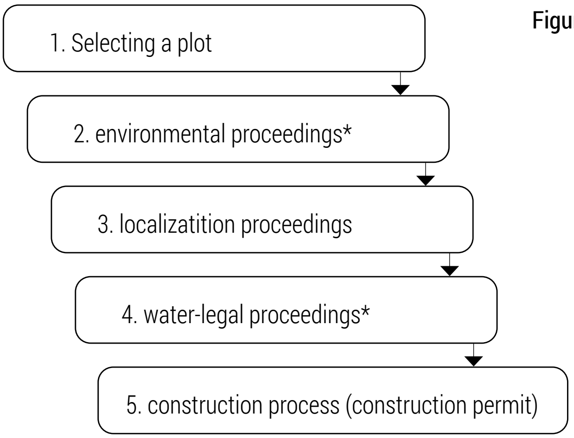
The assessment whether a given investment will have an impact on the environment must be undertaken by every investor who intends to implement an investment project within the territory of the Republic of Poland in order to confirm or eliminate the need to carry out an environmental impact assessment (hereinafter also: EIA) for the project being implemented.

The purpose of the environmental impact assessment is to anticipate potential environmental threats at the investment planning stage, including the scale of those threats and – as a result – prevent or reduce those threats and minimize the negative impact of the planned investments (Bołtryk, 2017, p. 82).

The environmental impact assessment, in accordance with Polish law, may be carried out, e.g. as part of individual proceedings regarding the issuance of a decision pertaining to the environmental aspect of receiving consent to move forward with the project (hereinafter also: environmental decision, decision on environmental dependencies for the implementation of an investment).

The procedure related to the issuance of the environmental decision is one of the stages of a broadly understood investment procedure:

Figure 1. The stages of an investment process



* non-obligatory proceedings, dependent on the type of investment

The procedure for issuing a decision is conducted pursuant to the Act from October 23, 2008 on the provision of information pertaining to the environment and its protection, public participation in environmental protection and environmental impact assessments (Journal of Laws No. 199, item 1227, as amended – hereinafter referred to as the Act), the Act from June 14, 1960,

DOI: 10.34659/eis.2022.83.4.549

the Code of Administrative Procedure (Journal of Laws No. 30, item 168, as amended – hereinafter also the Code of Administrative Procedure), as well as numerous executive regulations to the Act.

Pursuant to the provisions of the Act, decisions on environmental conditions for the implementation of investments are issued by:

Table 1. Bodies authorized to issue environmental decisions

Regional Director of Environmental Protection (hereinafter also: RDEP)	– projects that can typically have a significant impact on the environment, i.e. roads, overhead power lines, installations for the transmission of crude oil, petroleum products, chemical or gas substances, artificial water reservoirs, nuclear facilities, radioactive waste storage sites, – projects carried out in closed areas established by the Minister of National Defense, – projects implemented in maritime areas, – altering forests which are not owned by the State Treasury for agricultural purposes, – projects involving the implementation of investments in the field of a public-use airports, – investments in the field of terminals, – investments related to regional broadband networks, – undertakings in the field of flood protection structures, – undertakings involving the excavation or exploration of mineral deposits or the extraction of minerals from deposits, – overhead power lines or power stations that may typically have a significant impact on the environment or other projects that may potentially have a significant impact on the environment, – projects for which the applicant is an organizational unit of the State Forests, – investments accompanying nuclear energy, – projects to which the RDEP has previously raised objections, – projects consisting in altering or expanding projects to which the RDEP is competent to issue a decision on environmental conditions, – wind farms, – strategic investments in the oil sector, – investments in railway lines, – investments related to the Central Communication Port
General Director for Environmental Protection	– investments pertaining to the construction of a nuclear power plant.
Starosta	– consolidation, exchange or division of land.
Director of the Regional Directorate of State Forests	– altering forests which are owned by the State Treasury for agricultural purposes.
municipal leader, mayor, city president	– other projects (not listed above).

As shown in the table above, there are several administrative bodies established by law to consider the investor's application for environmental decisions. Most projects, however – due to the fact that they are implemented by private entities – are assessed in terms of environmental conditions by the executive body of the municipality, i.e. the municipal leader, mayor or city president relevant to the jurisdiction in which the project is to be imple-

DOI: 10.34659/eis.2022.83.4.549

mented (judgment of the Supreme Administrative Court in Warsaw from June 6, 2013, reference number II OSK 3064/12).

Zabłudów is a municipal community, therefore the mayor of Zabłudów is competent to consider the investor's application for environmental consent.

Case study

The discussed administrative proceedings regarding the issuance of a decision on environmental dependencies for the implementation of the project pertained to the assessment of the environmental impact caused by the construction of five buildings intended for the purpose of breeding chicken broilers or turkeys, along with the accompanying infrastructure, on a property located within Solniki, the municipality of Zabłudow.

The proceedings were initiated at the request of the investor on February 28, 2022. Pursuant to Art. 71 sec. 2 point 1 of the Act, the implementation of a project which typically may have a significant impact on the environment (specified in the Regulation of the Council of Ministers from September 10, 2019 on projects that may have a significant impact on the environment – Journal of Laws, item 1839, as amended – hereinafter also: regulation) is allowed only after obtaining a decision on environmental dependencies. In the course of the proceedings, it was found that the proposed investment belongs to the 1st group of projects listed in § 2 section 1 point 51 of the Regulation, for which the preparation of an environmental report and the environmental impact assessment (Figure 2) are required.

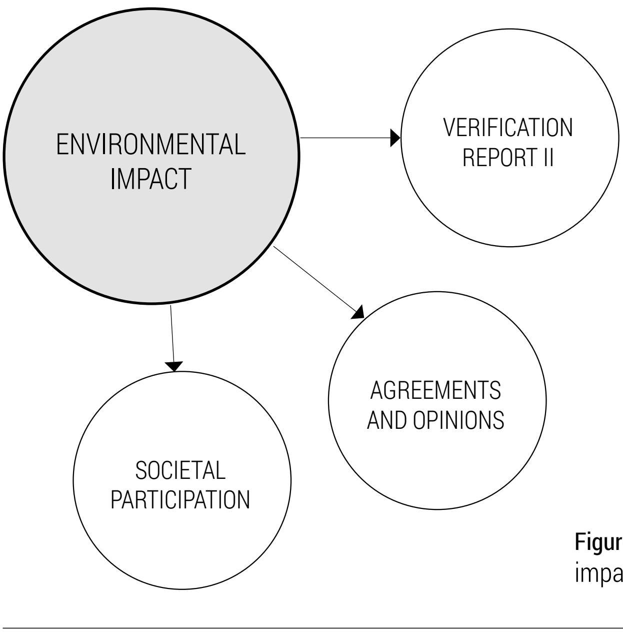


Figure 2. Stages of environmental impact assessment

DOI: 10.34659/eis.2022.83.4.549

The project was to be implemented in an area designated as zone B in the Study of Conditions and Directions of Spatial Development of the Zabłudów Municipality (Resolution No. XXIX/179/05 of the Zabłudów City Council from November 26, 2005, as amended). In this zone, agricultural land is preserved mainly for the purposes of agricultural production. The investment was planned to be implemented outside of the protected areas under the Act from 16 April 2004 on nature protection (i.e. Journal of Laws of 2022, item 916), including outside "Nature 2000" areas.

Agreement procedure

Due to the fact that it was deemed necessary to carry out an environmental impact assessment, the authority conducting the proceedings applied for the approval of the investment implementation with the environmental protection authorities listed in the Act (Figure 3). It should be noted here that the failure to seek the opinion of another body required by law before issuing a decision is a serious procedural error which may justify the resumption of proceedings in the case (Article 145 § 1 point 6 of the Code of Administrative Procedure), even after its final conclusion (Cempura, 2022).

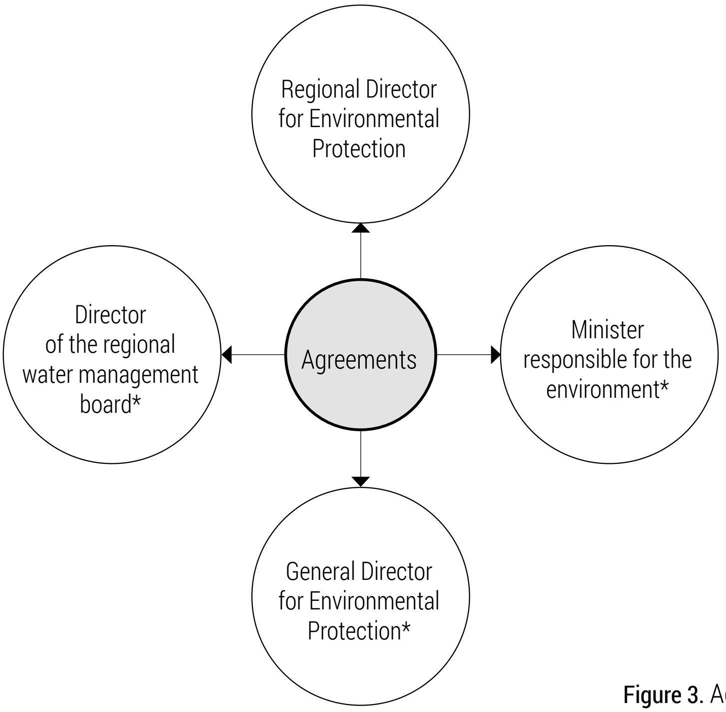


Figure 3. Agreements in the environmental procedure

DOI: 10.34659/eis.2022.83.4.549

The agreement is made in such a way that the authority conducting the environmental proceedings submits to the agreeing authority:

- the investor's application for a decision on environmental conditions,
- the investor's report on the environmental impact of the submitted project – for verification. The environmental report should be up-to-date and supplemented on the date of its submission for verification (judgment of the Provincial Administrative Court in Poznań of November 17, 2016, reference number IV Sa/Po 519/16 and the judgment of the Supreme Administrative Court in Warsaw of March 16, 2021, reference number III OSK 3925/21),
- extract from the local spatial development plan, if the plan has been adopted, or information about its absence.

The authority conducting the administrative proceedings (in this case, the Mayor of Zabłudów) is obliged to notify the parties about the commencement of the agreement procedure. The approval of RDEP is made within 30 days from the date the documentation referred to above was received. *"It must be emphasized that the above arrangements are not applicable to the provisions of art. 106 § 3, 5 and 6 of the Code of Administrative Procedure, with the stipulation in the Act that – if the opinion is not expressed in a timely manner – the silence of the authority shall be treated as lack of objections. However, no such reservation was made in relation to the agreement made by the Regional Director for Environmental Protection. In the event that it does not issue an appropriate decision within the indicated 30-day period, the authority competent to issue a decision on environmental conditions is obliged to wait for a position to be taken, which stems from Art. 106 § 1 k.p.a. The application of this provision has not been excluded."* (Kozińska, 2008, pp. 90-91).

The Regional Director for Environmental Protection, after analyzing the content of the submitted documents, issues a decision in which they consent to the project specifying the environmental conditions for its implementation, or refuses to give such consent (Figure 4). The decision is in the form of a ruling, against which the parties are not entitled to an appeal in the form of a complaint. However, the decision should include a justification, which allows for the verification of the arguments underlying the issued agreement. *"The justification for the decision must therefore be consistent with the content of the resolution of a given procedural issue contained in the operative part of this decision"* (Przybysz, 2022, Art. 124).

In the analyzed case, the Regional Director for Environmental Protection in Białystok, through a ruling from April 8, 2022 (no.: WOOŚ.4221.5.2022.RD) approved the implementation of the investor's project in terms of the environmental impact. Despite the above, the Mayor of Zabłudów, through a decision from August 30, 2022, ref. RGiGG.6220.3.2022 refused to specify the environmental conditions for the implementation of that project com-

DOI: 10.34659/eis.2022.83.4.549

prising the construction of five buildings for breeding chicken broilers or turkeys along with the accompanying infrastructure on a property with the registration number 5/7, Solniki, Zabłudów municipality.

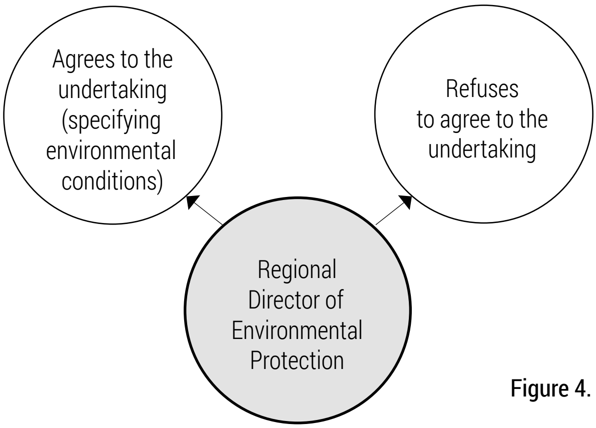


Figure 4. The ruling of the agreeing body

Considering the above, one should consider the legal significance of the agreement made as part of the procedure of issuing an environmental decision by the Regional Director for Environmental Protection. Does the Mayor of Zabłudów (as an entity not specialized in environmental issues) have the right to refuse to issue an environmental decision to the applicant, assuming (which was also the case in this situation) that other assessments were positive.

The answer to this question is not simple, especially considering that the literature and judicature on the subject present different positions.

First of all, the binding and significant nature of the agreement is pointed out. The decisions binding to the body that is conducting the proceedings whose goal it is to issue a decision are attributed a special, substantive character (Świątkiewicz, 1964, p. 778). Zimmermann (1983, p. 63) even claims that, in situations justifying the issuance of such decisions, "we are dealing de facto with a separate administrative decision or with a partial decision, which has effects both for the consulting authority, but also for the party". Manowska (2005, p. 24) expresses a similar opinion about this problem, assuming that in the case of provisions made in an arrangement or agreement, the cooperating authority participates in settling the case in such a way that its action is part of the resolution adopted in the case. Staniszewska also points out that the position of the cooperating authority can be construed as evidence in an administrative case, sometimes influencing, or even determining its final decision, becoming a substantive element of the decision, and thus the rights and obligations influenced by it (Staniszewska, 2021).

DOI: 10.34659/eis.2022.83.4.549

The jurisprudence of administrative law also expresses a similar sentiment: *"The consultation procedure is [...] applicable to assess the compliance of a decision with the provisions of the law governing a specific case, when the legislator imposes an obligation to consult this decision with another body, one specialized in issues that require a certain level of expert knowledge. Due to the specific subject matter of the case, the competence of the authority agreeing to the decision is to review the compliance of the investment project with the given regulations of substantive administrative law"* (judgment of the Supreme Administrative Court from March 22, 2017, reference number II GSK 1519/15). "*The position of the cooperating authority becomes evidence in an administrative case, sometimes influencing, or even determining its final decision, becoming a substantive element of the decision-making process, and thus the rights and obligations influenced by it"* (Staniszewska, 2021, p. 135).

With regard to the issuance of the environmental decision, it is undisputed that it is the authorities specializing in environmental protection and care (including the Regional Director for Environmental Protection) who are responsible for determining whether a given investment will have a negative impact on the environment in the future. The authority issuing the environmental decision (in this case, the Mayor of Zabłudów) is not legally appointed to this type of duty. Also, the linguistic definition of the word "agree" (PWN, date of access: November 11, 2022) presupposes that without the consent of one authority, there is no possibility of a positive resolution of the case by the other authority (the agreeing authority).

Therefore, it seems undisputed that a public administration body cannot issue a positive decision if it has not been positively agreed with the coordinating body. But what happens in the situation that we're dealing with in the present case. Is it possible and legally admissible to issue a negative decision (refusing to issue an environmental decision) when the decision of the RDEP (as well as other coordinating bodies) is positive.

At the very beginning, Romańska's position should be quoted, according to which both cooperating authorities must work out a common position regarding the settlement in the scope of circumstances requiring agreement. The agreement, unlike an opinion, is a form of decisive importance, as it binds the authority that decides in the main proceedings. The scope of the agreement made by the agreeing body usually includes (unless the legislator provides otherwise) the content of the decision to be issued by the body conducting the main proceedings and the position taken by the agreeing body determines the content of the decision issued by the decisive body. The principle of binding the main authority with the position of the agreeing authority should be interpreted in such a way that the decision issued in the main proceedings may not be contradictory to the position of the agreeing authority (it must therefore respect all recommendations formulated by the agree-

DOI: 10.34659/eis.2022.83.4.549

ing authority), but may also supplement the position of the agreeing authority, as long as the supplement did not change the meaning of the agreed decision (Romańska, 2019).

Similar theses can also be found in the jurisprudence: "Agreement – unlike an opinion – is a form of decisive importance, because it binds the administrative authority that decides in the main proceedings. The agreement procedure is ancillary in nature and is part of the broadly understood procedure in the main case; however, its result is necessary for the body conducting the main proceedings and cannot be verified by this body on its own, even if the agreement procedure is burdened with procedural defects." (judgment of the Provincial Administrative Court in Łódź from April 14, 2021, reference number II SA/Łd 51/21 and judgment of the Provincial Administrative Court in Poznań from February 7, 2018, reference number IV SA/Po 292/15).

Unfortunately, the above positions and judgments are of a general nature and do not directly apply to the arrangements referred to in the Act from October 23, 2008 on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessments, i.e. which took place in the discussed case. Below we provide various positions, often depending on a particular court or adjudicating panel:

"the decision on the determination of environmental conditions is issued after consultation, i.e. reaching a consensus with the regional director for environmental protection" (judgment of the Provincial Administrative Court in Warsaw from January 31, 2018, reference number III SA/Wa 627/17),

"Issuing a decision on agreeing to the conditions for the implementation of a project is binding for the authority issuing the decision in the field of environmental issues and shapes this decision in practice. The need to justify this decision emphasizes the substantive nature of such a decision, which actually settles the case on the merits" (judgment of the Supreme Administrative Court in Warsaw from February 21, 2012, reference number II OSK 2544/11),

"positive agreements on the part of the cooperating authorities are not binding for the authority specifying the environmental conditions for the implementation of a project and do not obligate the authority to issue a positive decision on environmental conditions, in a situation where the authority – for justified reasons – does not accept any of the significant findings or conditions set out in the decision of the agreeing authority" (judgment of the Provincial Administrative Court in Szczecin from November 22, 2017, reference number II SA/Sz 998/17, judgment of the Supreme Administrative Court in Warsaw of June 10, 2020, ref. II OSK 3873/19),

"the decision of the agreeing body to which Art. 80 sec. 1 point 1 pertaining to art. 77 act. 1 point 1 of the Act from 2008 on the provision of information on

DOI: 10.34659/eis.2022.83.4.549

the environment and its protection, public participation in environmental protection and environmental impact assessments is not binding. The mere fact of a contradiction between the environmental decision and such an agreement does not mean that the environmental decision is defective" (judgment of the Supreme Administrative Court in Warsaw from November 10, 2016, reference number II OSK 1784/15),

"Positive arrangements from the cooperating authorities (RDEP, PPIS) are not binding for the authority specifying the environmental conditions for the implementation of the project. A positive agreement does not obligate the authority to issue a positive decision on environmental conditions in the situation where the authority – for justified reasons – does not accept any of the significant findings or conditions set out in the decision of the agreeing authority. Therefore, when issuing a negative decision, the authority should demonstrate the defectiveness of the positive positions taken (opinions, arrangements), which requires substantive reference to the content of these documents" (judgment of the Supreme Administrative Court in Warsaw from 01.07.2016, reference number II OSK 339/15).

Conclusions

When analyzing the content of the above judgments, it should be noted that they are contradictory at first glance. It is possible to notice inconsistencies in the reasoning of the courts, as well as a lack of reference to the provisions of the Code of Administrative Procedure which, in this case, are applied alternatively, as long as the Act on the provision of information on the environment and its protection, public participation in environmental protection and environmental impact assessments do not contradict them. The provisions of the above Act do not exclude the obligation to apply Art. 106 § 1 k.p.a., the content of which de facto requires the body conducting the proceedings to issue a decision in accordance with the content of the agreement. There is no provision in the analyzed act which *expressis verbis* would authorize the administrative body to make a substantive decision contrary to the position of the agreeing body. An analysis in this respect could possibly be made under Art. 80 sec. 1 point 1 of the Act, which indicates that the authority issues an environmental decision "taking into account" the results of the agreements and opinions. "Taking into account," however, is nothing more than "not disregarding" or "acknowledging" (wiktionary.org, 2022). In connection with the above, the public administration body must include a positive agreement in the issued decision and, in the author's opinion, in such a way that the issued decision is not contradictory to it.

DOI: 10.34659/eis.2022.83.4.549

An additional argument proving the legitimacy of such a thesis is the undoubted expert knowledge of the Regional Director for Environmental Protection in the field of environmental issues. It seems obvious that, in the discussed case, the authority issuing the decision (the municipal leader, mayor or city president), despite the auxiliary apparatus in the form of officials of a given department, does not possess sufficient knowledge in the field of environmental protection comparable to that of the RDEP. It is not a body specialized in environmental issues. The issuance of a positive agreement should therefore bind the Mayor of Zabłudów and, if the content of the agreement is incomprehensible to them or raises doubts, they should apply to the agreeing body for clarification before issuing a substantive decision in the case. It must not be forgotten that, as part of the approval procedure, RDEP critically analyzes the environmental report, i.e. the basic document on which the investor who wants to obtain a positive environmental decision is based. Thus, the possibility of an equally specialized and critical reference to the report by the executive body of the municipality in the justification of the decision should be questioned. To sum up, in the opinion of the author, the positive agreement of RDEP implies a positive decision on the part of the public administration body (Figure 5), and the action of the Mayor of Zabłudów in this case should be assessed as incorrect and contrary to the law.

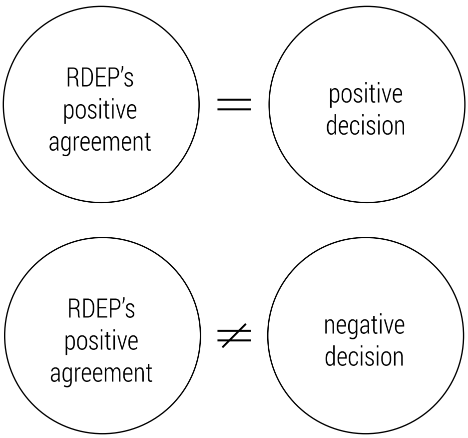


Figure 5. The influence of the RDEP agreement on the environmental decision – conclusions

DOI: 10.34659/eis.2022.83.4.549

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Łukasz ZBUCKI

INFLUENCE OF THE SARS-COV-2 CORONAVIRUS PANDEMIC ON THE DYNAMICS OF TOURISM IN SELECTED NATIONAL PARKS IN POLAND

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ABSTRACT: The SARS-CoV-2 pandemic that began in 2020 hit the tourist services sector very hard. This article aims to determine the impact of the coronavirus pandemic and its consequences on the tourism dynamics in nine Polish national parks. The statistical (descriptive) analysis method was used based on data collection regarding the number of tickets sold in parks in 2019 and 2020. Studies have shown that despite health concerns and several restrictions, the number of tourists in all parks, expressed in ticket sales in 2020, only decreased by 0.06%. Polish national parks, which are less popular, recorded increases in visitors by up to 66%, while in gardens with usually high attendance, there were decreases, especially during the spring lockdown. The obtained analyses allow the development of tourist mobility patterns in unique situations.

KEYWORDS: tourism dynamics, coronavirus, SARS-CoV-2, COVID-19, national parks

Introduction

Protected areas, including national parks, are tourist destinations that attract different groups of visitors. Granting an area status as a national park is an act of ennoblement, as its outstanding qualities are distinguished by experts, which is then confirmed by a legal decision. Consequently, however, this increases tourist traffic (Stasiak, 2007).

According to research by Balmford et al. (2015), protected areas occupy one-eighth of the Earth's surface and register over 8 billion visits a year, generating around USD 600 billion yearly in direct expenditure and around USD 250 billion indirectly. The intensive development of tourism in recent years – statistics from 2009 record 882 million international arrivals (UNWTO, 2011), and in 2019 as many as 1.481 billion (an increase of 67.9%) (UNWTO, 2021) – has contributed to the rise in visits to protected areas and financial revenues.

Poland's most incredible natural attractions include its national parks (Liszewski, 2009; Kruczek, 2017). According to the Nature Conservation Act (2004) a national park is: "an area distinguished by a special natural, scientific, social, cultural and educational values, with an area of not less than 1000 hectares, where all nature and landscape values are protected". They are created "in order to preserve biodiversity, resources, products and components of inanimate nature and landscape values, to restore the proper state of resources and natural components, and to restore disturbed natural habitats, plant habitats, animal habitats or fungal habitats" (Act, 2004).

So far, 23 national parks have been established in Poland, covering 1% of the country's total area. The number of tourist visitors shows an upward trend (Figure 1). In 2009, these places were visited by 10.69 million people, and ten years later, by 14.15 million (an increase of 32.4%). The most famous national parks are Tatra National Park (3.95 million tourists per year), Karkonosze National Park (2.16 million per year) and Wolin National Park (1.5 million per year). By contrast, the least popular are Narew National Park (12,800), Drawno National Park (20,300) and Tuchola Forest National Park (35,300) (Table 1). Statistical Poland published data regarding the number of tourists (GUS, 2010; GUS, 2011; GUS, 2012; GUS, 2013; GUS, 2014; GUS, 2015; GUS, 2016; GUS, 2017; GUS, 2018; GUS, 2019; GUS, 2020a) are only approximate and include all tourists visiting national parks in Poland, including those buying entrance tickets. The varied methodology, as far as data collection for 2019 is concerned, caused the difference in totals in Tables 1 and 2.

DOI: 10.34659/eis.2022.83.4.479

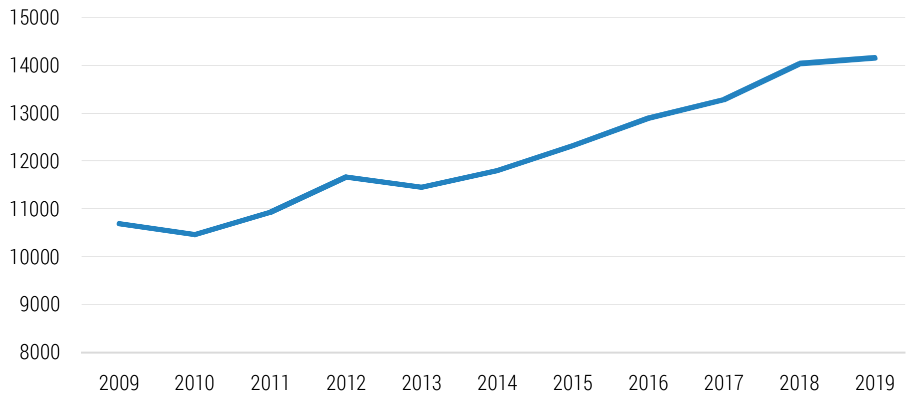

Figure 1. Number of tourists visiting Polish national parks in 2009–19 [in thousands]
Source: author's work based on GUS (2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018; 2019; 2020a).

In 2020, an unprecedented phenomenon occurred – a new strain of coronavirus (SARS-CoV-2) began to spread globally, causing a frequently dramatic respiratory disease (COVID-19). When the disease was diagnosed in 113 countries around the world, the World Health Organisation (WHO) declared a pandemic on March 11, 2020. By April, measures to reduce the spread of the virus were affecting 81% of the global workforce (ILO Monitor, 2020). Tourism is one of the sectors of the economy most sensitive to crises of various types – as confirmed by the spread of COVID-19 (Bahar & Çelik İlal, 2020; Khalid et al., 2021; Zhang et al., 2021). People safety, natural disasters, and epidemics are among the most critical factors in decisions to travel (Aydin et al., 2021; Sönmez & Graefe, 1998; Reisinger & Mavondo, 2005; Korstanje, 2011). According to the World Tourism Organization, between 2020 and 2019, the quantity of international tourism fell by 74%, with about 1.1 billion arrivals reaching the level in the late 80s. The collapse of tourism in 2020 caused financial losses of about 1.3 trillion US$ (Richter, 2022). The coronavirus pandemic (SARS-CoV-2) and the failure of tourism in this period have led to a significant crisis in many countries. A spectacular example of the impact of the pandemic on a country is the fall of Sri Lanka. In this country, the income from tourism provided 12-14% of GDP, so it became bankrupt with a severe economic, political and social crisis (Góralczyk, 2022).

DOI: 10.34659/eis.2022.83.4.479

Similarly, in Poland, as in the world, the pandemic caused the collapse of tourism. After the record, tourist traffic in 2019 (35.67 million) decreased by 49.9% in 2020 to 17.88 million (GUS, 2020b; 2021). The decrease in foreign trips amounted to 59.4%, probably due to the fear of infection with the virus and restrictions aimed at limiting its spread.

However, as the pandemic progressed, the sense of panic among Poles decreased, and the virus became part of a "new normal" (Kalinowski & Wyduba, 2020). People accustomed to the situation began to undertake ordinary activities – including tourism implemented mainly in the country (82% of respondents who planned to travel) (Polska Organizacja Turystyczna, 2020). It is in line with the forecasts contained in the documents of the European Commission (2020).

Research objectives and methods

The research aims to determine the impact of the SARS-CoV-2 pandemic and its consequences on tourism dynamics in selected national parks. In this study, the hypothesis was made that national parks in Poland recorded a decrease in tourist numbers as a result of the coronavirus pandemic. Measuring the number of tourists to a given destination, and in this case, to a national park, is not easy (De Cantis et al., 2015). Therefore, in the study, the author decided to use direct data on sales of admission tickets to parks, museums belonging to individual gardens, nature trails, etc., in 2019 (before the pandemic) and 2020 (the year in which the pandemic began).

To obtain ticket sales data, letters were emailed to national parks requesting data showing tourist traffic in their area, broken down by month in 2019–20. Most of the national parks replied, but only nine parks fully met the required criteria.

Statistical analyses (mainly descriptive due to the lack of large datasets and a frequent lack of data homogeneity) were carried out for those nine national parks. They are Babia Góra National Park National Park, Białowieża National Park, Biebrza National Park, Gorce National Park, Tuchola Forest National Park, Stołowe Mountains National Park, Pieniny National Park, Świętokrzyski National Park, Tatra National Park.

DOI: 10.34659/eis.2022.83.4.479

Table 1. Number of tourists in Polish national parks in thousands in 2009-2019

National park	Year										
	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
Babiogórski	52	54	75	63.0	81.0	76.0	81.0	114.0	83.3	107.0	150.0
Białowieski	82.3	170	133.8	120.6	119.0	120.0	132.9	163.4	248.7	156.1	173.5
Biebrzański	32	31	27.2	32.5	28.0	32.0	38.5	41.0	46.7	54.0	83.0
Bieszczadzki	273	280	330	297.0	332.0	355.0	388.0	487.0	513.0	589.0	572.0
Bory Tucholskie	60	60	60	60.0	33.0	33.0	33.0	34.5	31.8	37.1	35.3
Drawieński	23	22.2	48	25.5	19.0	18.0	22.0	16.0	13.0	20.5	20.3
Gorczański	60	60	65	70.0	70.0	80.0	80.0	80.0	90.0	90.0	90.0
Gór Stołowych	354	319	335	350.0	347.0	367.0	480.0	286.0	515.0	1063.0	907.0
Kampinoski	1000	1000	1000	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0	1000.0
Karkonoski	2000	2000	2000	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2000.0	2160.0
Magurski	50	50	45	40.0	50.0	40.0	40.0	50.0	50.0	50.0	50.0
Narwiański	8.6	12.5	10	12.0	15.0	15.3	15.0	20.0	19.0	12.0	12.8
Ojcowski	400	400	400	400.0	400.0	400.0	400.0	428.0	430.0	430.0	440.0
Pieniński	756	603	710	770.0	734.0	719.0	815.0	931.0	898.0	985.0	982.0
Poleski	15.4	24.3	23.7	28.1	28.0	28.0	41.0	44.0	49.0	73.0	135.5
Roztoczański	120	100	100	120.0	120.0	120.0	134.0	186.7	203.4	243.4	238.2
Słowiński	275.4	311.4	317.1	312.4	308.5	304.0	318.9	323.4	317.2	320.6	334.5
Świętokrzyski	210.5	145	193.4	162.0	148.4	135.0	132.0	144.0	144.0	149.0	120.0
Tatrzański	2078.7	2002	2234	2947.0	2764.0	3091.6	3309.5	3683.1	3779.2	3970.3	3947.4
Ujście Warty	20	10	20	56.9	53.8	50.6	52.4	43.2	34.4	45.3	58.4
Wielkopolski	1200	1200	1200	1200.0	1200.0	1200.0	1200.0	1200.0	1200.0	1000.0	1000.0
Wigierski	120	110	110	110.0	110.0	115.0	110.0	125.0	125.0	140.0	140.0
Woliński	1500	1500	1500	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0	1500.0
Total	10691	10464.4	10937	11677.0	11460.7	11799.5	12323.2	12900.2	13290.6	14035.4	14149.7

Source: author's work based on GUS (2010; 2011; 2012; 2013; 2014; 2015; 2016; 2017; 2018; 2019; 2020a).

DOI: 10.34659/eis.2022.83.4.479

Table. 2. Number of tourists in the analysed national parks in thousand

Month	Babia Góra National Park			Białowieża National Park			Biebrza National Park			Gorce National Park			Tuchola Forest National Park		
	Year														
	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month
January				4901	7598	55.0	622	2447	293.4				15	47	213.3
February				7981	8210	2.9	2446	2384	-2.5				8	38	375.0
March				6337	1742	-72.5	3495	1060	-69.7				33	15	-54.5
April	1791	829	-53.7	15371	330	-97.9	4923	1516	-69.2	1364	5032	268.9	391	34	-91.3
May	8268	10128	22.5	42812	9660	-77.4	8990	6727	-25.2	6779	21164	212.2	338	484	43.2
June	13529	13688	1.2	35393	25294	-28.5	11406	12013	5.3	7133	13336	87.0	882	747	-15.3
July	22553	33942	50.5	45081	53747	19.2	7660	13740	79.4	11399	20507	79.9	807	1419	75.8
August	27528	33642	22.2	59101	60267	2.0	10329	15948	54.4	18646	28807	54.5	1165	1753	50.5
September	16999	22298	31.2	25552	26816	4.9	5429	8359	54.0	12760	17196	34.8	585	870	48.7
October	14902	9262	-37.8	19134	11182	-41.6	1312	2112	61.0	14942	10118	-32.3	187	117	-37.4
November	2471	9825	297.6	7229	2739	-62.1	1095	1339	22.3	1571	7629	385.6	52	41	-21.2
December		179		5442	1839	-66.2	329	341	3.6				11	11	0.0
Total	108041	133793	23.8	274334	209424	-23.7	58036	67986	17.1	74594	123789	66.0	4474	5576	24.6

Month	Stołowe Mountains National Park			Pieniny National Park			Świętokrzyski National Park			Tatra National Park in		
	Year											
	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month	2019	2020	Change in % month-on-month
January				8553	12926	51.1				108285	228980	111.5
February				13922	13495	-3.1				203931	233605	14.6
March				8879	5418	-39.0	0	62		141079	50401	-64.3
April	18953	0	-100.0	28110	9251	-67.1	11651	0	-100.0	175532	1493	-99.1
May	94260	24497	-74.0	92542	28111	-69.6	51969	23598	-54.6	270439	113842	-57.9
June	80487	52322	-35.0	134983	78191	-42.1	38484	21659	-43.7	407979	285598	-30.0
July	107396	121100	12.8	211663	229112	8.2	30862	41938	35.9	732199	703361	-3.9
August	125078	135083	8.0	270834	264361	-2.4	41435	54133	30.6	882046	791484	-10.3
September	48721	64805	33.0	105096	111178	5.8	19787	21848	10.4	438643	522888	19.2
October	34113	30762	-9.8	64578	33480	-48.2	22709	10166	-55.2	204656	156066	-23.7
November	7598	605	-92.0	23010	20699	-10.0	0	3114		75023	115809	54.4
December				14346	15260	6.4				118319	58368	-50.7
Total	516606	429174	-16.9	976516	821482	-15.9	216897	176518	-18.6	3758131	3261895	-13.2

Source: author's work based on data from national parks.

The SARS-CoV-2 pandemic in Poland

The first case of COVID-19 was detected in Poland on March 3, 2020, and the highest number of daily new infections in 2020 was recorded in November, at 27,875.

In connection with the SARS-CoV-2 pandemic, the Polish government took several measures to reduce the spread of the disease in 2020. Among other things, the following was introduced:

- a state of epidemic threat was announced, and then after a few days (from March 20), a state of the epidemic: 12.03–31.12,
- suspension of classes in schools, above grades 3: 11.03–26.06, 23.10–31.12,
- rest of classes in schools, grades 1–3: 11.03–25.05, 9.11–31.12,
- restrictions on catering and entertainment activities: 12.03–3.05, 23.10–31.12,
- restrictions on the operation of shopping malls: 12.03–3.05, 23.10–27.11, 28.12–31.12,
- closure of Polish borders to air and rail traffic, 15.03–20.04,
- obligation to cover nose and mouth inside buildings: 16.03–31.12,
- obligation to cover nose and mouth in open spaces: 16.03–18.05,
- restrictions on movement: 25.03–20.04,
- closure of forests, parks, beaches, etc.: 01.04–20.04,
- limitation on the operation of nurseries and kindergartens: 12.03–6.05,
- closure of beauty and hairdressing salons: 14.03–18.05,
- limitations on the operation of cultural institutions, i.e. cinemas, theatres, operas, swimming pools, fitness clubs, parks: 13.03–6.06, 23.10–31.12 (Koronawirus informacje, 2021; Koronawirus u nas, 2021; Medicover, 2021).

Besides the general restrictions listed above, the most critical limits for tourism in the course of the SARS-CoV-2 coronavirus pandemic in Poland were those on domestic and foreign tourism, the need to perform tests when crossing the border, and the introduction of a tourist voucher in 2020 whose aim was to re-invigorate the internal tourism market when the epidemic situation was under control. All these activities meant that tourist traffic was utterly different in the pandemic year than in previous years. Tourist targets and the perception of tourist attractiveness also changed. Isolated, peripheral places with low population densities began to be considered exceptionally safe and attractive for tourism. Other changes in the labour market and education system, i.e. the transition to remote working and learning, resulted in a temporary – perhaps even irreversible – reorientation in Poland's population distribution. Indeed, the SARS-CoV-2 coronavirus pandemic has

DOI: 10.34659/eis.2022.83.4.479

affected all sectors of the economy – including the tourism market, which has been subjected to numerous restrictions and challenges.

Tourism in the researched national parks: a comparative analysis

The transformations in the tourist seasons of 2019 and 2020 that were seen in the research period are presented alphabetically by the park. They are preceded by a short description of the park, showing its most essential values from the perspective of tourist statistics.

Babia Góra National Park is located in the Lesser Poland Voivodeship in southern Poland. It occupies the north and south of the Babia Góra massif. It covers 33.92 km^2. In 2009–19, it was visited by 52,000 per year (in 2009) up to 150,000 (2019), placing it among the national parks of average popularity. Regarding the number of tourist visitors, it is 13th out of the 23 national parks in Poland (Table 1).

Based on the data on ticket sales in 2019 and 2020 provided by the Babia Góra National Park management, there are changes in tourist traffic dynamics during this period. The highest tourist attendance was recorded in the summer months (July and August): 22,553 and 27,528 visitors in 2019, and 33,942 and 33,642 in 2020. From May to October 2020, there was an increase in the number of tourists compared to the same month in 2019 of between 1.2% (in June) and 50.5% (in July). From the whole of 2020, the highest increase over 2019 figures was in November, at 297.6% (Figure 2). It should be noted, however, that this high increase may result from the low starting base in 2019, with only 2,471 people (Table 2). There is a notable decrease in tourist numbers in April (-53.7%), which should be associated with the fact that the restrictions aimed at limiting the spread of the coronavirus included a decision to close forests, parks and beaches from April 1 to April 20, 2020. Significant decreases were also recorded during the autumn peak of new cases in October, at -37.8% (Figure 2). However, this did not change the fact that in 2020 ticket sales increased to 133,793 from 108,041 (in 2019), i.e. by 23.8% (Table 2).

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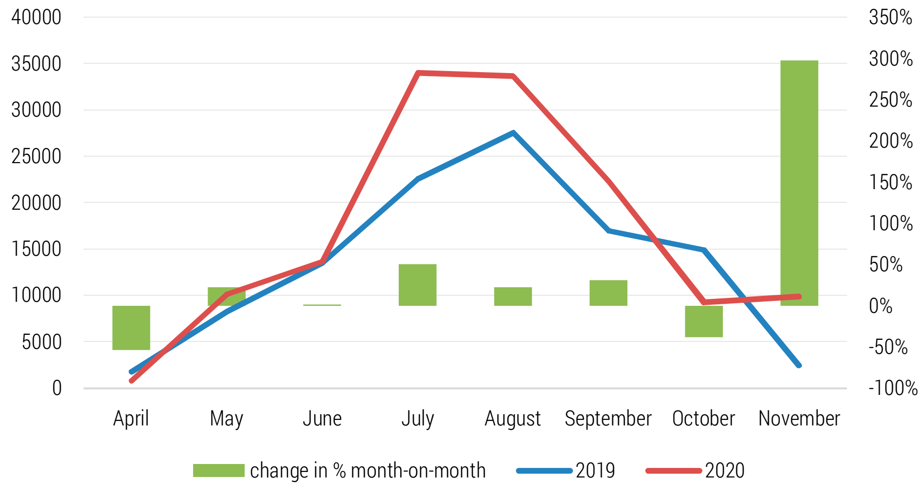

Figure 2. Tourist numbers in Babia Góra National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Białowieża National Park is located in central-eastern Poland, in the Podlaskie Voivodeship, where it occupies the central part of the Białowieża Primeval Forest. It began operating in 1921 with the establishment of a unit called "Rezerwat", which was then transformed into a national park in 1932. It covers about 105.2 km^2, one-sixth of the Polish part of the Białowieża Primeval Forest. This area protects the best-preserved part of the primaeval forest, the last natural ancient woodland in the European lowlands and is characterised by great diversity. The park is the only Polish natural feature on the UNESCO World Heritage List. From 2009–19, it was visited by 82,300 people (2009) and 248,700 (2017). Regarding the number of tourist visitors in 2019, it is 12th out of the 23 national parks in Poland (Table 1).

The 2019 and 2020 ticket sales data provided by the management of the Białowieża National Park show changes in tourist traffic dynamics. Tourist attendance was highest in August in both years – in 2019, it was 59,101, and in 2020 60,267 (Table 2). Tourist attendance was lowest in the winter months – from November to March. In the pre-pandemic year (2019), the number of tourists ranged from 4,901 in January to 7,981 in February. By contrast, in 2020, the period of low attendance extended to April when, due to numerous pandemic restrictions, it amounted to only 330 people (Table 2).

An increase in tourist traffic over 2019 was noticeable in January and February of 2020 when Poland's pandemic had not started. In the first month of the year, the number of tourists increased by 55%, which can be associated with the distribution of public holidays and school winter breaks (which differ between voivodeships and fall in January and February). The park was also visited more during school holidays and in September, when the increase ranged from 2% in August to 19.2% in July (Figure 3). For seven months of 2020, compared to the corresponding months of 2019, ticket sales decreased between -28.5% (in June) and -97.9% in April (Figure 3). For the entire year 2020, total ticket sales fell -23.7% from the 2019 total of 274,334 to 209,424 (Table 2).

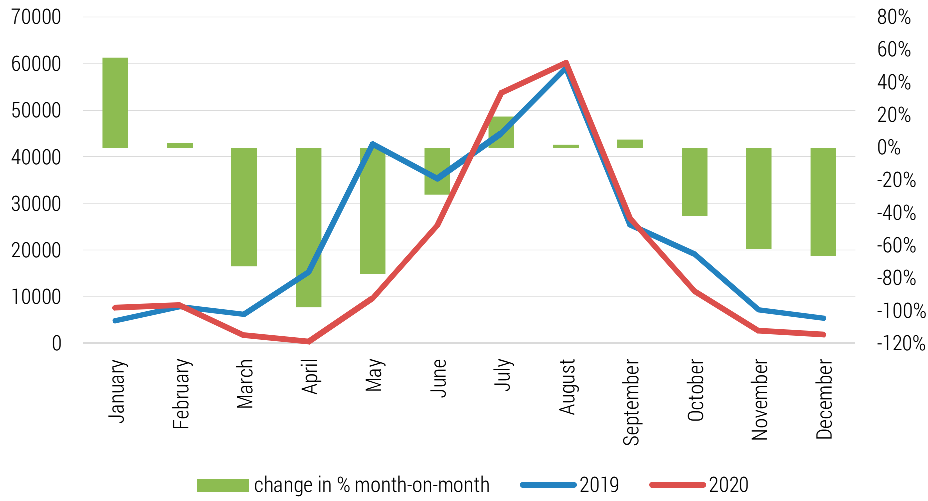

Figure 3. Tourist numbers in Białowieża National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Biebrza National Park is located in north-eastern Poland, in the Podlaskie Voivodeship. It covers the Biebrza Basin and neighbouring areas. It is the largest national park in Poland and one of the largest in Europe, covering approximately 592 km^2. The park's most valuable asset is the heavily meandering Biebrza River, which has created the largest complex of peat bogs in Poland in its valley. According to data from Statistics Poland (GUS), in 2009–19, visitor numbers ranged from 27,200 people (in 2011) up to 83,000 (2019). Regarding tourist visitors, in 2019, it was 18th out of the 23 national parks in Poland (Table 2).

The ticket sales data for 2019 and 2020 collected by the Biebrza National Park management show changes in tourist attendance in the two analysed

DOI: 10.34659/eis.2022.83.4.479

years. From May to October, tourist traffic grows, peaking in the summer months – in June of 2019, with 11,406 tickets sold, and in August of 2020, with 15,948 tickets sold. The dynamics of tourist traffic changes in 2020 relative to 2019 show a decrease in tourist numbers from February (-2.5%) to May (-25.2%), with maximum drops of approximately -70% in March and April. In the remaining months, there were increases, the greatest of which was in January, before the pandemic began, at almost 300%; this was influenced by the low base figure in 2019 (4,901 tickets sold) and the distribution of national holidays and school holidays (Table 2). In the second half of 2020, ticket sales increased by 3.6% in December and nearly 80% in July (Figure 4). The total number of tickets sold in 2020 increased by 17.1% over 2019, from 58,036 to 67,986.

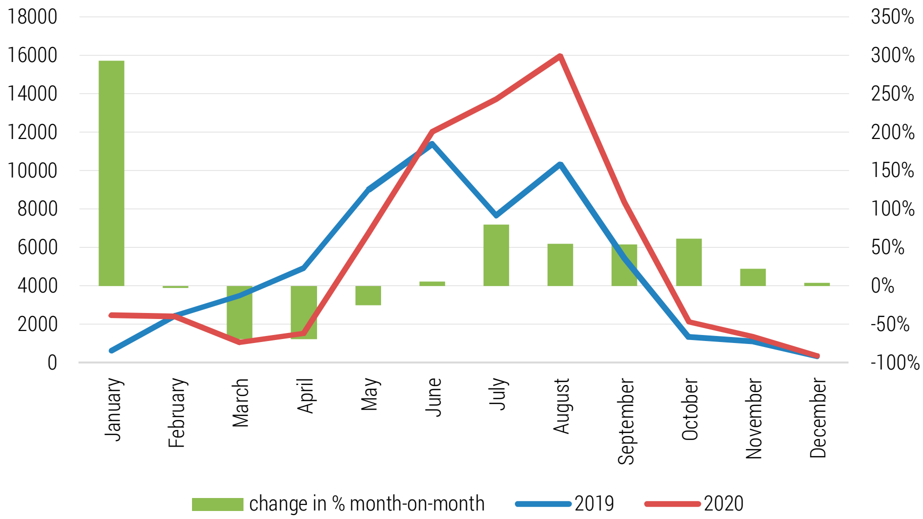

Figure 4. Tourist numbers in Biebrza National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Gorce National Park is located in southern Poland, and its protection covers the central Gorce range, including the Turbacz and Gorce ranges. The area's most incredible natural wealth is the Carpathian Forest. According to Statistics Poland (GUS) data for 2009–19 (Table 1), the number of tourists increased steadily from 60,000 in 2009 to 90,000 in 2019. Regarding tourist visitors, in 2019, it was 17th out of the 23 national parks in Poland (Table 1).

The park management records tickets sold and free entries (e.g. the Big Family Card) to some areas of the park from mid-April to November. According to the data collected (Table 2; Figure 5), tourist traffic here peaks in August, when 18,646 entries were registered for 2019 (i.e. about 25% of total annual traffic) and 28,807 for 2020 (approx. 23.3% of yearly traffic) (Table 2). Tourists increased over the previous year for almost the entire study period. The growth dynamics range from 34.8% for September to over 386% for November. The only month with a decrease in visitor numbers was October (-32.2%) when there was an autumn peak in SARS-CoV-2 cases in Poland. The collected data confirm an overall increase in tourist numbers of 66% (Table 2). For comparison: data from eco-counter tourist meters at five locations in the park (1 in Suhora; 2 in Szałasisko glade; 2 in Turbaczyk) confirm a 68.8% increase in tourist number (data obtained from park management).

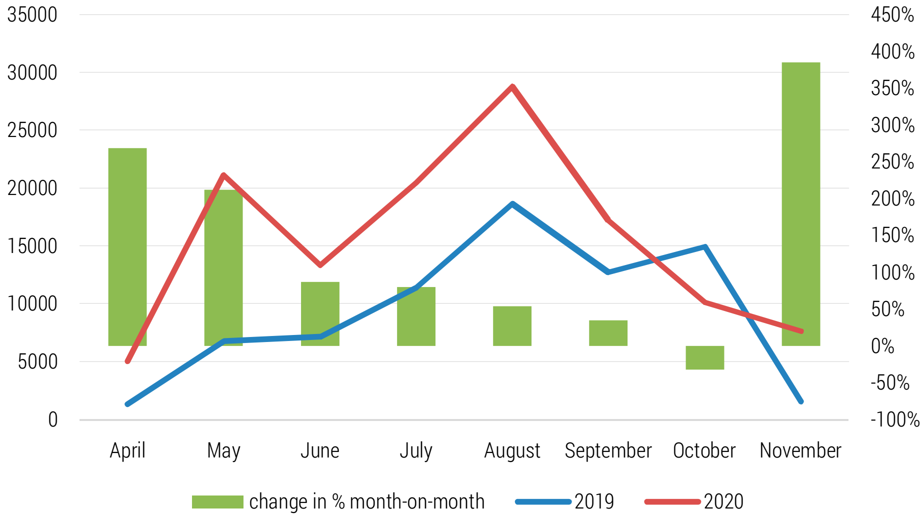

Figure 5. Tourist numbers in Gorce National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Tuchola Forest National Park is located in the Pomeranian Voivodeship. The protection here mainly covers forest communities, which cover about 83% of its area. These are primarily new and dry forests with numerous species of lichens and marsh habitats. There are 11 lakes (PNBT, 2021) in the park. According to data from Statistics Poland (GUS), in 2009–19, visitor numbers ranged from 31,800 (in 2017) up to 60,000 (2009–12). In 2019, it was one of the three parks least visited by tourists (Table 1).

DOI: 10.34659/eis.2022.83.4.479

The tourist season in the Tuchola Forest National Park lasts from April to October (Figure. 6), peaking in August when 1,165 tickets were sold in 2019 and 1,753 in 2020. By contrast, in the off-season, ticket sales drop below 55 – in December, for example, it is only 11 (Table 2). Due to the marginal sale of access during the cold season, changes in the tourist traffic dynamics only slightly affect tourist numbers. During the seven-month tourist season here, there was an increase in tourist traffic over 2019 in five months – ranging from 37.4% (October) to 75.8% (August). There were drops in April (-91.3%) due to lockdown and in June (-15.3%) (Figure 6) when other destinations are suspected of having been more attractive. Total ticket sales in 2020 increased by 24.6% over the previous year.

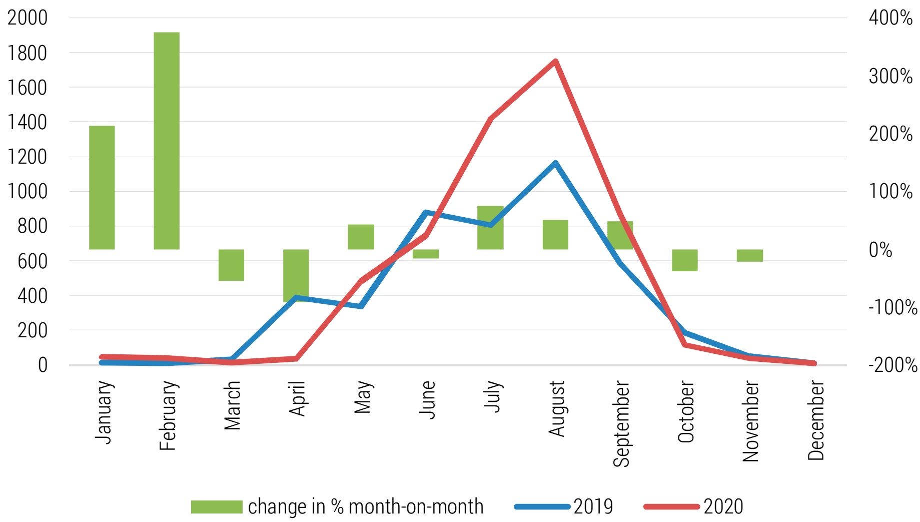

Figure 6. Tourist numbers in Tuchola Forest National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Park admissions certified by a ticket purchase constitute about 10–20% of entries to the park in 2020. The park's management estimates tourist numbers based on car numbers in nearby parking lots, the number of people staying in nearby holiday resorts, etc. These observations show that in 2019 the park was visited by 35,250 people, and a year later, by 28,910, a decrease of approximately -18% (information obtained from park management).

DOI: 10.34659/eis.2022.83.4.479

Stołowe Mountains National Park is located in south-western Poland, in the Central Sudetes, at the Polish–Czech border. In an area of 63.4 km^2, protection covers the only fault-block mountains in Poland. From 2009–19, this park was visited by 286,000 people in 2016 and over 1 million in 2018 (Table 1). The number of tourists, which has been about 1 million *per annum* in recent years, makes this national park one of the most visited in Poland. The ticketing period runs from April to November. In the analysed years, tourist traffic was highest in the summer holiday period, peaking in August, when the park was visited by about 125,000 people in 2019 and approximately 135,000 a year later (Table 2). The tourist traffic dynamics show a decrease in tourist numbers from April (-100%, when the parks were closed and sold no tickets) to June (-35%). Then, the number of tourists in 2020 over 2019 increased, and this trend continued until September (a rise of 33%). In October, however, there was a drop of -9.8% in ticket sales, which deepened in November to -92%. In 2020, there was a decrease in ticket sales of approximately 87,000, i.e. -16.9% (Figure 7).

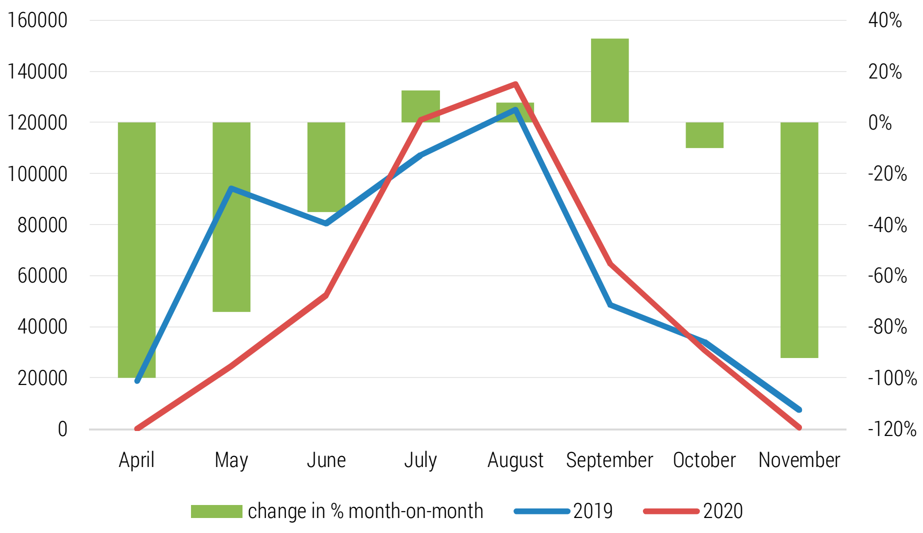

Figure 7. Tourist numbers in Stołowe Mountains National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Pieniny National Park is located in southern Poland, and its protection covers the most valuable areas of the Pieniny in terms of landscape and nature. The uniqueness of its local natural values led to the park being established in 1932 as the first in Poland. According to Statistics Poland (GUS) data for 2009–19, Pieniny park was visited by between 603,000 people a year (2010) and 985,000 (2018), which makes it one of the most visited areas of this type in Poland (Table 1). The tourist season in the park lasts from April to November, with traffic peaking in August at about 271,000 visitors in 2019 and 264,000 in 2020. During the 2020 tourist season, tourist numbers dropped – during the six tourist-season months, the drops were most significant in spring (April -67.1%; May -69.6%) and October (-48.2%), which was related to the restrictions introduced and the autumn wave of infections. From July to September, the variation in tourist traffic amounted to a few percent increase in numbers in July and September and a slight decrease in August (-2.4%). Outside the tourist season, the variation between 2020 and 2019 is generally tiny, high only in January (51.1%). This is due to the low base in 2019 when national holidays and winter breaks landed that year (Figure 8). Based on the attendance presented by the park management, the total number of tourists in the pandemic year fell by about 155,000 compared to the previous year – a drop of -15.9% (Table 2).

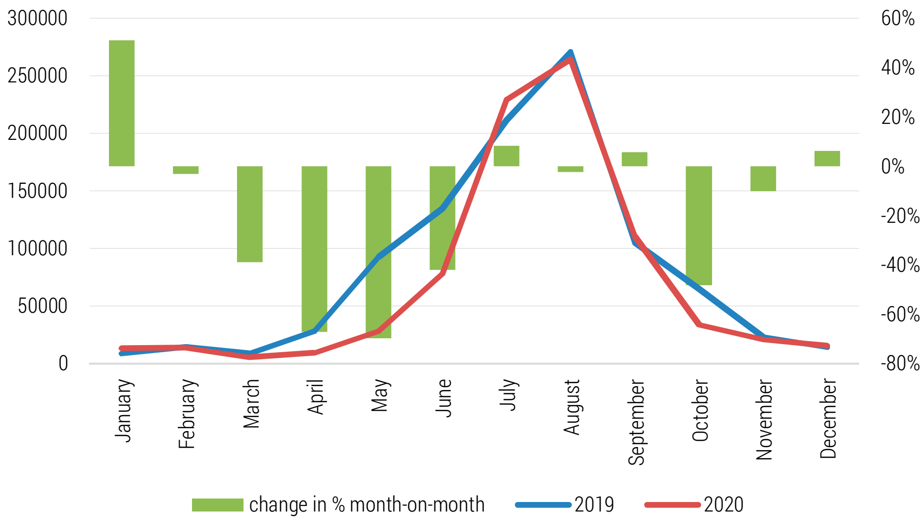

Figure 8. Tourist numbers in Pieniny National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Świętokrzyski National Park is located in the central part of the Świętokrzyskie Mountains, where 76.26 km^2 of the oldest mountains in Poland is protected. Forests cover 95% of the area, and 38% are under strict protection (ŚPN, 2021). According to data from Statistics Poland (GUS), for

DOI: 10.34659/eis.2022.83.4.479

the period 2009–19, park visitor numbers ranged from 120,000 (2019) up to 210,000 (2009), meaning that it was one of the few national parks in Poland to see a downward trend in numbers of visiting tourists (Table 1). The entire ticketing period in the park extends from April to October. In 2019, tourist numbers were most significant in May, at fewer than 52,000, while the second most considerable number of visitors was recorded in August at about 41,500. In 2020, tourist visits to the park peaked in August at approximately 54,000 (Table 2; Figure 9). The tourist traffic dynamics for 2020 relative to 2019 show a decrease from April (-100%) to June (-43.7%). This is due to the restrictions introduced and the collapse of the market for school trips, for which the Świętokrzyskie Mountains are a popular destination. This is followed by an increase from July (35.9%) to September (10.4%), followed by a further decline associated with the autumn pandemic wave (-55.2%) (Figure 9). Entrance ticket sales to the Świętokrzyski National Park decreased by -18.9% in 2020 relative to 2019 (Table 2).

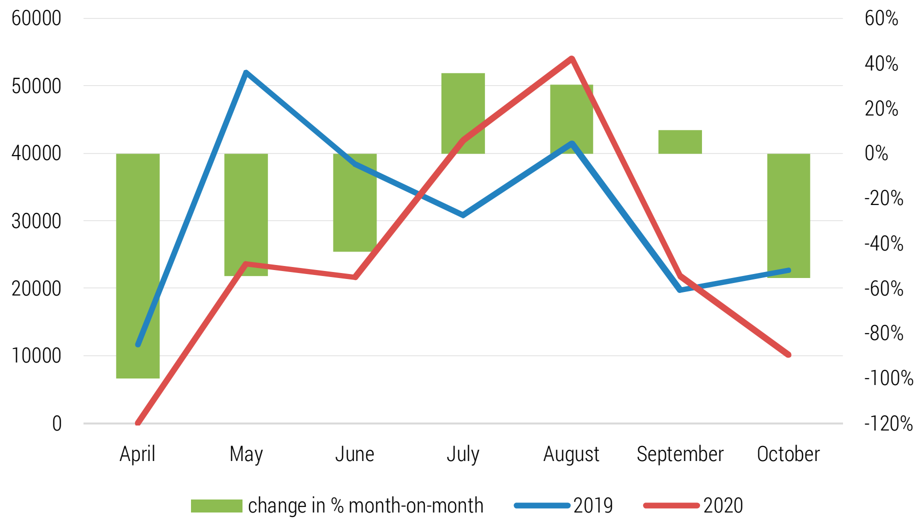

Figure 9. Tourist numbers in Świętokrzyski National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

Tatra National Park is located in southern Poland. It protects the only mountains in Poland with a high-mountain topography. The uniqueness of the Tatra Mountains makes it the most visited national park in Poland. According to data from Statistics Poland (GUS) for 2009–19, this park was visited by between about 2 million tourists (2009 and 2010) and as many as

DOI: 10.34659/eis.2022.83.4.479

4 million (2019) (Table 1). The number of tourists shows a constant upward trend, which – it should be emphasised – poses a threat to this valuable part of Poland that covers an area of only 211.6 km^2. There are two tourism peaks in the Tatra National Park. The winter peak is in February, at about 204,000 visitors in 2019 and about 234,000 in 2020. The summer peak, meanwhile, is in August, at about 882,000 in 2019 and 791,000 in 2020 (Table 2; Figure 10). The dynamics of variation in tourist traffic in the park in 2020 compared to 2019 show an increase in tourist numbers in the first two months of the year when the pandemic had not yet begun. As the pandemic spread, there was a drop from March to August, with the most significant reduction being in April, at -99.1%. Then, starting from September, the decline in tourist numbers increased month by month (Figure 10). The sale of admission tickets in 2020 over 2019 reflects a decrease in tourist numbers of almost 500,000, i.e. -13.2% (Table 2).

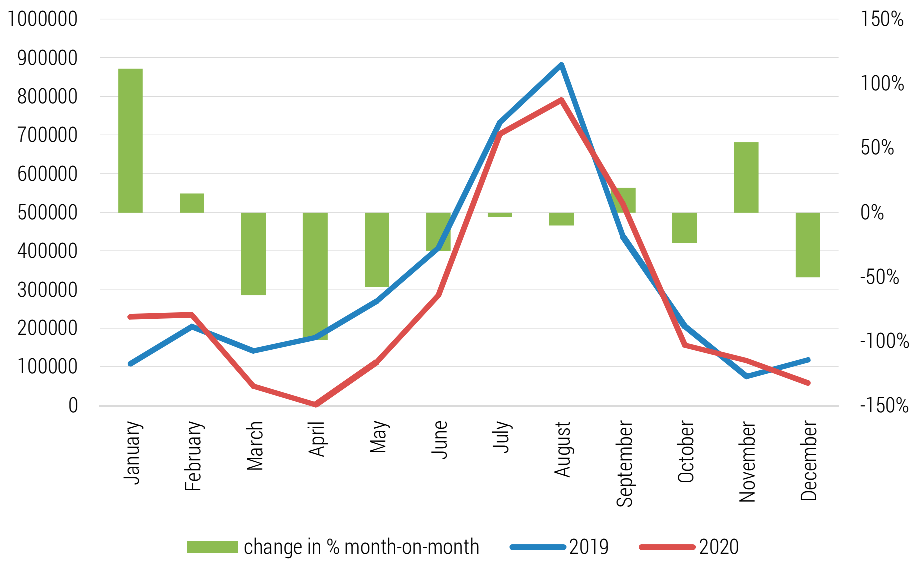

Figure 10. Tourist numbers in Tatra National Park in 2019 and 2020 and the increase/decrease [in %] in visitor numbers in a given month compared to the corresponding month of the previous year

Source: author's work based on data from national parks.

The sale of admission tickets to the researched national parks in 2020 shows high dynamics relative to 2019. In January and February, ticket sales rose, including an increase of over 100% in January. Then, from March (the beginning of the pandemic) to June, there were drops, which were greatest in

DOI: 10.34659/eis.2022.83.4.479

April (-92.8%). From July to the end of the year, the dynamics of tourist traffic was approximately a sine wave: after a month with an increase in ticket sales, there was a drop (Figure 11). Total ticket sales decreased from 3,758,131 to 3,261,895, i.e. by -13.2%.

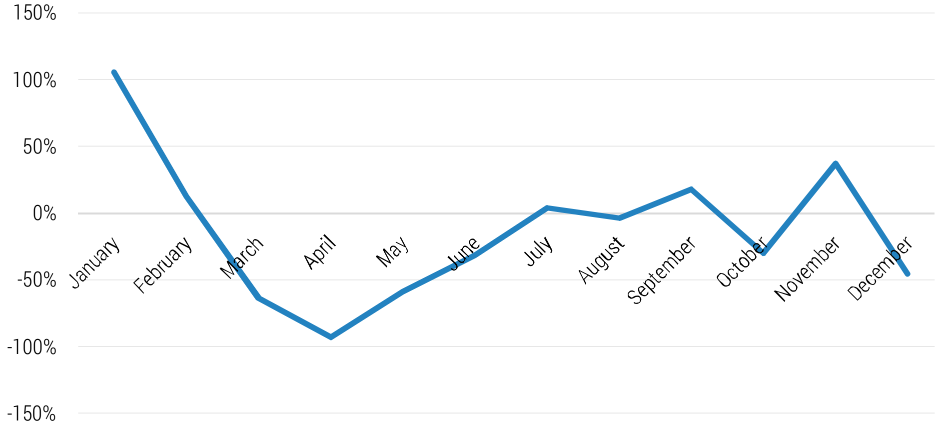

Figure 11. Change in the number of tourists in the surveyed national parks in the corresponding months of 2019 and 2020

Source: author's work based on data from national parks.

Results

The analysis based on ticket sales data, provided by the management of nine national parks, in connection with the epidemiological situation and the introduced restrictions, allowed us to achieve the following results:

- tourist traffic measured by the sale of admission tickets decreased -13.2% in 2020 compared to 2019,
- the introduction of severe restrictions in the spring and health concerns caused a drop in tourist traffic from March to June when ticket sales fell between -31.1% (in June) and -92.8% (in April),
- April was the month with the most significant drop in tourist traffic (-92.8%) when restrictions introduced by the government prohibited even access to parks and forests,
- during the summer holidays (July, August), the sale of tickets to national parks in 2019 remained close to 2019 levels; the 2.6 million tickets sold in this period in the pandemic year represent a decrease of -0.06% or 1,438 tickets,

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- the autumn wave of the SARS-CoV-2 pandemic caused a decline in tourist traffic in October, and ticket sales decreased by on average -30.1%,
- health concerns and the absence of the popular Christmas and New Year trips (restrictions in the hotel industry) resulted in a -45.1% drop in tourist traffic in December,
- in January 2020, i.e. a month before the pandemic, a significant increase (105.9%) in the number of tourists was recorded, which is due to how public holidays and school winter breaks fell at that time,
- for fear of contracting SARS CoV-2, tourists were more strongly attracted to national parks that are otherwise less popular: Babia Góra National Park (+23.8%), Biebrza National Park (+17.1%), Gorce National Park (+66%) and Tuchola Forest National Park (+24.6%),
- in the otherwise most famous national parks, ticket sales fell in 2020: Tatra National Park (-13.2%), Pieniny National Park (-15.9%), Stołowe Mountains National Park (-16.9%), Białowieża National Park (-23.7%) and Świętokrzyski National Park (-18.6%),
- only the Pieniny and Tatra National Parks did not record an August increase in tourist numbers in 2020 over 2019 numbers; all the others saw an increase, which may result from the introduced restrictions on leaving Poland, as well as from the desire to redeem a tourist voucher during the holidays,
- tourist traffic in the studied parks peaked in August, except in Babia Góra National Park, which peaked in July.

Conclusions and discussion

The conducted research allowed us to verify the research hypothesis, which assumed that national parks in Poland decreased tourist numbers due to the coronavirus pandemic. The hypothesis was partially confirmed, only for the most popular national parks. They recorded declines in the number of tourists, while the less popular ones recorded increases.

In Poland, after the period of strict restrictions- no entry to forests and parks, there were significant increases in the number of tourists, which is confirmed by the research. As a result, in 2020, the total decrease in the number of visits (as observed in relation to sold entry tickets) to the parks was only 0,06%. The situation occurred accordingly in other parts of the world (Ireri, 2022).

The consequence of crises, including pandemics, is a decrease in demand for less crucial activities, especially travel and tourism (Senbeto & Hon, 2020). In the face of the pandemic, tourists tend to isolate themselves, avoid crowds and turn to alternative forms of tourism (Ulemma et al., 2021). They

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choose places in the country of residence, avoiding crossing the border and long journeys (Dragomir et al., 2021). Consequently, local and regional destinations, especially those close to major cities, should notice an increase in visits. Moreover, this is when tourists are more interested in nature tourism with an increasingly popular model of sustainable tourism, which can be successfully achieved in Polish national parks. They tend to stay away from mass tourism.

Undoubtedly the pandemic period has noticeably affected the dynamics of tourist traffic in the studied parks. Global tourism has also changed its structure (Brouder, 2020; Hall et al., 2020). The change in travel patterns (e.g. decline in long-distance flights, personal means of transport) and the reopening of tourism after the pandemic is an opportunity for sustainable tourism (Lama & Rai., 2021; Purcell et al., 2021), regional, rural or health tourism (Wang et al., 2021), which can be successfully implemented in Polish national parks.

During the research, several restrictions were encountered, mainly from individual national parks' specificity. Not all parks sell entrance tickets in their area; in those where sales are carried out, it is not often conducted throughout the year but is only limited to the tourist season. Limitations resulting from data availability resulted in the analysis being carried out for 9 out of 23 national parks in Poland. Despite the rules, the research allows to development of patterns of mobility of tourists in Poland in exceptional situations. The influence of the SARS-CoV-2 coronavirus pandemic on the dynamics of tourism is a highly complex issue that has changed and will continue to change modern tourism.

This interesting scientific topic is intended by the author to be continued in future studies in relation using to more advanced, big data information on population traffic.

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DOI: 10.34659/eis.2022.83.4.479

GENERAL ENVIRONMENTAL AND SOCIAL PROBLEMS

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GREEN HUMAN RESOURCE MANAGEMENT

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ABSTRACT: Green human resource management means taking action and shaping and promoting pro-ecological attitudes in the working environment. The purpose of this study is to investigate the role of green Human Resource Management (HRM) and green corporate policies in environmental sustainability. Research in this area was carried out among 346 employees employed in enterprises from various industries in Poland in 2021. An online questionnaire was used in the study. The obtained results were subjected to statistical analysis; a logistic regression model was applied using the Statistica computer package. The conducted research showed that the employees' awareness of green competencies and the employer's activities in environmental training and education are statistically significant. Still, employers should emphasise the environmental education of employed staff in conjunction with their job position.

KEYWORDS: green human resource management (GHRM); pro-environmental activities of enterprises; the ecological context of HR; logistic regression model; green jobs and green competences

Introduction

In today's world, people and the natural environment are the most critical resources on a global scale. Attempting to combine the two current key management concepts, i.e. environmental management and human resources management, has become not only a necessity but also a real challenge for the organisation.

A green approach to human resource management comes down to taking action and shaping and promoting pro-ecological attitudes in the work environment (Peng et al., 2020). In this context, the need for Human Resources (HR) processes in organisations to be based on the principles of sustainable development is of particular importance. More and more frequently, the ecological context can be seen in the practice of enterprises, at least in the personnel decisions made or in the employees' behaviour. Pro-environmental solutions are implemented primarily in large international corporations but are not limited to those.

From an economic point of view, this allows companies to lower organisational costs, increases employee motivation and opens up new markets. It enables support for long-term changes in the mentality and behaviour of employees, which impact the sustainability process in enterprises (Wu Vienna, 2022).

As a leading strategic element of modern organisations, human capital should also become their "green energy", which is a real challenge, particularly for the managerial staff (Tang et al., 2020). Currently, Green Human Resource Management (GHRM) is seeing a noticeable upward trend in implementing the assumptions of this concept around the world, with the pandemic in the background, hence the authors' interest in this topic.

This study aims to investigate the role of GHRM and companies' environmental policies in environmental sustainability.

The issues of GHRM have not been thoroughly researched empirically (Andjarwati et al., 2019). Therefore, the authors of this paper try to pay attention to the aspects of indicating the level of "green" awareness in companies and good practices, as well as formulating conclusions and recommendations for employers in this area.

On the one hand, a thesis was adopted that GHRM practices are related to the ecological behaviour of employees and the increase in their awareness of the need for green jobs and green skills. On the other hand, the increase in the number of green jobs depends on the degree of the enterprise's commitment to the implementation of the principles of sustainable development through environmental education and employee training.

DOI: 10.34659/eis.2022.83.4.496

The carried out research is based on both in-depth literature studies and the results of a two weeks internet survey addressed to employees in different sectors of the Polish economy. As the statistical analysis tool, the econometric logistic regression model was implemented.

The literature review

Sustainable development in human resource management

The literature review proved that as a basis of GHRM is considered the phenomenon of sustainable development. It is defined as socio-economic development, in which the process of integrating political, economic and social activities occurs. Furthermore, it preserves the environmental balance and durability of fundamental natural processes in order to guarantee the possibility of satisfying the basic needs of individual communities or citizens of both the current generation as well as future generations (Act, 2001; Wielewska, 2018; Wielewska et al., 2017). Due to unfavourable changes that result from civilisation development, including the destruction of the natural environment, entrepreneurs are somehow forced to pay more and more attention to activities in the area of sustainable development and the implementation of its principles (Hu et al., 2021). It is currently one of the critical factors determining the company's image. The following tendency is also noticeable: the "richer" a society, the greater its emphasis on ecological activities.

One of the pioneering definitions of sustainable Human Resource Management (HRM) is presented by Zaugg et al. (2001). They based the concepts of HRM on three pillars, i.e. maintaining a balance between work and family life, remaining "attractive" in the labour market and increasing the independence and autonomy of employees in connection with their competencies (Zaugg et al., 2001; Zalesna & Wyrzykowska, 2017). The mentioned areas of HRM and their relationships are presented in Figure 1.

Somewhat later, the definition above began to be developed to include minimising the adverse effects of enterprises' activities on the natural, work and social environments (Kramar, 2014). A slightly different approach to sustainable HRM was presented by Pabian (2015). He claims that companies should focus their activities first on the recruitment process. Then, focus on selecting the right tools for influencing the employees so that they can help achieve economic, environmental and social goals most effectively while affecting the balance of intergenerational needs. Pfeffer (2010) approached the concept of sustainable development differently. He is linking HRM practices primarily with their impact on the physical and mental health of the employees and their life expectancy, which is presented in Figure 2.

DOI: 10.34659/eis.2022.83.4.496

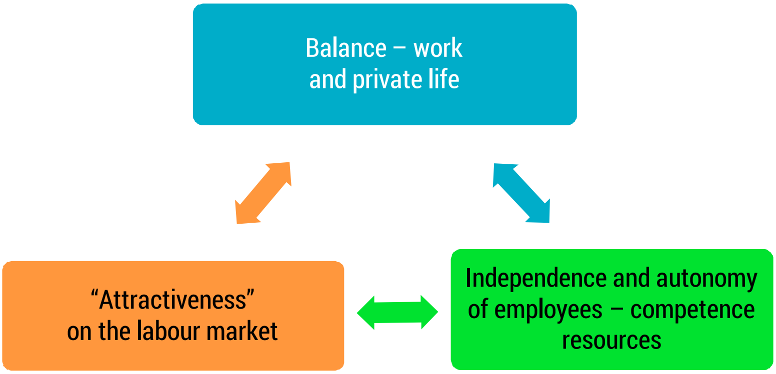

Figure 1. Three pillars of HRM

Source: authors' work based on Zaugg et al. (2001).

Figure 2. Sustainable management of human resources

Source: authors' work study based on Pfeffer (2010).

However, in the face of the COVID-19 pandemic, it is worth mentioning that corporate social responsibility is of particular importance. This is because enterprises face new challenges that allow them to authenticate their image by engaging in pro-health and pro-environmental activities which support society at this challenging time (Kacprzak et al., 2021).

DOI: 10.34659/eis.2022.83.4.496

As an integral part of sustainable human resource management, its green concept can be considered, i.e. Green Human Resource Management (GHRM). Therefore, GHRM is considered a subset of sustainable human resource management (Wagner, 2013). This is because some scientists have combined human resource management with environmental management (Renwick et al., 2013). Therefore, the term GHRM is still in the spotlight of environmental management research and is now considered a hot topic in the latest studies (Al-Ghazali & Afsar, 2020). Going further, it is worth quoting a few of its definitions. Generally, it can be considered the process of making employees green by implementing green human resources policies and practices. It ought to benefit the individuals, society, community and the whole planet (Opatha & Arulrajah, 2014). This concept integrates environmentally friendly human resource management initiatives and practices for the sustainable use of resources. It results in increased efficiency, reduced waste and improved work attitude.

Therefore, GHRM is an integral part of the concept of sustainable human resource management, as are activities in the area of corporate social responsibility (CSR). The main goal of the GHRM is to shape ecological sensitivity among the company's employees, to create a pro-ecological work and climate environment, and to transfer ecologically responsible attitudes and behaviour of employees to their private lives (Muster & Schrader, 2011; Datta, 2015; Regas et al., 2017). Other scientific works also included these aspects (Shalafei et al., 2020; Dumont et al., 2017; Pham et al., 2019).

Researchers who study GHRM, especially green jobs and green competencies, emphasise that these are systematically growing from year to year. Therefore, there is a real need to conduct systematic research that would enable the identification of factors that favour or inhibit the development of this area. This is particularly important from several perspectives. Firstly, the development of GHRM is conducive to improving activities for the natural environment and the surroundings in which we live and function. Secondly, it has a positive effect on shaping employees' desired attitudes and behaviours. Thirdly, it improves the image of enterprises. Fourthly, it is an essential and effective tool in combating unemployment. Therefore, further analysis of "green" development factors is legitimate. GHRM is a combination of good pro-ecological practices in the area of HRM with CSR activities in order to implement a coherent strategy of the organisation by creating a "green" culture in the organisation. The impact of pro-ecological HRM practices on the development of green organisational culture and on the environmental performance of companies has been demonstrated in the research of Roscoe et al. (2019). In such a culture, the fundamental values are primarily attitudes and behaviours aimed at active, committed activities of the organisation's

DOI: 10.34659/eis.2022.83.4.496

members to improve the condition of the natural environment and society's quality of life.

"Green" practices in human resource management

HR strategies based on sustainable HRM and green HRM must include not only the achievement of economic goals but primarily environmental and social goals. According to the literature, green HRM practices can be categorised into five primary groups, i.e. resource planning, recruitment of employees, employees' development, motivating, and management of employee performance.

The abovementioned areas include considering the ecological aspects, e.g. job descriptions, ethics codes of enterprises, HRM procedures, competency profiles (green competencies, ecological awareness of employees), and education. It is essential in the process of training on shaping and promoting pro-environmental attitudes and behaviours, motivational (WLB programmes, well-being, wage motivators, etc.) or employee evaluations (assessment of the level of commitment to sustainable development) (Różańska-Bińczyk et al., 2020).

Research shows that GHRM practices are also becoming more and more popular in companies in Poland. For the most part, their activities are limited to implementing ecological elements in various types of HRM procedures and instructions, in ethical codes, and in promoting the ecological image of the company in the labour market. Employers fare much worse when it comes to the incentive systems and tools used in companies as well as the management of employees' performance in the ecological aspect (Różańska-Bińczyk et al., 2020). Some examples of good green practices in the field of HRM are presented in Table 1.

It is worth mentioning that they should be promoted among as many companies as possible worldwide. This is due to the benefits that it brings, not only for the organisation itself but primarily because of the benefits for the natural environment.

Examples of practices presented in Table 1 are but a few selected activities from an extensive range, which should be adapted individually to the realities of a given company and the environment. One of the abovementioned examples of encouraging employers and employees is to use green transport forms. This is because transport and mobility are considered as one the main elements of sustainable development, especially in the EU transport policy (Czech et al., 2021).

Nevertheless, it must be remembered that various types of activities can be initiated and integrated when organisations need to turn towards green practices (Figure 3).

DOI: 10.34659/eis.2022.83.4.496

Table 1. Selected good environmental practices in HRM

Selected areas of HRM	Examples of good practices
Employment planning	Creation of green jobs or modification of existing ones as well as procedures, regulations, codes of ethics in terms of green competencies and a green work environment.
Selection of employees	Preference for green competencies in the recruitment and selection process of employees, including attitudes, behaviour, knowledge, skills and pro-environmental activity.
Motivating and engaging employees	Rewarding green competencies of employees (pay and non-pay incentives), green collar satisfaction survey, WLB programs, well-being programmes supporting employees' health (preventive examinations, additional insurance, multisport cards, healthy nutrition courses, etc.).
Development	Trainings to increase pro-ecological awareness among the staff, promoting patterns of attitudes and pro-environmental behaviours of the management, initiating and engaging employees in ecological initiatives/projects, competitions, considering green competencies in the promotion process.
Assessment	An assessment system related to the system of motivating and developing green employees, an assessment of involvement in activities based on sustainable development.
Organisational culture	Employee participation; appreciating employees' initiatives, their creativity and innovation in the area of green solutions and improvements; environmental education for employees and external and internal stakeholders and local communities; building a green image of the organisation; implementing activities in the area of corporate social responsibility; increasing quality standards and conduct towards employees and customers.
Work environment, working conditions	Pro-health and pro-environmental solutions, e.g. using recycled paper, ecological toners, encouraging the use of ecological forms of transport, setting creativity zones, electronic document circulation, purchasing bottles with filters for employees (reducing plastic), flexible working hours, hybrid work.

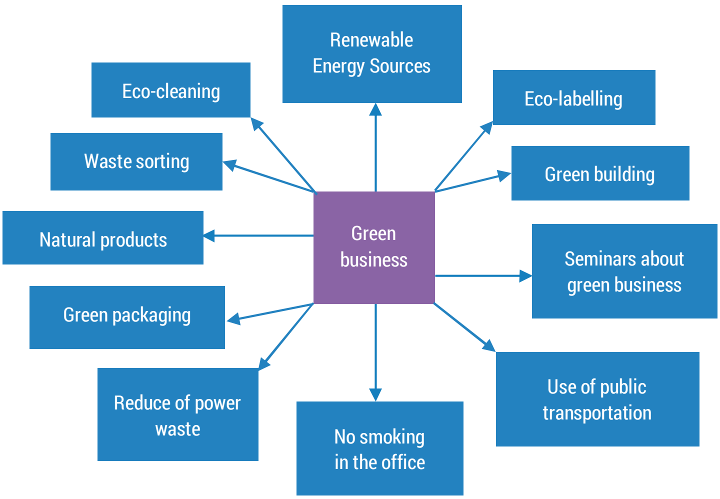

Figure 3. The most commonly used green business practices

DOI: 10.34659/eis.2022.83.4.496

Analysing the above-mentioned graphical presentation of a wide range of environmental activities, employers and employees should remember that the goals of the green company are usually achieved very slowly.

Green jobs and green competencies and barriers of GHRM implementation

The twentieth century saw the terms “white” (Xie et al., 2021; Elsadek et al., 2019) and “blue” (Almeida-Santos et al., 2010; Lips-Wiersma et al., 2016) collars being coined about the office and manual workers respectively, as a result of the ubiquitous changes that took place in the “brown” economies (those that exploit and ruin the natural environment) and on labour markets worldwide. As a result of the dominant pro-ecological trends and transformation towards a “green” (environmentally friendly) economy, the term “green collars” or “green workers” (Mustar & Schrader, 2011) has recently been coined about people who do work which saves the natural resources and wildlife, natural ones are preserved and renewed – but here the sense of the previous categorisation by the type of work done disappears.

“Green” workers must have specific competencies necessary for green workplaces. Those “green competencies” of employees result from their knowledge and skills in applying pro-environmental solutions in the enterprise (Kozar, 2017). This involves soft and hard competencies, which can be shaped by various types of training, engaging in practical activities and pro-environmental initiatives, or learning from others.

Competencies arise as a result of integrating skills mastered efficiently and consciously in order to be able to take action in a free, reflective and responsible way (Budniak, 2018). Green competencies should be noticed, appreciated, promoted and gratified by employers. Employees should use them professionally as well as in their private lives while contributing to the improvement of the quality of life of local communities and the restoration of the natural environment resources. Therefore, the critical green competencies will primarily include the creativity and innovation of employees.

The definition of green jobs adopted by the European Commission in 2012 is as follows: “any jobs dependent on the natural environment or created, converted or transformed (in terms of ecological qualifications, working methods, job profiles) in the process of turning towards a greener economy” (Kryk, 2014; Urząd Publikacji Komisji Europejskiej, 2013). Nevertheless, the is no unanimous agreement to a singular definition of green jobs (Bowen et al., 2018). In general, green jobs can be perceived in two ways, i.e. quantitatively and qualitatively (Rutkowska & Sulich, 2020). Firstly, it is considered a sector approach which relays on econometric model construction based on quantitative variables. The last is to classify green jobs distinguishing hard and soft skills specific to that area (Maclean et al., 2018).

DOI: 10.34659/eis.2022.83.4.496

Going further, green jobs can be divided into two ways (Kryk, 2014). On the one hand, companies manufacture products or provide services which benefit the environment and conserve natural resources. On the other hand, they create more environmentally friendly production processes or use fewer natural resources. Thus, green jobs can, directly and indirectly, relate to environmental protection.

According to research on labour markets, the number of green professions in the world is growing significantly. The literature studies provide a wide range of professions such as farmer/breeder, designer/engineer of green cars, water quality technologist, environmental researcher, biologist, recycling worker, etc. (Fazlagić, 2019; NIST, 2022). This list also indicates the critical economic sectors from the point of view of implementing pro-ecological activities and creating green jobs.

Green jobs and the implementation of green human resource management principles in companies are justified by many different premises and benefits for the enterprise, its employees, its environment, and its associates (Molina-Azorin et al., 2021). Undoubtedly, the GHRM predominantly affects the improvement of the employer's image. Companies with a "green" image find it easier to attract and retain competent employees, loyal customers, consumers and contractors. This is due to their active involvement in solving problems of local communities, supporting pro-environmental initiatives, raising the quality standards of the offered products and services, or standards of dealing with external and internal stakeholders. All this translates into the company's value, profits, competitiveness and finally achieved success.

Despite the growing interest in the concept of GHRM, there are still many obstacles to its implementation. The popularity of GHRM is determined by a particular paradox: on the one hand, it is a good image gimmick, and on the other hand, there is still much opposition from the management and employees, as well as difficulties in transforming cultures towards "green organisations".

As noted by Bombiak (2020), specific trends can be noticed in terms of critical barriers to implementing the GHRM concept in enterprises based on the results of empirical research conducted among Polish managers. Firstly, these include financial constraints, which largely determine subsequent barriers, i.e. the lack of an appropriate incentive system, lack of incentives in enterprises, low level of competencies of the managerial staff in the field of GHRM and low level of popularisation of GHRM tools. The surveyed managers also pointed out that organisations are dominated by cultures based on economic values rather than green cultures, which are based primarily on intangible values. Various world studies also indicate resistance from the managerial staff, lack of sufficient leadership support or a "good" GHRM

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implementation plan, barriers resulting from the complexity of green technologies (lack of appropriate infrastructure, technical support), cultural conditions (lack of clear green values), resistance from employees, low green awareness, lack of staff competencies in the area of implementing green practices, or mismatching HR structures.

Viswanathan (2014) also pointed to the two types of barriers to implementing GHRM – internal (lack of appropriate organisational resources) and external (legal regulations and policies of a given country).

To sum up, the barriers to implementing the GHRM concept will always exist. This is due to the different degrees of adaptability and innovativeness of organisations and the individuality and diversity of their cultures. Nevertheless, every effort should be made to minimise those barriers for the good of society and the natural environment.

Materials and methods

The literature studies proved that GHRM had been put under scientific investigation by implementing different methods. Generally, there are three methodological approaches, i.e. quantitative, qualitative and mixed (Hosna & Kaoutar, 2022a). First, adopted quantitative methods for examining the factors influencing GHRM where structural equation models were implemented. The second qualitative approach explores factors related to GHRM implementation to understand and analyse companies' green initiatives and practices. The last, the mixed approach, introduces mixed methods in the research process on GHRM. It is worth mentioning that such researches are very limited.

Therefore, the third approach was implemented into the research process combining the results of the carried-out surveys and the econometric logistic model as a quantitative tool.

The basis of the analysis carried out in the paper is the subjective assessment of employees on the impact of their awareness of the need for green jobs and green competencies in selected enterprises. The survey was conducted in Poland in 2021. The study used an online questionnaire filled out by 346 employees who work in enterprises operating in various industries in sixteen Provinces of Pol. and. The obtained results were analysed statistically. The analysis used the Statistica computer package (Luszniewicz & Słaby, 2008).

The statistical analysis in the form of a model was preceded by a study of the structure of the distribution of responses, which enabled the assessment of the strength of the impact of four selected factors on the existence of green jobs in the surveyed enterprises. These factors include:

DOI: 10.34659/eis.2022.83.4.496

1) undertaking actions by the employer in the field of environmental education and training in this area,
2) a set of crucial employee competencies, including green competencies,
3) the existence of positions for sustainable development in the surveyed company,
4) the company's incentive system for the pro-ecological activity of the employees.

The tool used to assess the influence of independent variables on one dependent variable in the situation of subjective assessments is the logistic regression, referred to as bimodal. Its application enables the analysis of the influence of several diagnostic features on a dichotomous variable. In contrast, independent variables (factors) can be qualitative and quantitative. An additional advantage of logistic regression is the ability to quickly interpret the results like the classical regression analysis methods (Stanisz, 2007; Stanisz, 2016; Menard, 2009; Hyeoun-Ae, 2013; Hibe, 2015).

The logistic regression model has already found application in economic sciences for assessing the quality of life in Polish households in the social cohesion survey conducted by Statistics Poland (GUS, 2013; GUS, 2017). Work was also carried out in relation to the marginalisation and social exclusion of the elderly (Kot & Słaby, 2013; Słaby, 2014; Słaby, 2016). Further work was also carried out in the area of quality of life in the spatial aspect, including regional aspects (Czech, 2017; Czech & Słaby, 2018; Czech & Słaby, 2021).

In addition to the areas covered by the study, this tool is perfectly applicable in various types of questionnaire surveys based on the measurement of features with weak measurement scales. In this study, it was therefore decided to use the logistic regression in order to deepen the analysis by getting to know the direction and strength of the impact of individual factors on the subjective employees' opinion of green jobs. In the model used for the analysis, the employee's subjective assessment of the presence of green jobs and green competencies in his company was implemented as a dependent variable. The respondent's opinion took the form of a binary feature. The value of one was assigned to the respondents who determined that there are green jobs in the employed enterprise and zero otherwise, which was reflected in the following provision:

$Y = 1$ – a dichotomous dependent variable for the respondents who chose "yes" in the given questionnaire,

$Y = 0$ – a dichotomous dependent variable for the answer "no".

The two survey questions were classified into independent variables called factors. The first consisted of one independent variable with the following two levels of responses: "yes" or "no". The second constituted three questions with answers measured on the following three levels: "yes", "no", and "no opinion".

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It should be noted that the implementation of logistic regression requires the presentation of qualitative features in the form of sets of binary features. This type of transformation is so performed that m-1 binary variables represent a feature having m variants. In fact, one survey question from a group of factors with two levels of response ("yes" or "no") was represented by one artificial diagnostic variable. However, the other three questions (factors) with three levels of answers were represented by two artificial explanatory variables, resulting in seven diagnostic features. This type of procedure, which replaces a quality feature with its artificial equivalents, is called coding or parameterisation and requires the definition of the so-called reference category. The reference category consisted of individuals who answered "no" to particular questions. It should be noted that there are also other parameterisation methods in the form of effect-type, ordinal, polynomial or orthogonal coding (Książek, 2013).

As a result of the presented method of transformation of individual diagnostic features (factors), the following set of artificial diagnostic variables was obtained:

$X_1 = 1$ – dichotomous independent variable, in which the respondent assessed: "yes", ecological education is provided in the enterprise; $X_1 = 0$ – "no" (reference group),

$X_2 = 1$ – the respondent said "yes", the competencies of the company's employees include green competencies; $X_2 = 0$ – for the remaining answers,

$X_3 = 1$ – the respondent stated "I have no opinion" in the question whether the competencies of employees include green competencies; $X_3 = 0$ – for the remaining answers,

$X_4 = 1$ – the respondent said "yes", there is a position for sustainable development in the company where he or she works; $X_4 = 0$ – for the remaining answers,

$X_5 = 1$ – the respondent stated "I have no opinion" in the question of whether there is a position for sustainable development in the company where he or she works; $X_5 = 0$ – for the remaining answers,

$X_6 = 1$ – the respondent stated "yes", in the company where he or she is employed, there is an incentive system that considers gratification for pro-ecological activity; $X_6 = 0$ – for the remaining answers,

$X_7 = 1$ – the respondent stated, "I have no opinion" whether there is an incentive system in the company where he or she is employed that considers gratification for pro-ecological activity; $X_7 = 0$ – for the remaining answers.

Thus, a prepared set of diagnostic features was the basis for diagnosing factors influencing the existence of the so-called green workplaces.

The logit transformation is based on the transformation of the probability $P = P(Y = 1)$, which is expressed by the following formula (Stanisz, 2016):

DOI: 10.34659/eis.2022.83.4.496

$$ln\frac{P(A)}{1-P(A)} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k. \quad (1)$$

The natural logarithm of the expression $\frac{P(A)}{1-P(A)}$ is called the logit. It forms a linear function of the independent variables X_1, X_2, ..., X_k. Therefore, the selected parameter β_1 is interpreted as the increase in the logarithm of the quotient caused by the increase of the selected exogenous variable by one unit with the controlled stability of the remaining diagnostic variables included in the constructed model.

The hypothesis about the lack of influence of the selected diagnostic feature $H_0{:}\beta_j = 0$ is tested based on Wald statistic in the form of the following expression:

$$W = \left(\frac{\hat{\beta}_j}{S(\hat{\beta}_j)}\right)^2, \quad (2)$$

where:

$\hat{\beta}_j$ – the estimated parameter value,
$S(\hat{\beta}_j)$ – standard error of the estimate.

If the null hypothesis is true, the Wald statistic has the form of the distribution with one degree of freedom. High values of Wald statistic weaken the null hypothesis, and the critical level of significance is estimated as:

$$p = p\left(\chi^2_{(1)} \geq W\right).$$

In interpreting the test results using logistic regression, the main emphasis is on the expression of the odds ratio. It can be seen that there are three main situations about this type of expression. In the first one, if the odds ratio is below one. This type of situation indicates that the chance of occurrence of the studied event is lower in the analysed group than in the reference group. In the second case, when the odds ratio takes the value of one, it means that the risks of the analysed group and the reference group are equivalent. However, in the third case, when the odds ratio is above one, the chance of occurrence in the analysed group is higher than in the reference group.

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Research results and discussion

The impact of various management activities that contributed to the name "green enterprise" influenced the differentiation of employees' responses to the question: "Are there green jobs in the company where you work? An in-depth statistical analysis in the form of a logistic model was preceded by a study of the structure of the distribution of responses, which allowed for the assessment of the strength of the impact of individual factors on the existence of "green" jobs in the surveyed enterprises. The highlighted main question in the further analysis took a closed form, including two types of answers in the form: "yes" or "no". The dichotomous distribution of the responses on this issue is presented in Figure 4.

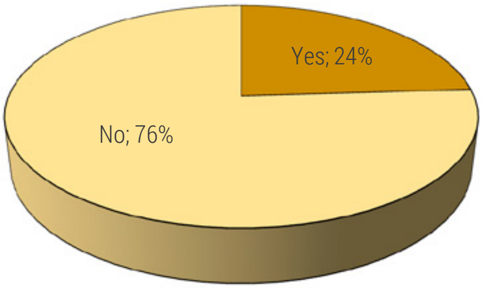

Figure 4. The existence of green jobs in the workplace, according to the surveyed

The analysis of the graphic presentation shows that only 24% of the respondents gave a positive answer to the research question. When considering the number of positive responses, it can be noted that eighty-three people employed in enterprises from various industries accounted for less than a quarter of all responses compared to the surveyed sample.

Regarding searching for the situation's determinants, a set of four selected questions taken from the research questionnaire was used. When carrying out the substantive analysis, potential issues are taken into account that may have a tangible impact on its development and a positive subjective employee's assessment of the existence of green jobs and green competencies in the enterprise. The first question was a closed-ended question of a dichotomous type, in which the respondent could answer "yes or "no" to the question about the employer's activity in environmental education and training. The distribution of the answers given by the surveyed respondents is shown in Figure 5.

The conclusions drawn from the graphic presentation indicate that in over two hundred cases, there was a negative answer regarding the possibility of participating in educational training, which accounted for more than

DOI: 10.34659/eis.2022.83.4.496

half of the total answers provided. This may prove that the employer puts too little emphasis on the environmental education of the employed staff.

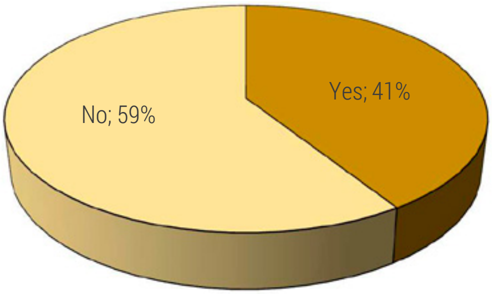

Figure 5. Environmental education and training conducted by the employer, according to the respondents

Further factors that determine the occurrence of the so-called green jobs also took the form of closed-type questions with the following three levels of answers: “yes”, “no”, and “I have no opinion”.

The second factor conditioning the presence of green jobs in a given enterprise was the question about the employee’s opinion on the set of their key competencies. In this question, the existing collection has been extended to the so-called green competencies. The distribution of the answers for the entire tested sample is shown in Figure 6.

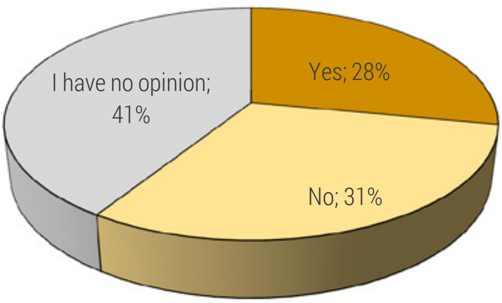

Figure 6. The opinion of the respondents indicating whether the critical competencies of the company’s employees also include green competencies

The analysis showed that only 28% of the answers given the “yes” variant were obtained, i.e. this group was composed of ninety-seven respondents. On the other hand, there were one hundred and seven employee responses in the area of negative responses. The last and the most numerous group were uncertain about recognising the so-called green competencies as key. This group included as many as one hundred and forty-two respondents, accounting for 41% of the total answers. Such a large group of undecided people may indicate a lack of knowledge of environmental (ecological) issues that could be associated with the positions held and, thus, the lack of appropriate education in this field.

DOI: 10.34659/eis.2022.83.4.496

The existence of sustainable development positions in a given company was assumed as the third-factor conditioning the presence of green jobs. The obtained results for the three response levels in the form of structure indicators are presented in Figure 7.

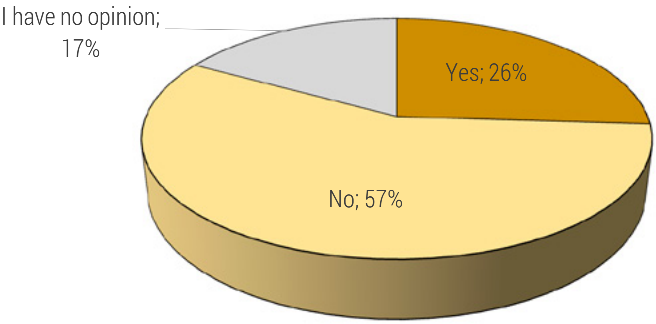

Figure 7. Existence of a position/positions for sustainable development in their workplace, according to the respondents

When doing the analysis, it can be concluded that the most numerous group were negative responses. Almost two hundred respondents were in this group, constituting 57% of the entire sample. The second group consisted of people who had no opinion on this issue. The most minor numerous group were the respondents who gave a positive answer regarding the existence of a position for sustainable development in their company.

The fourth (and last) question, which was classified as a potential determinant of the presence of green jobs and green competencies, concerned the company's motivation system. A graphic presentation, including three types of responses on the subject of consideration by the employer of gratifications for pro-ecological activity, is presented in Figure 8.

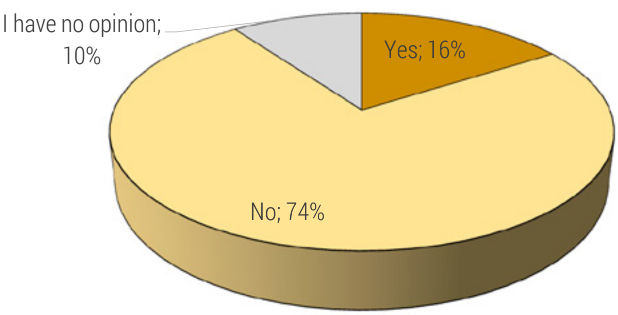

Figure 8. Including gratification for pro-ecological activity in the incentive system, according to the respondents in their workplace

DOI: 10.34659/eis.2022.83.4.496

As indicated by the survey results, two hundred and fifty-seven employees gave a negative answer and thirty-three people could not express an opinion on this issue. Only fifty-six respondents answered "yes", which constituted 16% of the total answers. The analysis of the distribution of responses to selected questions included in the questionnaire gave a general view of green jobs, green competencies and the factors that determine their presence in enterprises.

Table 2. Stages of logistic model estimation in the assessment of green jobs for n=346 respondents

	X_1	X_2	X_3	X_4	X_5	X_6	X_7
The first stage							
p	0.000	0.004	0.005	0.092	0.163	0.044	0.015
$e^{\widehat{\beta}_i}$	15.019	3.403	0.194	2.058	2.231	0.397	0.214
D	5.517	1.471	0.061	0.889	0.722	0.162	0.062
G	40.885	7.877	0.611	4.763	6.893	0.975	0.740
The second stage							
p	0.000	0.007	0.002	*	*	0.055	0.036
$e^{\widehat{\beta}_i}$	19.316	3.116	0.165	*	*	0.435	0.281
D	7.403	1.370	0.052	*	*	0.186	0.086
G	50.400	7.087	0.522	*	*	1.017	0.921
The third stage							
p	0.000	0.006	0.004	*	*	*	0.108
$e^{\widehat{\beta}_i}$	13.694	3.136	0.194	*	*	*	0.402
D	5.679	1.391	0.063	*	*	*	0.132
G	33.022	7.071	0.594	*	*	*	1.222
The fourth stage							
p	0.000	0.001	0.008	*	*	*	*
$e^{\widehat{\beta}_i}$	11.707	3.851	0.223	*	*	*	*
D	4.985	1.778	0.074	*	*	*	*
G	27.491	8.342	0.670	*	*	*	*

Explanations: * – statistically insignificant, p – critical significance level, $e^{\widehat{\beta}_i}$ – odds ratio, D – lower limit of the confidence interval for the odds ratio, G – upper limit of the confidence interval for the odds ratio

Unfortunately, the analysis results did not show the impact of individual factors and the levels of answers given in the questions asked. Moreover, apart from the direction of its influence, it is also worth knowing its strength. A logistic regression model was used to assess the influence of independent variables on the dependent variable in the situation of subjective assessments. The results of the logistic regression analysis in the evaluation of green jobs are presented in Table 2.

It should be noted that the study of the relationship between individual factors and the subjective assessment of the employee regarding the existence of the so-called green workplaces was carried out in four stages. The final set of diagnostic variables was considered in the first stage. Then, statistically insignificant variables were removed, and the model was re-estimated. The re-estimation process was performed until only statistically significant factors were identified. It should also be noted that the threshold of acceptable statistical significance was set at 0.05.

In the first step, the following two diagnostic variables were removed: X_4 and X_5. The elimination of these variables proves that the position for sustainable development has no impact on the subjective opinion of the company's employees regarding the existence of green jobs. In the third and fourth stages, the following variables were eliminated: X_6 and X_7, which were related to the question about the existence of an incentive system in the enterprise which would reward pro-ecological activities. It also proves the lack of influence of this kind of feature on the employees' opinions regarding the existence of green jobs.

In the fourth and final stage of the analysis, two main factors were identified that caused the employee to identify the so-called green posts.

The first factor is that the company conducts environmental education. When interpreting the odds ratio for this feature, it can be stated that for the respondents who said "yes", environmental education is conducted in the enterprise, compared to people with the answer "no", the value of the odds ratio was elevated to over eleven. This means that in the respondents who stated that ecological education is conducted in their enterprise, the probability of a subjective assessment of the existence of the so-called green jobs increases more than eleven times compared to the reference group (respondents with "no" answers).

The last factor which played an important role was the qualification of the green versions of competencies in the basic competency set. In the case of the X_2 feature, the value of the odds ratio oscillated below the level of four. It can therefore be concluded that in the case of employees who stated that the essential competencies include the so-called green competencies, the probability of identifying the existence of green jobs has increased by over 280 percent. On the other hand, in the case of the respondents who stated

DOI: 10.34659/eis.2022.83.4.496

"I have no opinion" about the perception of green competencies as basic by the employee, the odds ratio was much below the value of one. This means that the probability of the respondent identifying the existence of the so-called green jobs in their workplace decreased by more than 70 percent.

Going further, the literature studies confirmed that the research problems mentioned above in green human resources management have already been put under scientific investigation (Dimitrov, 2021; Diri & Elisha, 2021). For example, there was proven that employee perceptions of a company's environmental performance are vital (Dechant & Altman, 1994). Researchers discovered that effective implementation of green practices in the company requires environmental awareness of the employees. These companies' aims can be achieved by integrating green practices with training and development (Fernandez *et al*., 2003). Moreover, employees' understanding of pro-environmental initiatives in the workplace may be raised mainly by so-called a green training (Boiral, 2002). This state of affairs confirms the stand already indicated in the literature that well-designed green training, which constitutes a vital resource, may increase innovation and create values, thus allowing individuals to carry out their work in such a way that they can reduce the negative impact of their work on the environment (Siyambalapitiya et al., 2018). Going further, some literature studies proved that training and development programs might be implemented to raise knowledge in the area of waste management, energy consumption, and carbon footprint reduction in order to reduce pollution and provide a sustainable living environment (Mehta & Chugan, 2015). For example, Yong et al. (2019) proved that training plays a crucial role in developing environmental knowledge and awareness, motivating creativity for green innovation, strengthening green commitment, and improving environmental performance. All in all, promoting green training, i.e. educating and raising employees' awareness of environmental issues and developing new skills, can be considered the main factor of green human resource management. This factor was proved in the constructed logistic model as the strongest one, which has the most significant impact on considering the existence of green jobs by employees.

The second factor, which was indicated in the research, is connected with the green competencies as a part of the key competencies in the company. This issue is strongly combined with the green recruitment, selection and hiring of personnel which is considered an important area of green human resource management. This type of recruiting with knowledge, skills, attitudes and behaviours supports green organisations' management systems (Ullah, 2017). The abovementioned skills ensure that potential employees possess personality and attributes which would allow the company to avoid producing waste and implement innovative ideas in their work in relation to the natural environment (Mwita & Kinemo, 2018; Tang et al., 2018; Shah, 2019). Nevertheless, green recruitment is not considered an interesting practice. This is because assessing environmental awareness is not the recruiters' priority (Hosna & Kaoutar, 2022b). All in all, the carried out research, implementing logistic regression, proved that green competencies are the second-factor influencing employees to consider the existence of green jobs in their workplace. Similar research results were obtained by Law et al. (2017).

It is worth mentioning that besides the above factors, the existence of positions for sustainable development in the workplace was included in the econometric model. The position for sustainable development in the workplace turned out to be not significant. The employees do not consider it as necessary. Moreover, the literature studies do not pay direct attention to the point of view of GHRM. Despite the respondent's opinions and the lack of influence of this variable on the constructed logistic model, it is worth noting the role of leadership in the organisation. The problem leadership seems very important, especially in its ethical form. This is due to the fact that ethics in leadership focus on acting by such universal values as honesty, respect and trust, which influence behaviour and attitudes (Ren et al., 2020).

Furthermore, it can be seen that spiritual values are needed to take responsible, ethical, and sustainable actions (Samul, 2020). It seems that leaders of this type determine who the employees are and how they cope by undertaking various types of educational activities in the organisation. As a result, they can shape their pro-ecological attitudes and effectively transform organisations into more sustainable ones.

The last factor, i.e. gratification for pro-ecological activity in the incentive system, was also included in the constructed model. According to literature studies, green rewards and compensations are considered valuable tools to increase employees' motivation and commitment to the environment (Halawi & Zaraket, 2018). However, these rewards can be either financial or non-financial. Therefore, organisations should pay spatial attention to rewards and compensation systems as key factors in reinforcing employees' positive green mindset and behaviour (Diri & Elisha, 2021). Despite the literature proving that green rewards can be valuable, the constructed econometric model did not show their significance in indicating to the employees if green jobs exist in their workplace.

Summing up, it can be noticed that three artificial variables of the binary type, which corresponded to the two questions included in the questionnaire, turned out to be final and statistically significant from the potential set of diagnostic features. The first concerned the employer's activities in the field of environmental training and education, which more developed enterprises with high culture are already undertaking. The second and last are related to the employee's awareness of their essential competencies in the organisation they are a member of.

DOI: 10.34659/eis.2022.83.4.496

Conclusions

The analysis of the carried-out research, based on both in-depth literature studies and the carried-out survey, proved that the adopted thesis was confirmed. On the one hand, green HRM practices are related to the ecological behaviour of employees and the increase in their awareness of the need for green jobs and competencies. On the other hand, the increase in the number of green jobs depends mainly on the company's involvement in the principle's implementation of sustainable development through employees' environmental education and training.

The carried our research delivered some further conclusions in the area of literature studies and the constructed logistic regression model.

Firstly, in light of the in-depth analysis of the subject literature, it can be concluded that the GHRM concept is relatively new and appears in contemporary organisations in a not fully formalised form. The pro-ecological undertaken activities are not always thoroughly planned. Moreover, they are often spontaneous or "forced" by the circumstances. In general, they do not always create a coherent system but implement its elements. Nevertheless, this situation is undoubtedly systematically improving as the awareness of employers and employees in this area increases, and "green" organisations often act as a magnet when it comes to internal and external stakeholders. One of the factors that will undoubtedly affect the development of GHRM is the COVID-19 pandemic. It caused a change in the existing value systems of a part of society and its sensitivity to health and environmental problems.

Secondly, based on the logistic regression model, it was indicated that both the employees' awareness of green competencies and the employer's activities in environmental training and education turned out to be statistically significant. It should be emphasised, however, that employers should emphasise the environmental education of their employees in conjunction with the position they occupy. The employees' opinion of the surveyed enterprises from various sectors of the Polish economy on the existence of green jobs was not influenced by the existence of a sustainable development position in the company or an incentive system.

To sum up, it can be assumed that in the near future, the most desirable employees in the labour market will be those with green competencies. This is because it will be possible to prevent and solve various significant intergenerational and civilisation problems and to influence the generation of economic benefits. Therefore, it is necessary to develop model tools supporting the implementation of the assumptions of the GHRM concept in enterprises and to promote good practices in this area.

DOI: 10.34659/eis.2022.83.4.496

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All authors have read and agreed to the published version of the manuscript.

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Beata SKUBIAK • Mirosław BRONIEWICZ

IDENTIFICATION AND DELIMITATION OF PROBLEM AREAS ON THE EXAMPLE OF THE WEST POMERANIAN VOIVODESHIP (POLAND, EU)

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ABSTRACT: In Poland, even though there is already richer literature on the subject of the regional economy, there is still a need for knowledge on various dimensions and aspects of the development of problem areas. The reason for this is to search for ways to boost the country's development, to find new opportunities to activate both growth centres, as well as, and perhaps above all, to activate underdeveloped, backward areas burdened with hidden unemployment in agriculture and to activate those areas which lack features that favour the development of the modern, knowledge-based economy of the 21st century. The key problem addressed in this article is „what criteria should be taken into account when delimiting the problem areas in order for public intervention to be effective and to contribute to the desired changes?"
This article presents the method of delimiting problem areas on the example of the "Five Capitals" model. The case study is the West Pomeranian Voivodeship in Poland (EU).

KEYWORDS: problem areas, delimitation

Introduction

The problem area and development in a sustainable aspect: what connects these two phenomena, and what makes the interactions between them interesting and an important subject of study? The answer can be found in many fields: what today determines the nature of problematic areas, how to achieve the assumptions of sustainable development, especially in the social aspect, in a situation where there is a tendency of increasing differences in socio-economic development and increasing inequalities on various levels (economical, social, educational, digital/technological, income levels, etc.); what criteria should be taken into account when delimitating problem areas? The scale of these differences is increasing and becoming a contemporary challenge for the policy of sustainable development (7th Report, 2017). In research on the spatial differentiation of socio-economic development, one of the most important threads vividly discussed in the literature on the subject is the question of the causes of this process. Questions about the causes, i.e. the conditions, determinants or factors favouring the emergence and, in principle, the deepening or eliminating the degree of socio-economic differentiation in geographical space, seems to be of fundamental nature (Chojnicki, 2011).

The subject of this article is part of the issue of sustainable development because the sustainable development postulate assumes such an approach to planning and the decision-making process, which is aimed, among others, at achieving a real and lasting reduction of social and economic differences, and at meeting the needs of the present generations without reducing the possibility of meeting the needs of future generations, and at the same time providing the society with a long-term vision of development. In Poland, even though there is already a richer amount of literature on the subject of the regional economy, there is still a need for knowledge on various dimensions and aspects of the development of problem areas. The reason for this is to look for ways to boost the country's development, to find new opportunities to activate both growth centres, as well as, perhaps above all, to promote the underdeveloped, backward areas burdened with hidden unemployment in agriculture and lacking features that favour the development of the modern, knowledge-based economy of the 21st century. The key problem addressed in this article is what criteria should be taken into account when delimiting the problem areas for public intervention to be effective and contribute to the desired changes.

DOI: 10.34659/eis.2022.83.4.508

An overview of the literature

There are many different proposals for defining this concept in the scientific literature. Problem areas in scientific literature are also called conflict, depressive, peripheral, difficult, handicapped, delayed in development (underdevelopment), areas of threats or production reserves, or simply less developed areas (Śleszynski & Mazurek, 2020). For example, according to Zagożdżon (Zagożdżon, 1988), a problem area is that part of the geographical space that is characterised by negative phenomena of the social, economic and technical spheres, causing specific internal anomalies (in the spatial structure) and the abnormal nature of that said area. On the other hand, according to Ciok (1996), the problem area is characterised by the low effectiveness of socio-economic and spatial structures. It, therefore, requires solutions to the existing problems as part of planning and regional policy.

Generally speaking, the problem area is a part of the geographical space characterised by the occurrence of negative phenomena from the socio-economic and technical spheres, causing internal anomalies and abnormalities in that area (Bański, 1999). There are many criteria and ways of delimiting problem areas (e.g. high unemployment, depopulation, low GDP per capita, etc.).

In Poland, problem areas are most often considered to be areas characterised by a low level of economic development, showing poor development dynamics and characterised by negative social effects of the transformation process. In the EU, problem regions are defined as regions with a low GDP per capita and persistent crisis structures that require the restructuring of the economy. Without government intervention programs, these regions cannot overcome their problems and cannot generate sufficient funds for development on their own. Their chances for development derive from:

- the ability to use their own economic potential and to create income opportunities (apart from agriculture and forestry),
- their connection to the cross-regional (supra-regional) network of technical infrastructure,
- the improvement of a nearby supply of services (hospitals, schools, shops, offices),
- the care and restoration of natural advantages of the environment and their good usage.

The problem region is characterised by specific geographical, economical and cultural features. The geographical features are:

- few means of transport of the residents,
- high absolute and relative access costs (of getting into and out of that area),
- weak status in the local transport network,

DOI: 10.34659/eis.2022.83.4.508

- difficult access to other problem matters,
- peripherality,
- lack of natural resources.

The economical features are:

- raw material production,
- uncomplicated production system,
- lack of entrepreneurial attitudes,
- export of labor,
- import of final goods,
- predominance of traditional sectors of business (mainly agriculture) with little added value per employee,
- low income of households and the public sector (weak tax base),
- poor infrastructure,
- low qualifications of the population (including the elite), mainly due to the long-term migration outflow of the most ambitious and educated people,
- low organisational culture resulting from the underdevelopment of public institutions or low investment attractiveness.

Cultural features are:

- the need to bear the consequences of other social models,
- using symbols created outside the region.

In rural areas, the phenomenon of social marginalisation is increasing. This phenomenon is related not only with the process of exclusion, but also with adapting to life in marginal conditions. The main cause of marginalisation lies in the set of phenomena that make up the deactivation process, which causes a withdrawal to the basic dimensions of existence, to self-limitation, to living on benefits and pensions, to looking for sources of income in activities typical of the pre-agricultural era, i.e. gathering, fishing and hunting as well as theft. In the mental sphere, such an attitude may lead to the phenomenon of "self-taught" or "unconsciously acquired" helplessness. In the social sphere, this disintegrates rural communities and the occurrence of social pathologies. Therefore, rural areas can be classified as problem areas.

Economic capital includes everything that is traditionally understood as capital (resources produced that are used to produce other goods and services). This capital includes, for example, machines, tools, buildings, and infrastructure (Józefowicz et al., 2020).

Natural capital includes all forms of the ecosystem and natural resources that contribute to creating social well-being. Thus, apart from the traditionally understood natural resources (such as wood, water, energy and mineral resources), natural capital also includes natural resources that cannot be easily assessed, e.g. biodiversity, or an ecosystem that provides ecological services such as filtering water and air.

DOI: 10.34659/eis.2022.83.4.508

Natural resources used in the production process create specific goods. Their consumption affects the level of social welfare, measured by the general utility. Fully conscious use of the environment does not negate human access to its natural resources. They can be a factor of material production and a source of satisfying various human needs. Broadly understood, social capital is necessary for the proper functioning and development of societies; it is the essential element of the natural environment, next to human capital (Łuszczyk, 2010).

Natural values constitute the conditions defined as development-generating conditions, which affect the possibilities of the region's revival. However, it should be remembered that specific segments of the natural resources create an obstacle in implementing development plans, thus limiting their prospects. Resources have their value, depending on the accessibility to a given area, location, physical properties and development (Józefowicz et al., 2020).

One of the most important issues in the ongoing debate on regional policy is defining the main factors influencing regional development. According to G. Gorzelak (Gorzelak, 2007), the contemporary economy is shaped by three interrelated processes: globalisation, competition and innovation. Permanent competitive advantage is gained by those countries, regions and cities where enterprises capable of creating innovations are concentrated (because innovations create demand on the market). Quantitative factors of location (availability of natural resources, workforce, mass transport infrastructure, etc.) have been replaced by qualitative factors (qualifications, reliable, modern and fast infrastructure, research and development facilities, friendly and efficient public authorities, business support infrastructure, good living conditions and the beauty of the surrounding nature). As it is known, the concept of innovation was first introduced into the world economic literature by J. A. Schumpeter (Schumpeter, 1960), who at the same time formulated the thesis that the motivation and the ability to create, absorb and imitate innovation determines the development of an enterprise to a much greater extent than just mere financial capital of an enterprise and therefore determines its innovation level. Progressive globalisation forces enterprises and national economies to search for ways and solutions to strengthen their innovativeness. This is the main strategic goal for most enterprises, which, as J. Schumpeter proves, comes down to introducing a new product to the market, a new production method, opening a new market, launching a new source of raw materials or semi-finished products, and implementing new organisation or structure in the enterprise. Innovation can therefore be of a technical, economic or organisational nature.

Drucker (1992) sees innovation as "a specific entrepreneurial tool that gives resources new opportunities to create wealth." However, such a tool is not created in a vacuum. It is rarely the result of spontaneous, unorganised

DOI: 10.34659/eis.2022.83.4.508

activities. The source of innovation in enterprises may be the work of their own design offices, laboratories, R&D (Research and Development) works carried out by them, as well as the knowledge of managerial staff and employees who submit their proposals in the form of rationalisation, proposals, design, technological and organisational changes. However, the more complex the undertaking and the more modern the technology, the stronger the need for creating connections and interdisciplinary contacts and efficient organisation enabling partnership cooperation between the enterprise and the institutions surrounding it. However, the constant changeability of the economic reality surrounding us requires a less technical and more social approach to the issue of innovation. This is reflected, inter alia, in the views of Drucker, who believes that innovation should be considered together with the role of the individual person in the production and organisational processes and that innovation should be treated as a specific instrument of entrepreneurship, giving resources new opportunities to create wealth. The link between innovation and entrepreneurship is so strongly emphasised by him that he makes innovation the primary tool and characteristic of entrepreneurial people, enabling them to transform emerging changes into opportunities to start new business activities or to provide new services. Innovation, and Industry 4.0 in particular, is gaining much attention because of its potential impact on humanity, how we will live, work and how economies will function in the future. Available studies indicate that innovation and artificial intelligence (AI) have a substantial impact on achieving sustainable development goals (SDGs), in particular, on reducing poverty in underdeveloped areas (Mhlanga, 2021).

Nowadays, the role of intangible resources of an organisation is increasing, which contributes to the success of the market. Until now, most organisations have focused their activities primarily on material resources, i.e. financial resources, treating intangible resources as not economically measurable components. The constant changes in the organisation's environment, however, contributed to a new perspective on intangible resources. Organisations understood that it was they themselves who influenced the creation of external effects for their entire organisation. Among the intangible resources of an organisation, one can mention, among others, social capital, which is one of the components of intellectual capital, and currently, this subject enjoys a lot of attention from researchers. Despite the great interest in the subject of social capital, there is no single, universally accepted definition of this concept. Many authors dealing with this issue also disagree with the components of social capital. This term is understood both in relation to an individual and to the entire group of people and can also be applied to economic or political, social and cultural relations. Some researchers treat social capital as simply capital, and it is associated with a set of elements enabling its further deve-

DOI: 10.34659/eis.2022.83.4.508

lopment, while others treat it as a resource, i.e. something that can be exhausted.

The concept of social capital was popularised by R. Putman (Putman et al., 1995, p. 258), according to which social capital concerns such features of society and organisation as trust and loyalty, social responsibility, general norms of good social behaviour that can increase the efficiency of society by facilitating coordinated actions: "Like other forms of capital, social capital is productive because it enables the achievement of certain goals that would not be possible to achieve without it". Nahapiet and Ghoshal (1988) interpret social capital as "the sum of current and potential resources involved in the available (and obtained through them) networks of ties possessed by individuals and as well as by the social unit." In the modern economy, the market mechanism is supported by social capital, which is treated as a co-determining factor in economic development, determining the ability to compete and innovate at the micro- and macro-economic levels (Wildowicz-Giegiel, 2008). The social capital of civic communities, characterised by high levels of mutual trust, norms of commitment to the public good and a dense network of public associations, promotes economic growth (Pachura & Kozak, 2006). It is a factor that determines the differential level of wealth of societies under conditions of the same or similar development potential.

As argued by Wolfe and Nelles, social capital is a key factor in the success of many rapidly growing clusters and economies. Social capital, which they also call "civic capital", grows out of the intense interaction of key local individuals, sustaining cluster social dynamics of groups of people centred around that person. Local communities characterised by this level of integration can formulate strategies that change the trajectory of regional economic development. The initiation of this process depends on the ability to cooperate and the ability to cross boundaries, both geographic and social boundaries. This level of community-economy relationship brings lasting benefits and supports effective cluster development (Wolfe & Nelles, 2008, p. 374).

An analysis of selected definitions of social capital shows that this concept is an extension of human capital. This is because its scope includes human resources and the network of connections between them. Among the important elements of social capital are competence (knowledge, skills, experience), norms, commitment, networks, trust, the community and reciprocity of actions. Accordingly, social capital is defined as competencies and shared social norms, including trust and commitment, which, thanks to the network of connections, contribute to the achievement by the organisation or economy of measurable benefits in the form of profit or increased competitiveness. Among contemporary development factors, governance and cultural endowment are increasingly attracting attention in addition to those factors mentioned above.

DOI: 10.34659/eis.2022.83.4.508

It is assumed that new methods of governance are characterised by one of the following features (Kolarska-Bobinska, 2009):

1. Non-hierarchical management method, deviating from the command instruments in favour of incentives, encourages voluntary cooperation.
2. We are introducing the mechanisms of social participation to the practice of carrying out tasks.
3. We are striving for greater transparency and openness in administration and a better flow of information between society and the administration.
4. The high degree of computerisation. Without this element, one cannot talk about the formation of a knowledge-based economy and full empowerment of regions and the creation of new elements of the modern economy from them, which significantly affect contemporary socio-economic life (Korenik & Mempel-Śnieżyk, 2006, pp. 343-344).

In the World Bank's "Monitoring Environmental Progress Report" (World Bank, 1995), we find an attempt to estimate the sources of world wealth in the context of three types of capital: (natural, economic and human – the latter includes social and human capital in the sense of the four capitals model). According to this source, 20% of the world's wealth goes to Natural Capital, 16% to Produced Assets, and the rest, 64%, to Human Resources. So, as you can see from the example above, people and their abilities are the most important resource and the basis for the functioning of the economy.

Research methods

The research concept assumes the delimitation of problem areas based on contemporary factors of regional development – the model of the five capitals. The basic assumption of the model of this study was the gradability of the analysis of the effects. The study was multidimensional and multi-stage, as shown in Figure 1. Since modern human and social capital is decisive for development, actions should be taken to support and develop the capital mentioned above. Considering this, several recommendations relating to the analysed issue are formulated below.

Effective creation of development potential requires that problem areas be designated based on the contemporary development paradigm. This means that the main criteria for delimiting them should be innovative, human and social capital. An additional criterion is a natural and economic capital.

In practice so far, problem areas have been designated based on the effects (ex-post), i.e. the assigned scope of the intervention should concern the effects, e.g. low GDP, high unemployment, etc., based on the causes (ex ante) of their formation and determination of cause-effect relationships. Therefore, to properly target public interventions, regional and local systems

DOI: 10.34659/eis.2022.83.4.508

should be diagnosed in terms of innovation, human and social capital, and natural and economic capital.

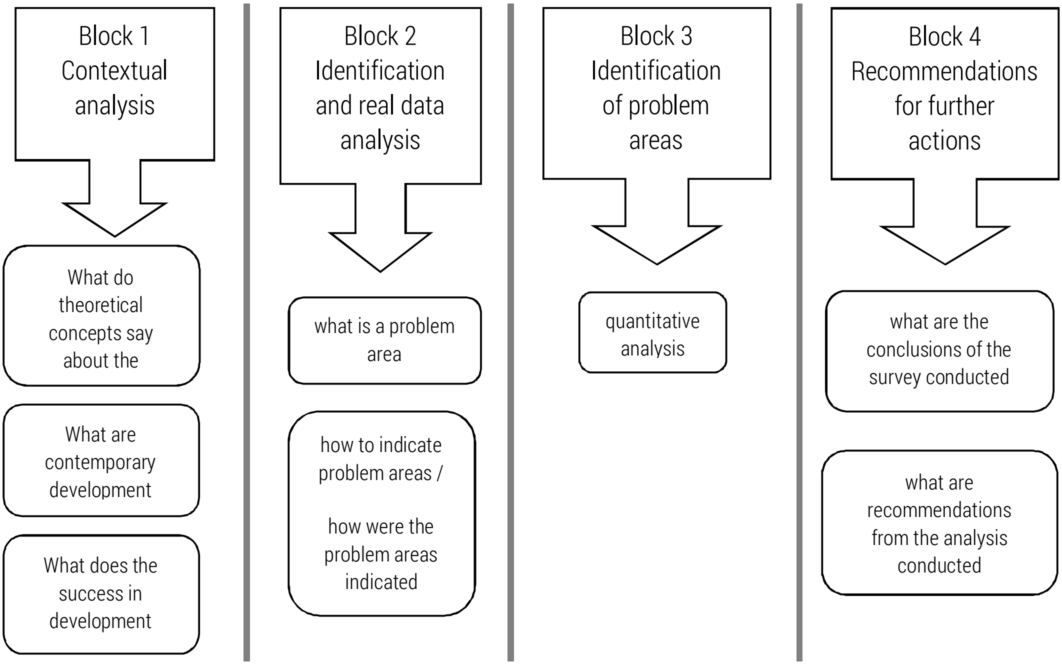

Figure 1. Phases of research

Additionally, when delimiting problem areas, quantitative-secondary research was supplemented with primary-qualitative research, as shown in Table 1.

Table 1. Linking research questions with the modules present in the quantitative and qualitative research

No.	Module	Research Question
1	Economic Capital	How do the respondents assess the areas that make up the development of the economy in the area managed by a given local government unit? Which areas require special improvement / attention on the part of the voivodeship self-government / central authority?
2	Social Capital	How do the respondents assess the areas that make up the development of social capital in the area managed by a given local government unit? Which areas require special improvement / attention on the part of the voivodeship self-government / central authority?

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No.	Module	Research Question
3	Human Capital	How do the respondents assess the areas that contribute to the development of human capital in the area managed by a given local government unit? Which areas require special improvement / attention on the part of the voivodeship self-government / central authority?
4	Natural Capital	How do the respondents assess the areas that make up the development of natural capital in the area managed by a given local government unit?Which areas require special improvement / attention on the part of the voivodeship self-government / central authority?
5	Innovative Capital	How do the respondents assess the areas that make up the development of innovative capital in the area managed by a given local government unit?Which areas require special improvement / attention on the part of the voivodeship self-government / central authority?

The research was carried out in accordance with the adopted scope of the subject. Three techniques were used:

- DESK RESEARCH (analysis of existing data).
- CATI/CAWI (telephone interviews / Internet survey).
- ITI (telephone in-depth interviews).

The use of triangulation allowed to obtain exhaustive research material, which allowed for a thorough analysis of the scope of the subject research by capturing various aspects of the subject matter. The strengths of each method were used while neutralising their weaknesses. Consequently, both quantitative and qualitative techniques were used in the data collection process. In this way, empirical material was obtained, which contributed not only to static data analysis, but also to the possibility of collecting explanatory information.

For the purposes of this study, the desk research analysis included a statistical analysis (grouping of communes, counties – on the basis of publicly available CSO data, the grouping of 3 counties with the smallest and the greatest development perspective and 10 communes with the smallest and greatest development perspective). Depending on the availability of CSO data, the analysis covered the level of countiess and/or communes of the West Pomeranian Voivodeship (Poland, EU):

Economic capital

- The share of the registered unemployed in the working-age population (data for 2019).
- Entities entered in the REGON register (i.e. National Business Registry Number in Poland) for 10,000 population (data for 2016).
- Investment outlays in enterprises in PKD (Polish Classification of Business Activities, meaning what type of business it is, e.g. production, trade, education, etc.) 2007 (data for 2018).

DOI: 10.34659/eis.2022.83.4.508

- Built-up and urbanised land, communication areas, and roads [ha] (data for 2014).
- Income to the budget of local government units (data for 2019).

Human capital

- The population at post-working age per 100 persons at working age (demographic burden, data for 2016).
- The population at post-working age per 100 people in pre-working age (demographic burden, data for 2016).
- Number of children aged 3-5 covered by preschool education per 1 thousand total children (data for 2018).
- The natural increase of all inhabitants (data for 2019).
- The share of the long-term unemployed, i.e. registered by the duration of unemployment – for a period of over 12 months (data for 2019).
- Higher education – (data for 2011).
- Secondary education – (data for 2011).
- Vocational education – (data for 2011).
- Primary education – (data for 2011).
- Quality of education / maturnity exam pass rate in general for secondary schools [%] – (data for 2016).
- Quality of education / maturnity exam pass rate in upper secondary vocational schools [%] – (data for 2016).
- Percentage of children aged 3-5 covered by preschool education – (data for 2018).

Social capital

- Number of foundations, associations and social organisations per 10 thousand.
- Inhabitants (data for 2017).
- Election turnout – local elections in 2018 – voivodship assemblies.
- Election turnout – 2018 local elections – poviat councils.
- Election turnout – local elections in 2018 – municipal and city councils.
- Election turnout – local elections in 2018 – meirs, mayors, village leaders (1st round of elections).

Natural capital

- Forest area – forest cover in % (level: counties, communes; data for the year: 2019).
- Area of legally protected areas (level: counties, communes; data for the year: 2019).

DOI: 10.34659/eis.2022.83.4.508

Innovative capital

- Investment outlays in enterprises (counties; data for the year 2018).
- Financing and co-financing of EU programs and projects (communes; data for the year 2019).

The interviews were conducted using the CAWI technique (Computer-Assisted Web Interview). CAWI is a face-to-face interview technique conducted over the Internet. The respondent receives a message via e-mail with a link to complete the questionnaire, in which he is asked to complete the questionnaire himself. To increase efficiency, a telephone reminder will be used to remind you about the test.

If the respondents did not answer to other forms of an interview, the CATI (Computer Assisted Telephone Interview) technique was implemented. It is a quantitative research technique that uses the work of interviewers contacting respondents by phone. During the contact, the interviewer reads out to the respondent the questions included in the electronic version of the questionnaire, including the answers.

As part of the study, 131 interviews were carried out, including 113 interviews with representatives of communes (mayor, commune head or a person directly indicated by him) and 18 interviews with representatives of counties (the starost/district governor or a person directly indicated by him). It was assumed that representatives of individual communes, cities and counties taking part in the survey will undertake to evaluate the individual factors that contribute to the development of economic, social, natural and innovative capital. Then, they will present the areas that, in their opinion, require special improvement and attention from the voivodeship self-government or the central government. As a result of the research, it turned out that it was not possible to reach all units within the prescribed period. The table below shows the assumed structure of the sample and the completed sample.

Table 2. The assumed sample structure vs. Realized sample in the CAWI / CATI survey

Group of respondents	Established sample structure	Realized attempt
Municipalities	113	103
Counties	18	14

Individual in-depth interviews are one of the basic methods of qualitative research, consisting in a detailed, in-depth conversation with the respondent. The interviews were conducted based on a standardised scenario.

DOI: 10.34659/eis.2022.83.4.508

The aim of the study using the technique of individual interviews was to obtain the precise information and to expand knowledge related to the topic. The basis for the interpretation of the results is an in-depth analysis of the information obtained in the series of interviews.

The adopted research methodology provided for the implementation of in-depth interviews with the use of targeted selection with representatives of communes with the highest and the lowest development potential (areas of growth and stagnation). Within each capital, 4 interviews were carried out (n = 3 in communes with the lowest development potential and n = 1 in communes with the highest development potential).

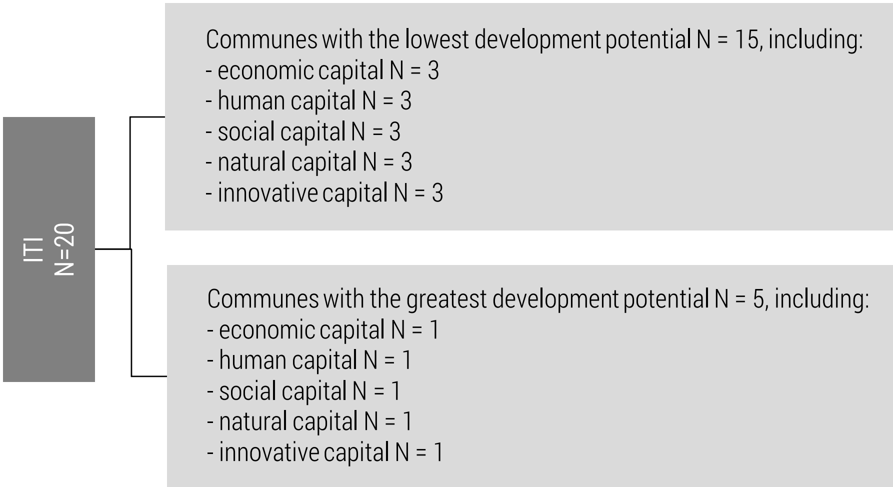

Figure 2. The structure of the realised sample in the ITI survey

Supplementing the secondary quantitative research with qualitative-primary research allowed for a more complete analysis of the causes of the low development potential of the studied area and the diagnosis of the sources of the "problematic area".

Correct diagnosis of the causes of a low level of development will allow for the proper use of impact tools as well as effective and efficient public policies.

According to the administrative division currently in force in Poland, the West Pomeranian Voivodeship consists of 113 communes.

After determining the order of communes in a given criterion, from 1 to 113 points were awarded in each of the 5 areas. In total, 452 points could be obtained (in points A to D). On this basis, a collective list of communes with the largest and the smallest development potential was prepared.

Table 3. Development potential of communes – economic capital

Communes with the greatest development potential	Communes with the lowest development potential
Szczecin (urban commune)	Brzeżno (rural commune)
Goleniów (urban-rural commune)	Dobra (urban-rural commune)
Gryfino (urban-rural commune)	Krzęcin (rural commune)
Koszalin (urban commune)	Białogard (rural commune)
Stargard (urban commune)	Świdwin (rural commune)
Wałcz (urban commune)	Radowo Małe (rural commune)
Kołobrzeg (urban commune)	Rąbino (rural commune)
Gryfice (urban-rural commune)	Szczecinek (rural commune)
Myślibórz (urban-rural commune)	Sławoborze (rural commune)
Dobra (Szczecińska) (rural commune)	Świerzno (rural commune)

After determining the order of communes in a given criterion, from 1 to 113 points were awarded in each of the 5 areas. In total, 452 points could be obtained (in points A to D). On this basis, a collective list of communes with the largest and the smallest development potential was prepared.

Table 4. Development potential of communes – human capital

Communes with the greatest development potential	Communes with the lowest development potential
Koszalin (urban commune)	Szczecinek (rural commune)
Stargard (urban commune)	Białogard (rural commune)
Szczecinek (urban commune)	Darłowo (urban commune)
Kołobrzeg (urban commune)	Stargard (rural commune)
Sławno (urban commune)	Marianowo (rural commune)
Wałcz (urban commune)	Wałcz (rural commune)
Międzyzdroje (urban-rural commune)	Sławno (rural commune)
Białogard (urban commune)	Świdwin (rural commune)
Darłowo (rural commune)	Stara Dąbrowa (rural commune)
Dziwnów (urban-rural commune)	Kołobrzeg (rural commune)

The analysis of social capital did not take into account the turnout in the local government elections for the functions of president, mayor and commune head in the second round during the 2018 elections. In the territory of the West Pomeranian Voivodeship, there were communes where the second round of elections was not necessary (the head of the commune, mayor, and

DOI: 10.34659/eis.2022.83.4.508

president were elected already in the first round), therefore only the results of the voter turnout in the first round were taken into account to make the analysis more consistent.

After determining the order of communes in a given criterion, from 1 to 113 points were awarded in each of the 5 areas. In total, it was possible to get 565 points (in points A to E). On this basis, a collective list of communes with the largest and the smallest development potential was prepared.

Table 5. Development potential of communes – social capital

Communes with the greatest development potential	Communes with the lowest development potential
Nowe Warpno (urban-rural commune)	Rymań (rural commune)
Ustronie Morskie (rural commune)	Przybiernów (rural commune)
Kobylanka (rural commune)	Suchań (urban-rural commune)
Rewal (rural commune)	Siemyśl (rural commune)
Cedynia (urban-rural commune)	Stepnica (urban-rural commune)
Mielno (urban-rural commune)	Dolice (rural commune)
Stare Czarnowo (rural commune)	Resko (urban-rural commune)
Trzcińsko-Zdrój (urban-rural commune)	Dobrzany (urban-rural commune)
Dobra (Szczecińska) (rural commune)	Dygowo (rural commune)
Postomino (rural commune)	Banie(rural commune)

Table 6. Development potential of communes – natural capital

Communes with the greatest development potential	Communes with the lowest development potential
Człopa (urban-rural commune)	Warnice (rural commune)
Drawno (urban-rural commune)	Stargard (rural commune)
Manowo (rural commune)	Pyrzyce (urban-rural commune)
Wierzchowo (rural commune)	Sławno (rural commune)
Mirosławiec (urban-rural commune)	Darłowo (urban commune)
Kalisz Pomorski (urban-rural commune)	Kołobrzeg (rural commune)
Borne Sulinowo (urban-rural commune)	Kołbaskowo (rural commune)
Tychowo (urban-rural commune)	Przelewice (rural commune)
Przybiernów (rural commune)	Bielice (rural commune)
Kobylanka (rural commune)	Świdwin (rural commune)

DOI: 10.34659/eis.2022.83.4.508

During the analysis of natural capital, the forest area was taken into account – forest cover in % (data for 2019).

After determining the order of municipalities, 1 to 113 points were awarded in this area. In total, 113 points could be obtained in the entire area. On this basis, a collective list of communes with the largest and the smallest development potential was prepared.

During the analysis of innovative capital, the financing and co-financing of EU programs and projects were taken into account (data for 2019). After determining the order of communes in a given criterion, from 1 to 113 points were awarded. In total, 113 points could be obtained

in this area. On this basis, a collective list of communes with the largest and the smallest development potential was prepared.

Table 7. Development potential of communes – innovative capital

Communes with the greatest development potential	Communes with the lowest development potential
Kołobrzeg (urban commune)	Świnoujście (urban commune)
Myślibórz (urban-rural commune)	Nowe Warpno (urban-rural commune)
Gryfino (urban-rural commune)	Bielice(rural commune)
Szczecinek (urban commune)	Postomino (rural commune)
Darłowo (urban commune)	Mieszkowice (urban-rural commune)
Koszalin (urban commune)	Polanów (urban-rural commune)
Widuchowa (rural commune)	Tuczno (urban-rural commune)
Tychowo (urban-rural commune)	Marianowo (rural commune)
Karlino (urban-rural commune)	Białogard (rural commune)
Drawsko Pomorskie (urban-rural commune)	Rymań (rural commune)

On the basis of the above lists of communes in each of the areas, a collective analysis was made. 5 capitals were analysed: economic, human, social, natural and innovative capital, in 15 areas in total. In each of the areas, 113 to 1 points were awarded (as shown in tables 3 to 7). In the collective summary, each commune could obtain a maximum of 1695 points and a minimum of 15 points.

DOI: 10.34659/eis.2022.83.4.508

Results of the research

Based on the information collected as a result of the methodology used, Table 8 presents the development potential of the analysed communes of the West Pomeranian Voivodship. There is the ranking of communes with the highest and the lowest development potential, along with the total number of points obtained.

Table 8. Development potential of communes – in total (including economic, human, social, natural and innovative capital)

Communes with the greatest development potential	Number of points	Communes with the lowest development potential	Number of points
1.Szczecinek (urban commune)	1349	1.Białogard(rural commune)	353
2.Koszalin (urban commune)	1340	2.Szczecinek (rural commune)	414
3.Wałcz (urban commune)	1296	3.Dolice (rural commune)	430
4.Kobylanka (rural commune)	1265	4.Pełczyce (rural commune)	430
5.Rewal (rural commune)	1252	5.Stargard (rural commune)	434
6.Kołobrzeg (urban commune)	1236	6.Rąbino (rural commune)	438
7.Ustronie Morskie (rural commune)	1226	7.Suchań (urban-rural commune)	447
8.Stargard (urban commune)	1201	8.Siemyśl (rural commune)	458
9.Gryfice (urban-rural commune)	1167	9.Sławno (rural commune)	459
10.Dobra (Szczecińska) (rural commune)	1164	10.Stepnica (urban-rural commune)	472

Figure 3 shows the average score of all capitals (economic, human, social, environmental and innovative). The communes with the lowest development potential, identified at the Desk Research stage, were taken into account. Among the communes with the lowest development potential in the voivodship, only one commune (rural commune – Szczecinek) was rated above the average (3.2).

DOI: 10.34659/eis.2022.83.4.508

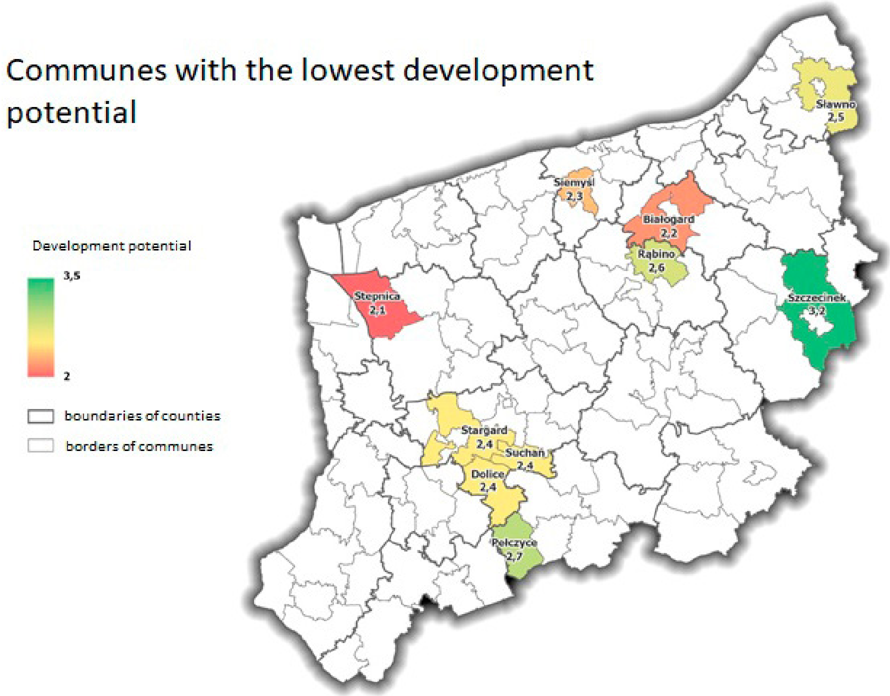

Figure 3. Assessment of the development potential of communes with the lowest development potential. The communes with the lowest development potential, identified at the Desk Research stage, were taken into account. The presented average score includes the assessment of all capitals (economic, human, social, natural, innovative)

Conclusions

The model of five capitals used to designate problem areas assumes that sustainable development (i.e. meeting human needs and aspirations) takes place thanks to various services provided by human, economical, innovative, social and natural capital. Satisfying people's needs and increasing the quality of life can be seen as an increase in social welfare or utility (through consumption, satisfactory work, good health, satisfactory interpersonal relationships and well-functioning social institutions, and ensuring access to the full range of resources and services provided by the natural environment). Maintaining the sustainability of development requires that the capital resources, thanks to which human needs are met and the quality of life increases, be kept at a constant level or increase over time. The use of the five capitals model allows us to structure the analysis of the local system easily. A particularly useful feature of the model is the ease of identifying development con-

DOI: 10.34659/eis.2022.83.4.508

tradictions between individual capitals. Clear capture of development contradictions (trade-offs) is particularly important in the context of the sustainability of the development of a given system. The use of the model for strategic planning makes it possible to minimise the risk of development contradictions in the future, and is also an analytical tool that can help minimise the negative effects of existing contradictions. The model of five capitals allows for a clear presentation of the dynamics of a given system, capturing the most important relationships and indicating the most serious threats to the stability and durability of the development of a given system. Additionally, by using methods such as stakeholder surveys, we can obtain a good starting point for the strategic planning process. It should be emphasised that the method presented in this article, based on the example of the local system, has also proven to be successful at the regional level (for the evaluation of the region's development strategy, the regional spatial development plan and the regional operational program) and as such can be used for various ex-ante evaluations. The proposed method of determining the level of socio-economic development of communes can also be used to determine development paths and changes in their trends for individual local government units and thus more precisely indicate potential areas and types of needed interventions supporting development. Nowadays, the problem area should be determined and defined based on the causes (ex ante) of their occurrence and the determination of cause-effect relationships. Therefore, to appropriately target public interventions, regional and local systems should be diagnosed in terms of innovation, human and social capital, and natural and economic capital.

The conducted primary and secondary studies indicate that:

1. Problem areas are still stuck in the old paradigm of development, in which development is seen in hard factors, i.e. in the technical infrastructure (water supply, sewage, roads, shop areas, etc.), and this in turn translates into decisions made and directions of spending financial resources.
2. Little importance in developing soft factors such as leadership, cooperation, social participation, quality of education.
3. The level of financing and co-financing of innovative programs is low and basically comes down to the purchase of modern equipment by individual farmers and the expansion of the scope of crops.
4. Despite the fact that communes in problem areas are leaders in obtaining external funds, this does not translate into an improvement into their economic situation. This is probably due to the privileged nature of these areas in acquiring funds on the one hand, and spending directions on the other hand. Acquiring financial resources becomes the goal of governing, not a tool to improve the socio-economic situation of a problem area.

DOI: 10.34659/eis.2022.83.4.508

5. According to the contemporary development paradigm, the socio-economic situation of an area is influenced by qualitative factors (quality of social and human capital).
6. Therefore, a problem area should be delineated and defined on the basis of causes (ex ante): a problem area is an area characterised by a low level/quality of human and social capital.
7. Therefore, problem areas in strategic documents should be delimited on the basis of human and social capital.
8. Territorial development is (to a small extent) determined by exogenous factors, while the main factors influencing the potential of local development are human and social capital, and later natural resources, infrastructure, etc.
9. Since innovative, human and social capital determines development today, actions should be taken to support and develop the above-mentioned capitals.

The proposed method of determining problem areas, describing the level of socio-economic development using the five capitals model, is part of the research on the delimitation of functional areas, areas of strategic intervention and problem areas, success or broadly understood regional development (e.g. Tomczak et al., 2021; Śleszyński et al., 2017; Stanny et al., 2018).

Acknowledgements

This publication is based on the research entitled "Qualitative factors of regional development as the basis for delimiting problem areas" – part one – conducting quantitative and qualitative research, financed by RID (Regional Excellence Initiative).

The research was carried out as part of research work no. WZ/WB-IIL/4/2020.

The contribution of the authors

Beata Skubiak – 70%.

Mirosław Broniewicz – 30%.

DOI: 10.34659/eis.2022.83.4.508

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DOI: 10.34659/eis.2022.83.4.508

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SOCIAL ATTITUDES TOWARDS ELECTRONIC WASTE AND THE IMPLEMENTATION OF CIRCULAR ECONOMY PRINCIPLES

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ABSTRACT: This article addresses the issue of electro-waste and the role of the consumer of electrical and electronic equipment within the organisation of a circular economy. The aim of the article is (i) to identify the attitudes of the consumers surveyed towards unused electrical and electronic equipment, (ii) to assess the consistency of the attitudes displayed with the principles of the circular economy, and (iii) to identify the most important factors influencing these attitudes. The theoretical part approaches issues such as consumers' subjective perception of electro-waste, the increasing amount of electro-waste globally, and the problems associated with limited recycling opportunities. The conducted study revealed the potential of the surveyed consumers for the organisation of the circular economy in the field of electro-waste management, as well as the risk factors in the form of depositing electro-waste into the municipal waste stream. The analysis also showed a correlation between attitudes towards electro-waste with factors such as age, gender and education. In the concluding part, the most underlying consumer problems related to electro-waste management were systematised; more thorough research was also signalled.

KEYWORDS: circular economy, e-waste, consumer behaviour

 DOI: 10.34659/eis.2022.83.4.531 JEL: O13, Q53

Introduction

One of the biggest challenges in building a sustainable economy is reducing environmental impact. This impact is linked to resource extraction on the one hand and the need to dispose of waste on the other. The linear model of production and consumption, based on the pathway from raw material to waste, has generated an entire spectrum of negative environmental effects (Korhonen et al., 2018; Hanumante et al., 2019; Puntillo et al., 2021). The widely observed accumulation of waste in the environment demonstrates the inefficiency of waste management systems. These systems are becoming increasingly inefficient in the face of the ever-increasing waste stream volume, which is an inevitable consequence of the linear model of production and consumption (Jørgensen & Pedersen, 2018). Escalating the capacity of waste management systems – while desirable – can only bring temporary improvements. The solution to this dilemma is seen in the development of the circular economy, which is an alternative production and consumption model (Corona et al., 2019; Camilleri, 2020). This model emphasises changes in design and production processes (den Hollander et al., 2017; Talens Peiró et al., 2017), as well as in the realm of consumer attitudes (Hazen et al., 2017; Romero-Hernandez & Romero, 2018). These attitudes may show variability depending on socio-economic factors. This issue becomes particularly relevant for products with a high environmental footprint, which includes electrical and electronic appliances. The production and disposal of such products are also strongly related to the issues of energy consumption and greenhouse gas emissions (Zu et al., 2012). Reducing the negative environmental impact of these products depends primarily on the attitudes of their users. This article aims to verify how Polish consumers manage electrical and electronic equipment, identify the most critical factors influencing this process, and assess its consistency with the assumptions of a circular economy. The research method included the analysis of literature and empirical research. The literature analysis focused on publications focusing on the issues of circular economy or e-waste. The empirical part focuses on analysing data obtained from a survey conducted among Polish consumers.

This topic is particularly important in the case of countries where organised methods of e-waste management have been introduced relatively recently (for example, in Poland). The present research's particular importance is related to the recognition of the degree of consumer adoption of modern forms of dealing with electro-waste (such as the use of specialised collection points). An essential part of the research is also the assessment of the consolidation of habits developed in the absence of an organised waste management system. Some of these habits are unsustainable (for example,

DOI: 10.34659/eis.2022.83.4.531

throwing electrical waste into municipal waste). Other habits, on the other hand, may have a decidedly positive impact on the environment (for example, repairing broken appliances). The widespread occurrence of such attitudes may become an unexpected advantage for Polish consumers and be an essential element in implementing the circular economy model. In this context, the article raises the relatively poorly researched issue of social determinants of implementing the circular economy in post-socialist countries. Identifying such conditions can contribute to developing a well-adjusted, and thus effective, circular economy implementation strategy (Gradinaru & Maricut, 2022). Implementing the circular economy by the EU Member States will bring closer the achievement of EU strategic goals, such as reducing the volume of unmanaged waste, reducing dependence on imported raw materials and implementing climate policy (Tomić & Schneider, 2020).

Literature overview

Any device which, for various reasons, has lost its usefulness (Elektro-Eko, 2022) is classified as electronic waste (e-waste/electro-waste). The reasons for classifying a device as electro-waste are varied. The most common reasons include the following:

- physical damage, precluding the possibility of repair and making further operation completely impossible,
- physical damage that is potentially repairable but not economically viable (for example, when the cost of repair exceeds the price of a new device),
- partial damage, causing loss of part of the appliance's functionality or inconvenience in its use (for instance, difficult switching on and off),
- the presence of visible, natural traces of wear and tear (scratches and scrapes on the surface, cracks and splinters, losses) that reduce the aesthetic value of the product,
- loss of functionality as a result of technological change (e.g., media players withdrawn from the market by manufacturers, TV not adapted to new transmission standards),
- a desire for enhanced functionality that is only available in new equipment (for example, software that is incompatible with older generation equipment),
- too high level of energy consumption compared to new equipment,
- lack of availability of necessary consumables necessary for the continued use of the equipment (for example, printer cartridges),
- lack of availability of necessary spare parts necessary for the continued use of the appliance (e.g. charger suitable for a particular type of socket, filters adapted to a particular household appliance).

DOI: 10.34659/eis.2022.83.4.531

The variety of reasons for discontinuing the use of appliances, along with the increasing number of appliances being equipped in households, results in an ever-growing volume of electro-waste. In 2019, the volume of electro-waste generated globally reached 53.6 million metric tonnes, and the level projected for 2030 was expected to be close to 75.0 million metric tonnes (Forti et al., 2020).

Electro-waste falls into the hazardous waste category, requiring a unique approach from waste management systems. Such an approach is necessary due to the presence of heavy metals such as zinc, cadmium, nickel and mercury (Shuptar-Poryvaieva et al., 2020), as well as chlorofluorocarbons, hydrochlorofluorocarbons and brominated flame retardants as well as other substances with an irritant, toxic and carcinogenic effects (Chakrabaty & Nandi, 2021; Santato & Alarco, 2022). On the other hand, electro-waste also contains many valuable raw materials, most notably precious metals and Rare Earth Elements (REE) (Pitron, 2019; Althaf et al., 2021). Moreover, other raw materials such as copper and steel are present in this type of waste, the recovery of which is mainly determined by economic factors (the cost of the resources required to separate and purify them). Plastics – serving as housing components and insulation material – are also a significant part of electro-waste. Due to their complex chemical composition, these plastics can release a number of substances hazardous to health and the environment (Lam et al., 2012). Physical fragmentation of such plastics, leading to the formation of microplastics, is also a growing problem (Jung et al., 2022). The inability to physically reprocess and use this type of substance is one of the critical arguments regarding the possibility of fully implementing the circular economy principles (Cullen, 2017; Moreau et al., 2017).

Waste management in a circular economy is defined by a set of general principles. These principles, sometimes referred to as strategies, describe a hierarchy of actions to be taken for efficient waste management. This hierarchy is defined with varying degrees of precision. It can take the form of nine principles (Potting et al., 2017), although the most commonly cited hierarchy consists of three core activities: reduce, reuse and recycle (Goyal et al., 2018; Li, 2012).

Reduction in the case of electro-waste refers to any activity aimed at eliminating the need to purchase a new device. This should primarily include the repair of broken devices but also the abandonment of the purchase of products deemed to be actually unnecessary. This activity is, however, relatively demanding on the user of the appliance. Here, it becomes necessary to use technical knowledge and skills or to make use of specialised maintenance services. In the first case, in addition to the necessary skills, the user must have the necessary tools, a place to carry out the repair (problematic in the case of small-scale housing conditions), as well as free time and readiness to

DOI: 10.34659/eis.2022.83.4.531

spend it on repairing the device. If a repair service is used, the cost of the service and transport have to be taken into account.

Reuse is the disposal of an unused appliance. A distinction can be made between the situation where the item is given away free of charge (usually to family or friends) and where it is offered for sale. Activities focused on extending the product lifespan are the basic mechanisms for reducing environmental impact in the circular economy model (Xavier et al., 2021). In cases where reuse is no longer possible (either because the item is completely unusable or because it is not possible to find people interested in owning it), the product is passed on for reprocessing/recycling.

The first step in this process is the transfer of e-waste to specialised collection points. These collection points can be public facilities (managed by local governments) or private, functioning as part of reverse supply chains (Sasikumar & Kannan, 2008).

For all the activities described, the device's size is an important factor. The classification of electro-waste in this respect is set out in Directive (2012) and includes:

- bulky waste, with dimensions exceeding 50 cm (for example, large household appliances, large power tools, vending machines and others),
- small volume waste, not exceeding 50 cm (for example, small household appliances, smaller power tools, toys and others),
- small-sized waste of IT and telecommunications equipment with dimensions not exceeding 50 cm,
- heating and cooling equipment,
- lamps,
- devices with screens larger than 100 cm^2.

The most problematic electro-waste is bulky waste, the transport of which is usually beyond the capacity of the individual consumer. On the one hand, this situation provides an incentive to undertake on-site repairs, while on the other, it contributes to the phenomenon of long-term storage of unused equipment. The problems associated with small-scale electro-waste are related, by contrast to the previous case, to its ease of handling. This results in infiltration into the municipal waste stream and consequent diversion to incineration or landfill. In industrialised countries, the scale of this phenomenon is estimated at 8% of the total volume of electro-waste generated, and this type of waste is also found in segregated waste such as plastic and metal (Forti et al., 2020).

DOI: 10.34659/eis.2022.83.4.531

Research Methodology

The data used in the study has been obtained in the project "The role of social capital in the strategy of sustainable development of highly urbanised and industrialised regions on the example of the Silesian Province." The study was conducted in several stages.

In the first stage, a survey was conducted on a group of 300 adult consumers from the Silesian Voivodeship. A specialised research centre surveyed respondents from its panel. As a result, 300 completely completed questionnaires were obtained (although some of the respondents refused to specify their monthly income). The demographic profile of the study group is presented in Table 1.

Table 1. Socio-economic profile of respondents

gender	women	55.0%
	men	45.0%
age	18-25	25.0%
	26-39	33.0%
	40-65	25.0%
	66 and above	17.0%
education level	basic	6.7%
	lower secondary	0.7%
	vocational	13.0%
	secondary	30.3%
	post-secondary	6.3%
	bachelor/engineer	13.3%
	higher	29.7%
place of residence	house	43.0%
	flat	57.0%
monthly income	less than PLN 1000	6.3%
	PLN 1000-1999	12.7%
	PLN 2000-2999	27.3%
	PLN 3000-3999	11.6%
	PLN 4000-4999	3.0%
	PLN 5000 and above	12.0%
	no income	12.0%
	refuse to answer	15.1%

DOI: 10.34659/eis.2022.83.4.531

In the second stage, the data obtained were narrowed down to variables relating to handling electrical and electronic equipment. The respondents could indicate the following ways of handling unused or damaged equipment:

- disposing of municipal waste,
- disposing into bags or containers for further recycling,
- giving away to other people,
- delivery to collection points,
- repair and continue to use.

The third and final stage of the study was to obtain a statistical picture. For this purpose, the percentages of individual answers and the correlation coefficients between the research and demographic variables were calculated. All calculations were performed using the STATISTICA package.

Results and discussion

In the surveys carried out, the most important issue is to find out what attitudes towards damaged or unused electrical and electronic equipment are manifested by consumers. This is summarised in Figure 1 (the respondents could mark more than one answer).

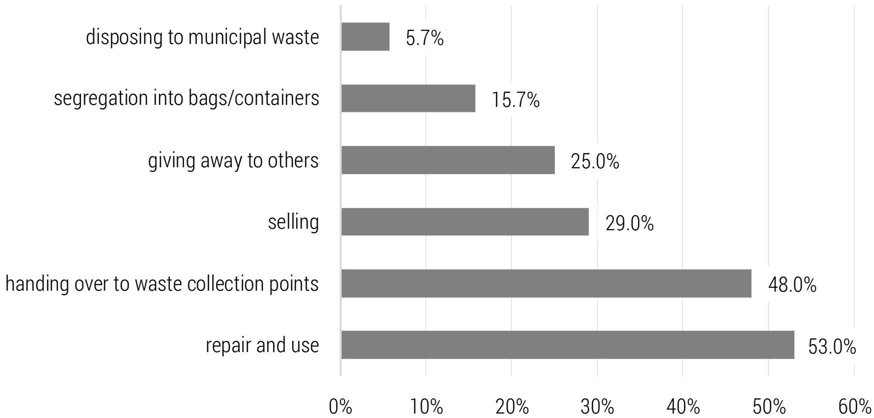

Figure 1. The popularity of attitudes towards unused electrical and electronic equipment

The analysis of the responses shows that the most common attitude, indicated by more than half of the respondents (53%), is repair and continued use. This attitude should be assessed as converging with the principles of circular economy. In the correlation analysis carried out (Table 2), no factors were found that clearly correlated with the declaration of this attitude.

DOI: 10.34659/eis.2022.83.4.531

Table 2. Correlation analysis of user attitudes and socioeconomic factors

	Disposal to municipal waste	Segregation into containers/bags	Giving away to others	Sales	Delivery to collection points (communal or in stores)	Repair and use
Age factors						
18-25	x	x	X	x	0.15	x
26-39	x	0.15	X	x	0.18	x
over 66	x	-0.15	-0.20	-0.21	-0.29	x
Education factors						
Basic	x	x	x	x	-0.18	x
Lower secondary	0.16	x	x	x	x	x
Vocational	x	-0.14	x	x	-0.23	x
Post-secondary	x	x	x	x	0.16	x
Higher	x	x	x	x	0.12	x
Bachelor/Engineer	x	0.13	x	x	0.11	x
Income factors						
Income PLN 3000-3999	x	x	x	x	0.19	x
Income PLN 4000-4999	x	x	0.17	x	x	x
Professional status factors						
Pupil/student	x	X	x	0.27	x	0.13
Farmer	0.16	X	x	x	X	x
Teacher	x	0.14	x	x	X	x
Pensioner/retiree	x	-0.17	-0.22	-0.19	-0.29	x
White collar worker	x	X	x	x	0.18	x
Trade worker	x	X	x	x	0.14	x
Labourer	x	X	x	x	-0.14	x
Manager	x	X	x	x	0.14	x
Business owner	x	X	x	x	-0.13	x
Other profession	x	X	x	-0.15	x	x
Other factors						
Female	x	X	0.12	x	0.24	0.20
Living in flat	x	X	x	x	x	-0.17

x – no correlation, $p<0.05$.

DOI: 10.34659/eis.2022.83.4.531

A positive correlation was found for women (0.20) and pupils and students (0.13). The shape of the survey questionnaire does not allow to determine whether repairs are carried out independently at home or with the use of service points. A negative correlation emerged for residents of townhouses and blocks of flats, which is presumably related to the limited possibilities for repairs in a limited area. It should be added that carrying out repairs at home, without adequate preparation, promotes secondary damage, as well as fragmentation of the appliance, the components of which may then end up in a municipal waste or be used as recyclable materials. In the conducted survey, disposal of whole appliances or their components in this way was declared by 5.7% of respondents for municipal waste and 15.7% for recyclables.

The second most common attitude is the transfer of unused appliances to specialised collection points (43% of responses). In order to correctly assess the consistency of this approach with circular economy principles, it is necessary to distinguish whether the transferred appliances are repairable or whether the owners do not intend to continue using them. Unfortunately, the survey design does not make it possible to distinguish between these situations. As for appliance repairs, the strongest correlation was shown for women (0.24). The other factors correlating positively were secondary and higher education, performing a job related to intellectual work and the younger age of the respondents. The negatively correlating factors were retirement age, primary and vocational education and having an occupation associated with manual work. Among people of retirement age, there is a general trend of not wanting to dispose of electro-waste in any way. This may indicate a lower need to use such appliances or ingrained habits such as keeping faulty or unused appliances for long periods of time to use them in some unspecified way in the future.

The sale and free transfer of electrical and electronic equipment are far less popular attitudes. Both activities are characterised by a similar level of popularity among users (29% of responses for selling and 25% for giving away for free). Another common feature is a negative correlation in the case of people of retirement age. The highest propensity for selling is found among pupils and students and for giving away free of charge among women (0.13).

Conclusions

In light of the research conducted, the degree of compliance of consumers' attitudes using electrical and electronic appliances with the principles of the circular economy should be assessed as relatively good, nevertheless certainly not sufficient. Although the repair of electrical and electronic equip-

DOI: 10.34659/eis.2022.83.4.531

ment for further use is declared by more than half of the respondents, a significant proportion of consumers do not show interest in such activity. The reasons for this approach can be varied: lack of necessary skills, safety concerns during repair and subsequent use, lack of suitable conditions (equipment and premises), negative experiences from previous repairs, lack of technical possibility of repair or its economic unviability. However, determining the impact of individual reasons on consumer attitudes requires more detailed research in this area.

Directing unused equipment to collection points is the second most popular declared attitude. Polish consumers thus have the potential to participate in reverse supply chains, ensuring that electro-waste can be appropriately managed. On the other hand, the source of electro-waste infiltration into municipal and segregated waste was also confirmed. Disposing small-scale electro-waste by throwing it into municipal waste is much simpler than handing it over to a collection point. Reducing this phenomenon will primarily be a challenge in terms of changing awareness. Disseminating information on the dangers of this phenomenon will undoubtedly contribute to reducing it, albeit it is doubtful that it will allow it to be eliminated. Changing attitudes is complicated for people with established habits. In the research carried out, a trace of such conditioning is revealed in the case of some elderly people, who are likely to practice their ways of dealing with electro-waste (such as long-term storage).

Selling, as well as free transferring, are attitudes which are less frequently declared. The likely causes for this are the need to find someone interested in purchasing or receiving a used device. This situation points to the limited possibilities for implementing the so-called sharing economy. This fact proves that not all mechanisms to support the circular economy have equal potential. Product life extension and reverse supply chains are the most favoured mechanisms for electrical and electronic equipment consumers. The development of these mechanisms is primarily the responsibility of enterprises.

Nonetheless, state economic policy is also not insignificant. This policy could provide for stimulus instruments (for instance, in the form of concessions for companies carrying out such initiatives). As a result, it would be possible to develop a consumer-oriented offer in the form of increasing the number of collection points, on-site collection and transport of large appliances, assistance in the disposal of problematic electro-waste (e.g., significant heating and cooling appliances), which could contribute to solving the issue of electro-waste penetrating the environment.

One of the basic principles of the circular economy is the prevention of waste generation. This principle is related to several activities aimed at extending the product's lifespan (such as repairing broken devices or giving

DOI: 10.34659/eis.2022.83.4.531

unused devices to others) but also to all attitudes related to resignation from the purchase and use of the device. While the first group of attitudes was included in the study, attitudes related to resignation were not examined. The future direction of research, in addition to identifying the presence of such an attitude, should also include the determination of related factors. These factors include economic conditions, the level of consumer and environmental awareness, the level of electricity prices and other factors. Another research direction is related to the relative perception of electrical and electronic devices as waste. Again, such a study should determine whether there are socio-economic factors related to the perception of a given device as waste and its discontinuation.

The contribution of the authors

Elżbieta Lorek – 50%.
Paweł Lorek – 50%.

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DOI: 10.34659/eis.2022.83.4.531

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SOCIAL ATTITUDES TOWARDS ELECTRONIC WASTE AND THE IMPLEMENTATION OF CIRCULAR ECONOMY PRINCIPLES

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ABSTRACT: The article aims to evaluate criteria that should be considered when deciding on the adaptive reuse of existing buildings. Reusing a building by means of renovation is in line with the concept of sustainability, as it makes it possible to extend the useful life of a building without incurring significant financial expenses. The concept is related to the theory of the circular economy, which maintains that by designing a system of closed-loop processes – in which waste from one process is used as raw ma-terial for another – the consumption of raw materials, the amount of waste and energy losses can be minimised. The article discusses criteria that local governments, municipalities, architects, and de-signers should consider when deciding whether to reuse a building. The criteria were classified as technical, economic, social, spatial and environmental. To achieve the main objective, we looked into the preferences of current and potential practitioners who might be involved in the adaptive reuse of buildings with regard to the criteria. The most significant criteria were validated using a survey method.

KEYWORDS: adaptive reuse, renovation, buildings, criteria

Introduction

To meet the Paris Agreement commitment, it is essential to decarbonise the building and construction industry, which accounts for 40% of final energy consumption and 36% of energy and process-related CO_2 emissions (Renovation Wave, 2022). Decarbonising the building sector by 2050 is key to achieving these GHG reductions. However, as the 2022 Global State of Buildings report shows, the sector is not making the deep systemic changes necessary to achieve this goal. The energy intensity of the building sector did not improve in 2021, and the growth of renewable energy in buildings remains modest (Towards a Zero-emission, 2022). In 2021, construction activities rebounded back to pre-pandemic levels in most major economies, alongside more energy-intensive use of facilities as workplaces reopened. In addition, more emerging economies increased their use of fossil fuel gases in buildings. As a result, buildings' energy demand grew by around 4 per cent from 2020 to 135 EJ – the most significant increase in the last 10 years. CO_2 emissions from buildings operations have reached an all-time high of around 10 Gt CO_2, around a 5% increase from 2020 and 2% higher than the previous peak in 2019 (Towards a Zero-emission, 2022).

In 2020 the European Commission published its Renovation Wave Strategy to improve the energy performance of buildings. The Commission aims to at least double renovation rates in the next ten years and makes sure renovations lead to higher energy and resource efficiency. This will enhance the quality of life for people living in and using the buildings, reduce Europe's greenhouse gas emissions, foster digitalisation and improve the reuse and recycling of materials. This strategy is in line with the European Green Deal and action "Building and renovating in an energy and resource-efficient way". Increasing the rate, quality and effectiveness of the renovation of existing buildings is the biggest challenge for the coming decades in UE. The main priorities of the "Renovation wave" are: 1) tackling energy poverty and worst-performing buildings, 2) renovation of public buildings and social infrastructure, and 3) decarbonising heating and cooling (Renovation Wave, 2022).

Poland is one of the European countries with the highest carbon dioxide emission into the atmosphere. For this reason, on February 9, 2022, the Council of Ministers adopted the Long-Term Building Renovation Strategy (LBRS, 2022). LBRS sets out a kind of roadmap for the renovation of building stock in Poland in the short and long term. The realisation of the goals contained in the Strategy also involves the renovation of already existing buildings while improving their energy efficiency. Such renovations will contribute to improving air quality by reducing greenhouse gas emissions into the

DOI: DOI: 10.34659/eis.2022.83.4.575

atmosphere. They will also have a positive impact on the creation of new jobs related to the thermal modernisation of buildings.

The document outlines the steps that must be taken for Poland to have highly energy-efficient buildings and emitting little emissions by the year 2050. The environment and the Polish economy will benefit from investments made to increase building energy efficiency. Up to 2050, one of Poland's biggest infrastructure issues will be the renovation of the existing building stock.

The LBRS strategy is intended to transform the national building stock into nearly zero-energy buildings cost-effectively. To develop the strategy, a review of all buildings in Poland, both public and private, was carried out, which shows that there are 14.2 million buildings in Poland, of which almost 40% are single-family residential buildings. Many buildings are characterised by low energy efficiency and will require thermal modernisation in the coming years. The data indicate a large variation in the energy efficiency of buildings, both in terms of their intended use and the year of commissioning. Buildings constructed in the twenty-first century are known for their comparatively great energy efficiency, whilst older structures are known for their high energy demand and call for thermal renovation. This is especially true for single-family homes, where solid fuel boilers remain the dominant heat source.

Thermal upgrading of 236,000 m^2 is anticipated to take place between 2020 and 2030 buildings each year, 271 thousand m^2 in the years 2030–2040, 244 thousand m^2 in the years 2040–2050, and 7.5 million m^2 of thermal modernisations in the years 2021–2050 have all been planned.

The plan also contemplates working toward greater utilisation of the existing building stock by repairing, modernising, or converting them into contemporary structures that adhere to the principles of sustainable development. This also applies to buildings with a steel structure, the transformation of which into a modern building is very simple. According to the strategy, by 2050, it is estimated that approximately 7.5 million thermal modernisation investments will be carried out, including 4.7 million deep thermal modernisation projects (LBRS, 2022).

Poland adopts extensive steps to promote building renovations by carrying out the intents stated in this policy. These measures include legal and administrative tools as well as financial support from both national and EU funding. Polish Thermo-modernization and Renovation Fund (2022) has important public programs, e.g. “Stop Smog” or “Clean Air”, aiming at progressively transitioning to a climate-neutral economy.

Decision-making processes related to the adaptive reuse of construction projects are complex. This complexity lies in the various challenges and opportunities that must be considered simultaneously. These may include

DOI: DOI: 10.34659/eis.2022.83.4.575

technical criteria, economic, social, environmental, etc. In this topic, little research has been done on developing methodologies to improve the decision-making process for the adaptive reuse of buildings. They are mainly based on descriptive approaches with few objective measurements that depend on the intuition and experience of practitioners. This article aims to identify criteria that should be used when making decisions about the adaptive reuse of buildings and to investigate the preference for the importance of the criteria of those who may be directly involved in future processes of adaptive reuse. The respondents' group include practitioners and students in the field of construction. The scope of the article consists of a review of the law and literature in this area, examples of good practices in Poland, and survey results.

Fundamentals of adaptive reuse of old structures

As the working period elapses, more buildings and engineering structures with a rich history and architectural value require renovation and adaptation to new conditions of use. Reusing a building or structure is a deliberate decision to preserve the past while planning for the future. As we began to realise the importance of reusing existing structures and the numerous benefits it provides, the government and other local, national, and international organisations began to consider it.

Reusing existing buildings is an excellent technique to bring an obsolete building structure back into service while preserving resources and their industrial or social value. Whether it's for environmental concerns, land availability, or a desire to preserve a historical feature, adaptive reuse is gaining ground as a response to some of the problems with the current built environment.

The renovation of buildings may involve the need for actions such as expanding the building with a change of its purpose, replacing the facade while maintaining the existing structural system or thorough reconstruction of the building. Adaptive reuse refers to the process of reusing an existing building for a purpose other than which it was originally built or designed for. It is also known as recycling and conversion (Caves, 2004). Adaptive reuse can be an attractive alternative to new construction in terms of sustainability and the circular economy. There are many environmental benefits associated with this process: energy efficiency, water efficiency, and saving of natural resources (Dewiyana et al., 2016). Achieving the benefits of adaptive reuse partly depends on the effective scheduling of the adaptive process (Sanchez & Haas, 2018).

DOI: DOI: 10.34659/eis.2022.83.4.575

There should be several stages involved in the reuse of building structures. Of these, the most important is the reuse of existing buildings or structures and design for future deconstruction and reuse. Reuse of existing buildings is typically described as converting an underutilised or abandoned building into a facility fulfilling a new purpose. In a circular economy, designing for reuse requires considering disassembly in addition to reuse and recycling. If a product can be disassembled, it makes it much easier to reuse the individual components. If the product's components are composites or alloys that are challenging to separate, cast in extremely particular shapes, cemented together, have specialised fasteners, etc., the potential of recycling or reusing the parts is severely constrained. This occurs as a result of either the recycling being too challenging or the applications becoming highly limited.

Many researchers argue that the decision-making for the adaptive reuse of existing buildings is a complex process (Douglas, 2006). This is because many stakeholders are involved in making decisions, and each party has a different view. Those involved in the adaptation decision-making are the owners, developers, producers, investors, regulators and marketers. They come from various backgrounds, and when the building adaptation is considered, it has triggered a range of views and perspectives based on their choice. According to the book's author, there are a wide variety of adaptation options, such as partial to complete changes in use, minor or significant renovations, or small- to large-scale extensions. His work also includes information on adaptation works that are not easily found in a single construction textbook. For framed and unframed extensions, for instance, it includes jointing techniques. The main technical, legal and financial concepts of building adaptation are the subject of this book. In his work, numerous case study examples are also provided. Reuse may transform wasteful property into useful community assets, significantly lower land purchase and construction costs, revive existing neighbourhoods, and aid in preventing sprawl. Furthermore, it is simple to understand how renovation aligns with the issues of sustainable development (Wilkinson et al., 2009).

Garcia and Kwon (2021) discovered that when looking at the possibilities of adaptive reuse, a variety of factors, such as political and legal restraints, economic feasibility concerns, and architectural considerations relating to the existing structure, had an impact. The original building's design and footprint, which defines both how many units may be constructed on-site and whether those units are suitable for residential use, is one of the most significant elements impacting the potential for adaptive reuse. Bringing the existing building up to modern residential health and safety requirements provides a substantial obstacle to commercial to residential adaptive reuse, and risks are not usually obvious at the project start. The profitability of adaptive reuse projects can also be increased by local regulations that clarify and sim-

DOI: DOI: 10.34659/eis.2022.83.4.575

plify planning and construction codes. The authors claim that adaptive reuse development can be more financially feasible if it has characteristics that are common to commercial buildings, such as architectural detailing and higher floor-to-ceiling heights. Furthermore, land use and entitlements in areas where new development is strictly regulated and adaptive reuse projects can result in quicker building approvals.

Building reuse is becoming more prevalent in the Swedish construction industry, where it has a significant potential to reduce waste and CO_2 emissions from the sector. Frändberg and Nyqvist (2021) analysed the hurdles to adopting building reuse and their causes and effects in their research. Research has been focused on the barriers found in international literature and those felt by various participants in the Swedish building industry. The findings are organised into the categories of knowledge, market, technical, culture and norms, laws and regulations, and infrastructure. Barriers discovered through actor interviews were analysed in relation to their sources and effects. Laws and some subgroups of culture and norms are only contributing to and being impacted by barriers. Primary attention was paid to the three most emphasised relationships among the examined aspects. Firstly, companies hesitate to begin with reuse because of the sector's inertia. Due to the perceived danger of starting with reuse, organisations require assistance setting priorities and sharing information among companies. The issues of profitability and competition could be resolved by allowing for greater expense or shortening the time required for reuse by creating suitable routines. Thirdly, greater social acceptance is needed for reused residential and public utility buildings, which is related to high facilities' finishing standards. People who were questioned generally agreed that it is currently not financially advantageous to reuse existing structures and that some other issues must be fixed before this procedure can be implemented on a larger scale.

Decisions on the protection of the built-in environment were in the past, mainly the domain of architects, historians and urban planners. In recent years, however, the rising costs of adaptations and renovations and funding shortages have led to greater attention being paid to the financial aspects of these decisions. As a result, facility owners, accountants, economists and financial analysts were increasingly drawn into the decision-making process. For instance, building owners who want to make changes will consider their financial resources, investors want to envision the future before investing, and marketers will consider the most recent market demands (Barrett, 2009).

Making decisions about the reuse of a building should be correlated with its original architecture, structure, function and space in which it exists (Murtagh, 2006). This is very important in historical, artistic and cultural buildings. Anelli and Tajani (2022) point out that it is often the case that the

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full preservation and enhancement of a heritage site are hindered by buildings that are incompatible with valuable features of the surrounding urban environment. The project team must define and properly justify the reasons for the modernisation in order for the project to succeed. The phase of project planning known as project scope entails identifying and recording a list of the precise project objectives, deliverables, tasks, costs, and deadlines. A scope statement or terms of reference is a document that details the parameters of a project. This documentation assists the project team in staying concentrated and on task throughout the project. The team can use the scope statement to decide whether to accept or reject modification requests throughout the project (Langston, 2010).

The prognosis for office properties is especially cloudy, according to Cohen (2021), when it comes to the possibilities of modifying buildings in the post-pandemic period. Office spaces have been vacant for more than a year due to home-based work, and it is unclear how many individuals will start driving to work again when their health and the law allow it. He claims that some real estate experts are speculating whether there would be a surge of office-to-residential conversions due to the potential for an excess of vacant office space and the persistent lack of affordable housing in many cities. Such conversions present special design and regulatory difficulties and aren't always more cost-effective than starting from scratch. He claims most of those tenants are bound by long-term leases and will be returning in some capacity once it is safe to do so, despite the fact that many workplaces currently have few inhabitants. Where it may be justified financially and sustainably to reuse existing space rather than starting from scratch, he anticipates that smaller buildings in built-out metropolitan centres would undergo conversions.

Adaptive reuse of a building in Poland means its modernisation or permanent improvement, leading to an increase in the utility value of the building. The concept of modernisation is understood very broadly. It may be related to improving the aesthetics (e.g. by changing the facade of the building), replacing elements leading to better technical parameters (e.g. replacing the existing casing of the facility in order to achieve better thermal insulation, replacing technological equipment), and making new installations.

Examples of buildings adaptive reuse in Poland

The adaptive reuse of industrial buildings in Poland faces numerous obstacles. A large number of owners of buildings or their absence makes it difficult or impossible to make a decision on the reconstruction or redevelopment of buildings. The legal status of some buildings in Poland, particularly

DOI: DOI: 10.34659/eis.2022.83.4.575

older and historical ones, is unregulated in terms of who actually owns them. Usually, these are properties whose owners disappeared during World War II, making it difficult to locate their legal heirs today. Owners are deterred by complicated procedures related to renovating or repairing old buildings, especially historical ones or located in areas with a special purpose in spatial development plans. After all, it can be difficult for owners to raise funds for redevelopment.

The adaptation of post-industrial buildings to new uses in light of the escalating climate crisis and the need to change the approach to urbanisation has taken on new importance. Such a strategy offers the opportunity to preserve better history and artefacts from the past, including those with "only" sentimental value and those most significant and priceless. It is usually possible to preserve certain parts of a building after it has been modernised. In addition, even if the remodelling is more serious, it always preserves the local character in the bigger picture.

A good example of how many positive phenomena can include the preservation of the existing building and giving it new functions is an expansion of Centrum Praskie Koneser, an old production building located in Warsaw (CPK, 2022) – Figure 1. The investment is regarded as being among the biggest of its sort in Warsaw in recent memory. Genuine manufacturing artefacts should be valued for both their high level of preservation and their excellent adaptation to new uses. The size of the new auxiliary structures, which have an average of 4 to 6 floors and were designed to complement the dominant tenement residences in the area, is also a notable concern. Centrum Praskie Koneser is an urban quarter. The Warsaw Vodka Factory "Koneser" complex of ancient brick buildings served as the foundation for the construction of the Koneser shopping centre. The plant was made up of eight historic structures that served various functions, including administration, production, and storage. They were constructed of red brick in the shape of one-story pavilions with Gothic arches, pointed gables, and turrets. They were built in the manner of medieval architecture, which in the 19th century was practically a standard for industrial design. The renovation took place in 2017-2018. It is the largest renovation of an industrial facility so far carried out in Warsaw. Currently, the multifunctional architecture referred to as "mixed-use" integrates the following functions in one space: residential, commercial, business and cultural. In addition to lofts and soft lofts, modern offices, original gastronomic concepts, intimate boutiques and elegant fashion salons, service outlets and a fitness club were be built. The area of the retail section is approximately 22,500 m^2. The project also provides access to approximately 22,000 m^2 of offices. All revitalised buildings meet current insulation standards, and they are modified for people with different disabilities, elders, those who are temporarily suffering from health problems, or people who are physically fit.

We need to provide welcoming public spaces and comfortable housing for each of them and ourselves in the future.

Figure 1. Centrum Praskie Koneser
Source: (CPK, 2022).

The second case study also covers a 19th-century brick building's revival. However, the object's first usage as well as its later use serve entirely distinct purposes. It is a public utility building that houses a train station rather than a commercial structure. This time, a Polish State Railways firm owns the facility instead of a private business. This project won the title of Modernization of the Year 2021 in the "social welfare" category by taking into account the original structure and design of the building and adapting it to the needs of individuals with disabilities. The station's refurbishment took place between 2017 and 2020. From the Kuyavian-Pomeranian Voivodeship's Regional Operational Program for 2014–2020, the EU contributed more than PLN 2.8 million. To revitalise the Tuchola railroad station, it was necessary to renovate the building and modify it to meet the requirements of the existing building environment – Figure 2. Due to its location in a conservation protection zone, the building was preserved. Inside, a new elevator and staircase were made, and the social room was connected to the current service room. Six offices are arranged on the different levels of the building, each with a waiting room, toilets, common areas and corridors.

The building is accessible to people with disabilities, a ramp and elevator installed especially for them. The original facade of the station has also been restored.

DOI: DOI: 10.34659/eis.2022.83.4.575

Figure 2. Tuchola railway station
Source: (Transport Publiczny, 2022).

Known as the Warsaw Power Plant and the Municipal Power Plant, Elektrownia Powiśle is a now-extinct power plant built in Powiśle, Warsaw, in 1904. Some of its protected buildings were modified for the requirements of a 2020-opened shopping and service complex with the same name. Private investors built the power plant. It was placed under state control in 1933 before being taken over by the Warsaw City Council in 1937. It was in use until September 1944, both during the Warsaw Uprising and the 1939 defence of Warsaw. It was shut down in the early 1990s after reopening in April 1945. Elektrownia Powiśle was given the President of the Capital City of Warsaw's Architectural Award in 2021 (7th edition, category: commercial architecture).

During the revitalisation of the historic Elektrownia Powiśle [eng. Powisle power plant] in Warsaw, attempts were made to preserve as much of the buildings' original character as possible while creating new versions and giving them new goals – Figure 3. These included several renovated 30-meter chimneys, dormers that illuminated the engine room's attic, and a coal crane that had been converted into a panoramic lift. Most of the coal storage rooms from the original structure of the power plant have been preserved. Above the rooms is a technical floor, and in the attic, there are two service and office floors with a view of Warsaw. The original steel structure supporting the funnels was painted with fireproof paint and stiffened with new ceilings. The construction still bears traces of bullet holes and alterations from the war.

Due to damage and insufficient load-bearing capacity, the roof girders were suspended to a new steel structure hidden in the roof layers. All historical elements were painted light grey, the new ones, for contrast, in a darker shade. Also noteworthy is the original overhead crane, which is visible behind

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the engine room's suspended northern wall. The building's roof contains a distinctive blue shed that once housed the shaft's engine room. There is a charging station for electric cars with energy storage on the premises.

Figure 3. Powisle power plant
Source: (Sztuka Wnętrza, 2022).

Criteria for adaptive use – the situation in Poland

The concept that communities gain significantly from the adaptive reuse of ancient structures is already widely accepted in Poland. One of the many significant environmental advantages of adaptive reuse is the simple avoidance of the costly demolition and reconstruction process. The adaptive reuse of historic buildings is a crucial part of sustainable development because of these environmental advantages, energy savings, and the social advantage of reusing a treasured heritage location. Certain significant obstacles still exist. Concrete and steel embodied carbon removal technology is still in its infancy. However, raising standards is proving to be difficult, even when the remedies are straightforward. In the future, adaptive reuse may be crucial to lowering the amount of carbon that is embodied in building and construction materials used in Poland and contributing to a considerable reduction in the nation's overall carbon emissions. The adaptive reuse of buildings in Poland is a subject that is frequently addressed in research, papers, and conversations at conferences nowadays, either directly or indirectly (Broniewicz, 2013; Broniewicz & Broniewicz, 2020).

DOI: DOI: 10.34659/eis.2022.83.4.575

The adoption of construction standards for facilities and structures already in use is a natural need in Poland as a result of the fact that more than half of the current and future construction projects will cover already existing structures.

Some European countries have already developed standardisation documents devoted exclusively to existing buildings. In European Union, in the frame of CEN/TC250/WG2 activities, a JRC Science and Policy report has been worked out. The report provides guidance on assessing and retrofitting existing structures (European Commission, 2015). The International Organization for Standardization (ISO) has also produced an agreed document containing technical specifications and precise design criteria to assess the safety of existing structures ISO 13822:2010 (2010). The main principle of these standardisation documents is that activities related to existing structures and facilities are carried out in accordance with the assumptions of sustainable development of the environment, i.e., with full respect for users' individual and social needs. Modernisation and repair projects, in particular, should meet the following conditions:

- meet the requirements related to the reduction of unfavourable environmental aspects,
- must ensure the safety and usage of the structure,
- must protect the facility's material and cultural characteristics while considering its economic and aesthetic values.

Of particular importance in the Polish legislation on the renovation of buildings is the development of an integrated plan for the assessment, maintenance and management of the facility construction, ensuring the energy efficiency of the facility, water protection and the quality of the internal environment in the building, or the type of materials used.

Among the plans to determine whether it is possible to adapt existing buildings to a new purpose, the following are presumptive:

- evaluation of the facility's technical condition, its technological systems and processes, and identification of areas where it may be possible to make improvements or modifications,
- establishing codes of conduct that ensure that criteria for saving energy and water, reducing consumption, recycling used materials and raw materials are met throughout the facility's entire life cycle; and
- taking into account user needs and comfort levels.

Before modernising the facility, a technical analysis should be carried out. To do this, you should investigate the following:

- technical condition of the main load-bearing elements,
- the risk of loads resulting from unlikely events but possible to occur during the operation of the structure (for example, vehicle impacts, earth-

quakes, floods, wind hurricanes, fire outbreaks or caused by uneven settlement of the structure),
- presence of hazardous materials (asbestos, PCBs, paints containing lead).

Compared to demolishing an existing building and then creating a new one, the mere act of reusing buildings significantly reduces the energy used during construction. The building's embodied energy – the energy used to create it and all the materials used – is not lost. Even though most adaptive reuse projects require some new construction work, the energy and building materials used are much less than in new construction. The energy cost will only rise in the future, making adaptive reuse a more financially appealing idea in addition to its well-established benefits for history, authenticity, and placemaking (European Commission, 2015).

Method and results

Questionnaire surveys were used as the main method of data collection. These are useful for learning about things that cannot be immediately observed. Research questionnaires were made among two groups of relevant professionals: (i) practitioners – architects, planners, engineers and project managers, (ii) students – master's degree students in civil engineering. The research sample included 116 people, 69% practitioners and 31% students. In each group of respondents, about 30% were women. The survey was conducted in November 2022.

The survey's main objective was to identify the most important criteria that should be taken into account when deciding on a building adaptation. Respondents were asked to rate each of the 19 criteria. A five-point Likert scale was used for responses, where '5' means extremely important, '4' important, '3' average, '2' less important and '1' negligible. The data from the questionnaire survey were quantitatively evaluated using the descriptive statistical approach.

We have identified criteria that should be considered when deciding on the adaptive reuse of a building based on a literature review and our own experience. The criteria are grouped into 5 areas: technical, economic, social, spatial and environmental, as shown in Figure 4. Each component was given the opportunity for respondents to rate its significance.

The ranking of tested criteria is shown in Table 1. We counted the mean value from all the responses received and determined the standard deviations (SD). The five criteria received a rating of 4 and above. They represent the technical, economic and social areas.

DOI: DOI: 10.34659/eis.2022.83.4.575

TECHNICAL
- Law requirements
- Layout of rooms
- Technical condition of the facility
- Technological difficulties
- Building age
- Type of current operation

ECONOMIC
- Market demand
- Land cost
- Cost of con-version and subsequent use
- Government incentives
- Building ownership

SOCIAL
- Location, transport availability of the facility
- Social interest
- Protection of history and cultural property
- Health and safety issues

SPATIAL
- Official planning and zoning
- Compatibility with the existing surroundings

ENVIRONMENTAL
- Environmental impact
- Energy efficiency

Figure 4. Area and criteria for process decision on adaptive reuse of the building

Table 1. Ranking criteria influencing the adaptive reuse of buildings

No.	Criteria	Mean	SD
3	Technical condition	4.3	0.9461
9	Cost of conversion and subsequent use	4.3	0.9556
1	Law requirements	4.1	0.9677
12	Health and safety issues	4.1	0.9901
7	Market demand	4.0	0.9910
13	Location, transport availability of the facility	3.9	1.0273
5	Building age	3.8	1.1631
15	Protection of history and cultural property	3.7	0.9182
4	Technological difficulties	3.7	1.0453
8	Land cost	3.6	1.0207
19	Energy efficiency	3.6	1.0236
17	Compatibility with the surroundings	3.5	0.9342
16	Spatial planning	3.4	0.9803
18	Environmental impact	3.3	1.1090
14	Social interest	3.2	1.0257
6	Type of current operation	3.2	1.1176
11	Building ownership	3.1	1.1877
2	Layout of rooms	2.7	1.2028
10	Government incentives	2.3	0.9232

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The *Technical condition of the facility* (4.3), *Cost of conversion and subsequent use* (4.3), *Health and safety issues* (4.1), *Law requirements* (4.1), and *Market demand* (4.0) are five crucial success variables that were found based on a questionnaire survey. These fundamental components may be the focus of future adaptive strategies regarding the reuse of buildings by the government, building owners, investors, and other stakeholders. According to survey respondents, they should significantly influence decision-making regarding the renovation of buildings.

The respondents claim that one crucial aspect affecting decisions on adaptive reuse is the technical state of the facilities (4.3). Degradation processes significantly impact the strength and condition of any building. These are natural processes that are directly related to the existence of any building, exposure to the external environment, operation and ageing, resulting in a reduction in its functional qualities.

The second most important factor is the cost of adapting the building structure (4.3). The costs of reusing a building can vary greatly depending on the tenant's needs, the property's condition, and the cost of materials and labour. Tenant requirements in the instance of office space will have different requirements than a doctor's or lawyer's office. Additionally, more expensive are specialised areas and high-end finishing. An older property that has been modified to meet the demands of the previous tenant may require less finishing work than a new development. On the other hand, older spaces might also require more renovations before they are ready for habitation. The cost of labour and supplies varies by location and equipment quality.

Health and safety issues (4.1) and law requirements (4.1) are other significant elements influencing the decision to adaptive reuse. The building structure must be used in accordance with its intended use and environmental protection standards. It must be kept in good technical and aesthetic condition to prevent excessive degradation of its functional qualities and technical efficiency. It is necessary and required to comply with the regulations to guarantee the structure's safety, incandescent light, and use at the operational stage of a building.

Market demand is an important factor among the surveyed people (4.0). Market demand is rated as the most significant for adaptive reuse. This suggests that market demand is the main force behind the adaptive reuse of industrial buildings in Poland. Adaptive reuse offers a quick means of meeting rising demand. In Poland's current market environment, adaptive reuse of buildings still only makes up a small portion of the market. However, based on observations of markets in Western Europe, its potential can be calculated. Despite the current strong market demand for residential construction, it could be difficult to convert existing structures to residential use because of the development plans or circumstances that dictate that use.

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Developers may desire to renovate older facilities, but challenges with obtaining the necessary permits from the authorities in some places may stand in their way. The idea of utilising existing buildings and converting them into residential structures is viewed favourably by developers in Poland. By, for instance, lowering the demand for cement, the manufacturing of which accounts for 5% of the world's energy consumption, this solution is consistent with the broader trend of environmental conservation.

With a mean value of 2.3 – government incentives, according to the respondents, do not play a significant role.

According to respondents, social issues are most important when deciding about the adaptive reuse of a building. On average, they received a score of 3.7. The high position of the criterion Health and safety issues influenced this. However, comparing the responses of practitioners and students, it can be observed that future civil engineers attach more importance to technical and environmental issues than those working in the field of construction and architecture – Figure 5.

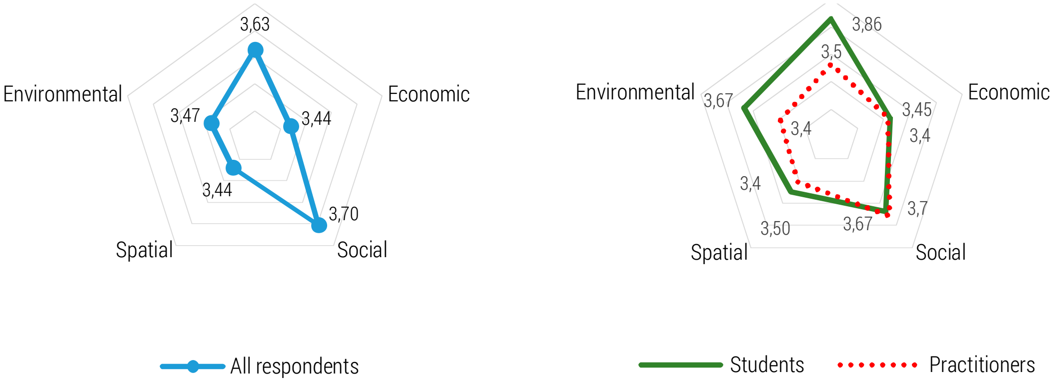

Figure 5. Ranking of the area in respondents' opinion

Discussion

Tan et al. (2018) conducted a similar study in Hong Kong. They made a ranking of 33 factors based on questionnaire surveys conducted among people involved in the process of building adaptation. Three criteria were considered the most important by both Polish and Chinese respondents: Market demand, Cost of conversion and subsequent use, and Law requirements. In Tan et al.'s research, in addition, a rating above 4 was given to the criteria: *Location, transport availability of the facility* and *Building ownership*. In Poland, respondents gave them a score of 3.9 and 3.1, respectively.

DOI: DOI: 10.34659/eis.2022.83.4.575

For many people – also in Poland – the location and availability of the facility is the most important factor that affects the attractiveness of a given object. It is fashionable to live close to the centre and, at the same time, in a place where we can enjoy peace and quiet. The combination of these two factors often prompts buyers to look for locations where living close to nature and convenient access to work or school are not mutually exclusive. The city centre is a natural reference point for the location of each property. Almost every developer gives an estimated travel time to the centre for a simple reason – this is where many residents of the estate work, and spend their free time in popular restaurants and clubs, and the city centre is where culture and art are concentrated. At the same time, however, after returning to the apartment, each of us wants to rest in peace and quiet. You can get used to many things, but the location on the main communication route and the resulting noise can permanently destroy satisfaction with your apartment. However, people living in big cities are less sensitive to noise.

The *Building ownership* criteria in Hong Kong was rated as the third most important criterion. On the other hand, they were classified as one of the last places in Poland. This is mainly due to the fact that in Hong Kong, all land is owned by the government and may be leased to users for different uses. Owners need to pay a full market premium for lease modification. In Poland, both government and private buildings can be adapted after obtaining the required permits.

Conclusions

Building adaptive renovation is an effective and environmentally friendly way to reuse buildings. This allows existing structures to be adapted to market requirements. In this way, a building's lifespan can be increased. Various factors can affect a building's potential for reuse, including building regulations, the age of the building and its current use. The goal of the current study was to evaluate the variables that affect adaptive reuse in Poland. Five criteria considered most important by the survey participants were identified based on the questionnaire survey, including technical condition, cost of conversion and subsequent use, health and safety issues, law requirements, and market demand. In addition, the 19 factors were grouped into five main areas. It was concluded that social aspects should be considered first in the adaptive reuse of buildings. Technical issues are also significant. Economic, spatial and environmental variables are only of secondary relevance.

To sum up, the main findings from the research are as follows:

- Changing one's perspective from the conventional ways of viewing the building process as beginning with the use of new materials and conclud-

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ing with demolition to circular thinking (e.g., closing the loop of material flow) is necessary to advance the sustainability of the construction industry.

- Since existing buildings have various structural and architectural features, it is best to modify the renovation techniques according to the type of building.
- One of the most significant and influential players in enhancing the sustainability of the construction industry is the financial sector, which includes insurance companies.
- Policies for strengthening or rebuilding building structures and/or for improving energy efficiency should be coordinated to avoid duplication of procedures for assessing current performance and to offset increases in management costs.
- Policies for the adaptive use of buildings and the process for approving building regulations for renovation should be flexible in the face of changing social and environmental demands.
- The government is expected to take the lead in relevant technology development, such as creating flexible building systems that are simple to disassemble, given how fragmented and un-innovative the construction industry is.
- Public procurement is anticipated to play a significant role in creating a market where environmentally friendly products are commercially viable since the public sector is the largest single client.
- Demand changes are the main factor that influences the market. In order to increase "good clients" and decrease ignorance, it is crucial to provide more information to end users.

Future studies might take into account choosing the best option for the adaptive reuse of buildings by using multi-criteria decision-making techniques.

Acknowledgements

The research was carried out as part of research work no. WZ/WB-IIL/4/2020, WZ/WB-IIŚ/1/2020 at the Bialystok University of Technology and financed by a subsidy provided by the Ministry of Education and Science.

The contribution of the authors

Conceptualization, E.B. and M.B.; methodology, M.B.; validation, E.B., B.S. and P.G.; formal analysis, E.B., B. S., A.B. and P.G.; resources, E.B., M.B. and P.G.; data curation, E.B.; writing, E.B. and M.B.; visualisation, E.B. and M.B. All authors have read and agreed to the published version of the manuscript.

DOI: DOI: 10.34659/eis.2022.83.4.575

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DOI: DOI: 10.34659/eis.2022.83.4.575

SUMMARIES IN POLISH

Jerzy ŚLESZYŃSKI

NORMATYWNA EKONOMIA EKOLOGICZNA WARUNKIEM TRWAŁEGO ROZWOJU

STRESZCZENIE: Celem artykułu jest podkreślenie rzeczywistej konkurencyjności między ekonomią pozytywną a ekonomią normatywną. Artykuł rozpoczyna się od przedstawienia tej kontrowersji, która jest tylko pretekstem do analizy konkretnego pola działania ekonomii ekologicznej. Podejście normatywne w ekonomii ekologicznej jest potrzebne w trudnym wieku narastających deficytów i stawiania czoła zagrożeniom dla trwałości biologicznej i społecznej. Wiarygodne dane z biologii, fizyki, chemii i medycyny informują o tym, co jest naprawdę niebezpieczne. Tym samym sugerują kierunki zmian i ich niezbędną skalę. Podejście normatywne, oparte na wytycznych nauk podstawowych, pozwala tworzyć teorie i modele ekonomiczne, a następnie wyprowadzać konkretne, ilościowe przesłanki dla działań podejmowanych w gospodarce. Teza tego artykułu sprowadza się do stwierdzenia, że efektywne zaangażowanie ekonomii ekologicznej w teoretyczne i praktyczne rozwiązywanie problemów zrównoważonego rozwoju jest możliwe tylko poprzez zastosowanie podejścia normatywnego.

SŁOWA KLUCZOWE: normatywna ekonomia, ekonomia ekologiczna, trwały rozwój

Agnieszka BECLA, Stanisław CZAJA

ZASADY GOSPODAROWANIA W REALIZACJI ZRÓWNOWAŻONEGO I TRWAŁEGO ROZWOJU – WYBRANE PROBLEMY

STRESZCZENIE: W opracowaniu przedstawiono wybrane zagadnienia dotyczące zasad gospodarowania (zarządzania) realizacją zrównoważonego i trwałego rozwoju. Są to między innymi zasady: (1) tradycyjnej gospodarki ekstensywnej, (2) intensywnej tradycyjnej gospodarki, (3) gospodarek alternatywnych, (4) ekorozwoju, (5) Sustainable Development i (6) zrównoważonego entropijnie rozwoju. Scharakteryzowano również wybrane kryteria oceny tych zasad.

SŁOWA KLUCZOWE: zrównoważony i trwały rozwój, zasady realizacji zrównoważonego i trwałego rozwoju, kryteria oceny zasad realizacji Sustainable Development

Muhammad MUSHAFIQ, Błażej PRUSAK

CZY BYCIE SPOŁECZNIE DOBRYM URATUJE FIRMY OD UPADŁOŚCI? SYSTEMATYCZNY PRZEGLĄD LITERATURY I ANALIZA BIBLIOMETRYCZNA

STRESZCZENIE: Celem artykułu jest ustalenie, czy bycie społecznie odpowiedzialnym chroni przedsiębiorstwa przed bankructwem? Podjęto także próbę znalezienia odpowiedzi na następujące pytania: Jaki jest związek między społeczną odpowiedzialnością biznesu a ryzykiem niewypłacalności? Jakie metody i miary są stosowane w literaturze przedmiotu do oceny tej zależności? Jaka jest podstawa teoretyczna tych studiów badawczych? Ponadto podjęto próbę określenia luki badawczej dla celów kontynuacji dalszych badań. Bazy danych Web of Science i Scopus zostały wykorzystane do pozyskania odpowiednich artykułów naukowych. Po przeprowadzeniu selekcji, ogółem przeanalizowano 24 artykuły przy zastosowaniu systematycznego przeglądu literatury PRISMA i bibliometrii. Z przeglądu wynika, że występuje jednokierunkowy, odwrotny związek między społeczną odpowiedzialnością biznesu a ryzykiem niewypłacalności. Ponadto większość pozycji literaturowych odwołuje się do perspektywy interesariuszy jako podstawowej ramy teoretycznej tych badań. Istnieje luka badawcza w zakresie wyjaśniania związków między różnymi teoriami oraz możliwość rozszerzenia modelu o dodatkowe aspekty makro- i mikroekonomiczne oraz finansowe. Artykuł stanowi wkład w aspekt teoretyczny, ponieważ przedstawia klasyfikację metod, aproksymant i podstaw teoretycznych wykorzystywanych w badaniach nad społeczną odpowiedzialnością biznesu i ryzykiem niewypłacalności.

SŁOWA KLUCZOWE: ryzyko niewypłacalności, społeczna odpowiedzialność biznesu, systematyczny przegląd literatury, analiza bibliometryczna, PRISMA

Piotr SWACHA, Zbigniew KARACZUN, Daria MURAWSKA

EUROPEIZACJA POLSKIEJ POLITYKI KLIMATYCZNEJ

STRESZCZENIE: Celem pracy była analiza stanowisk głównych polskich partii politycznych w odniesieniu do europejskiej polityki klimatycznej oraz ocena, czy i w jakim stopniu w Polsce zachodzi proces europeizacji polityki klimatycznej. Skutki zmiany klimatu powodują negatywne konsekwencje zarówno dla bezpieczeństwa żywnościowego, jak i produkcji przemysłowej, spowalniając w ten sposób rozwój gospodarczy. Obniżają także produktywność siły roboczej i wpływają na międzynarodową wymianę handlową. Siła i zakres negatywnego wpływu skutków zmiany klimatu zależeć będzie od decyzji politycznych i efektywności działań podejmowanych przez poszczególne rządy. Negatywne podejście do konieczności ochrony klimatu ze strony partii politycznych może spowodować, że niezbędne i efektywne działania nie będą prowadzone, nawet pomimo zmian w społecznej percepcji.

SŁOWA KLUCZOWE: polityka klimatyczna, patie polityczne, programy wyborcze, europeizacja, społeczna percepcja

Agnieszka CIECHELSKA, Marta KUSTERKA-JEFMAŃSKA,
Sabina ZAREMBA-WARNKE

SYSTEM GOSPODARKI ODPADAMI KOMUNALNYMI JAKO SYSTEM POLICENTRYCZNY – NA PRZYKŁADZIE POLSKI

STRESZCZENIE: W krajach rozwiniętych główny ciężar gospodarki odpadami spoczywa na zorganizowanym (sformalizowanym) i masowym systemie gospodarki odpadami komunalnymi. Funkcjonowanie tych systemów regulowane jest przepisami prawnymi na poziomie lokalnym, krajowym i międzynarodowym. Jednocześnie niektóre frakcje odpadów są całkowicie lub częściowo wyłączone z tego systemu (np. odpady gabarytowe, odzież używana, żywność, odpady zielone, czy metale). Są one, podobnie jak w krajach rozwijających się, częściowo zagospodarowane w drodze nieformalnych działań. Organizacja, sposób funkcjonowania, skala czy zasięg przestrzenny tych działań jest bardzo różny. Cały system formalny jest zorganizowany w sposób hierarchiczny i ściśle regulowany przepisami prawnymi. Natomiast działania nieformalne podlegają regulaminom lub zestawom reguł. Tym samym gospodarka odpadami komunalnymi w krajach rozwiniętych tworzy skomplikowaną mozaikę działań, organizacji i instytucji przyczyniających się do redukcji odpadów oraz ich uciążliwości. Celem artykułu jest określenie, czy systemy gospodarki odpadami w krajach rozwiniętych posiadają cechy, które pozwalają na osiągnięcie korzyści, jakie niesie policentryczny system zarządzania. Analizę przeprowadzono na przykładzie Polski. W tym celu wykorzystano *Theoretical Model for the Commons* (Carlisle & Gruby, 2019).

SŁOWA KLUCZOWE: gospodarka odpadami komunalnymi, dobra wspólne, policentryczność

Agnieszka TRĘBICKA

MODELOWANIE ZMIAN WIEKU WODY W SYSTEMACH DYSTRYBUCJI WODY W CZASIE I PRZESTRZENI

STRESZCZENIE: W artykule przedstawiono szczególnie ważny wariant badawczy w procesie modelowania systemów dystrybucji wody (SDW), jakim jest wiek wody. Wiek wody w rurach jest parametrem, który określa świeżość wody. Głównym celem przedstawionych badań była analiza zmian wieku wody poprzez obserwację podstawowych parametrów: ciśnienia i przepływu wody. W rezultacie założonych symulacji wyodrębnione zostały potencjalne miejsca wtórnego zanieczyszczenia. Wynikiem rozwiązania zaistniałej sytuacji było wprowadzenie wszelkich prac, mających na celu wyeliminowanie i ulepszanie zaistniałych negatywnych zmian poprzez: znacznie częstsze monitorowanie wody na tym obszarze pod kątem właściwości fizykochemicznych i bakteriologicznych oraz regularne płukanie rurociągów. Badania prowadzono w oparciu o model matematyczny sieci wodociągowej. Jako narzędzie badawcze wykorzystano Program EPANET, które umożliwia modelowanie zmian wieku wody w całym systemie dystrybucji wody w czasie. Podstawą przeprowadzonych badań stał się czynnik czasu, który pełni szczególnie ważną funkcję w procesie zarzadzania systemem dystrybucji wody. Biorąc pod uwagę czas, zaobserwowano, ile wody pozostaje na danym odcinku od momentu, w którym spływa ona z ujęcia i jest mieszana z wodą już obecną w całej sieci. Analizowano szereg wariantów symulacyjnych pod kątem działania systemu dystrybucji wody, gdzie kluczowym problemem była stagnacja wody. Należy zaznaczyć, że stagnacja wody jest szczególnie niebezpieczna w przypadku SDW, a uzyskane wyniki wykazały widoczne jej miejsca na badanym modelu. Przy symulacjach trwających więcej niż 8, 10 dni zauważono, wyraźne pogorszenie jej jakości. Wyodrębniono potencjalne miejsca wtórnego zanieczyszczenia. Powyższe badania mają szczególne znaczenie z punktu widzenia zarządzania efektywnością działania sieci wodociągowej. Przeprowadzona analiza wody w systemach wodociągach, ulegającej stagnacji, a tym samym starzejąca się, pokazuje że efektywność pracy systemu znacznie spada. Zmienność warunków w systemie dystrybucji wody sprawia również, że wydajność pracy SDW, a zwłaszcza jednostek pompujących staje się zmienna.

SŁOWA KLUCZOWE: model matematyczny, system dystrybucji wody, wiek wody, właściwości fizykochemiczne i bakteriologiczne, przepływ świeżej wody

Małgorzata KRASOWSKA, Małgorzata KOWCZYK-SADOWY, Sławomir OBIDZIŃSKI

KOMPOSTOWANIE USTABILIZOWANEGO KOMUNALNEGO OSADU ŚCIEKOWEGO Z POZOSTAŁOŚCIAMI Z PRZETWÓRSTWA ROLNO-SPOŻYWCZEGO W POLSCE

STRESZCZENIE: Ustabilizowane komunalne osady ściekowe oraz wybrane odpady z przetwórstwa rolno-spożywczego mogą być wykorzystywane w celach rolniczych, co wpisuje się w zagadnienia gospodarki o obiegu zamkniętym. W związku z tym wybrane pozostałości zbadano pod kątem możliwości wykorzystania ich na cele nawozowe. Następnie poddano je procesowi kompostowania w bioreaktorze, ze sztucznym napowietrzaniem. Mieszanki kompostowe sporządzono biorąc pod uwagę zawartość w nich między innymi węgla, azotu, fosforu oraz wody, a w przypadku osadu ściekowego określono także zanieczyszczenia biologiczne i zawartość metali ciężkich. Na podstawie przeprowadzonych badań stwierdzono, że odpady organiczne z przetwórstwa rolno-spożywczego oraz ustabilizowane komunalne osady ściekowe mogą być wykorzystane w procesie kompostowania, a otrzymany kompost charakteryzował się dobrymi właściwościami nawozowymi. Biorąc pod uwagę właściwości fizykochemiczne otrzymanego kompostu stwierdzono, że może on stanowić bardzo cenny nawóz wykorzystywany jako dodatek do gleby.

SŁOWA KLUCZOWE: kompost, nawożenie, przetwórstwo rolno-spożywcze, osady ściekowe

Aleksander KIRYLUK, Joanna KOSTECKA

ZRÓWNOWAŻONY ROZWÓJ OBSZARÓW WIEJSKICH Z PERSPEKTYWY DEKADY ODBUDOWY EKOSYSTEMÓW

STRESZCZENIE: Obszary wiejskie stanowią ważne zaplecze dla zrównoważonego rozwoju, ponieważ charakteryzują się dużą różnorodnością flory, fauny i siedlisk. Obok funkcji produkcji żywności mogą pełnić liczne funkcje związane z ochroną i kształtowaniem środowiska. W pracy scharakteryzowano wpływ rolnictwa na środowisko przyrodnicze, pokazując także wybrane parametry rolniczej produkcji roślinnej w Unii Europejskiej, Holandii i Polsce. Wskazano czynniki istotne w kontekście trwania Dekady Odbudowy Ekosystemów ONZ (2021-2030). Jako punkt odniesienia dla oczekiwanych wyników w zakresie tworzenia zrównoważonego rozwoju w obszarach wiejskich wybrano cechy rolnictwa w powiecie hajnowskim (gdzie ponad 50% powierzchni zostało objęte ochroną), traktując ten powiat jako model organizacji rozwoju rolnictwa w XXI wieku. Podkreślono znaczenie bioróżnorodności dla budowania zrównoważonej strategii dobrobytu człowieka. Wykorzystywanie świadczeń ekosystemów będzie trwałe, gdy elementy Dekady Restytucji Ekosystemów zostaną szeroko zakorzenione w świadomości obywatelskiej mieszkańców Polski i podobnych przestrzeni w Europie. Aby tak się stało trzeba Dekadę Restytucji Ekosystemów jak najszerzej promować, pisząc o niej w różnych kontekstach.

SŁOWA KLUCZOWE: obszary wiejskie, ograniczanie antropopresji, Dekada Odbudowy Ekosystemów (2021-2030)

Konrad PRANDECKI, Wioletta WRZASZCZ

WYZWANIA DLA ROLNICTWA W POLSCE WYNIKAJĄCE Z REALIZACJI CELÓW STRATEGICZNYCH EUROPEJSKIEGO ZIELONEGO ŁADU

STRESZCZENIE: Celem artykułu jest wskazanie najważniejszych wyzwań dla rolnictwa w Polsce w kontekście realizacji celów strategicznych Europejskiego Zielonego Ładu oraz Krajowego Planu Strategicznego dla Wspólnej Polityki Rolnej na lata 2023-2027. Głównym narzędziem wykorzystanym w badaniu była analiza porównawcza dokumentów prawnych unijnych oraz polskich. Porównanie to zostało uzupełnione o analizę danych statystycznych dotyczących rolnictwa w Polsce, głównie z lat 2005-2020. Posiłkowano się m.in. danymi: Powszechnego Spisu Rolnego 2020, Głównego Urzędu Statystycznego, Krajowego Ośrodka Bilansowania i Zarządzania Emisjami, Inspekcji Jakości Handlowej Artykułów Rolno-Spożywczych oraz Europejskiej Agencji Leków. Uzyskane wyniki pokazują, że krajowe cele do roku 2030 są znacznie niższe od europejskich, ale zostały ustalone z uwzględnieniem możliwości ich realizacji, co oznacza, że spełnienie każdego z podstawowych, krajowych celów w sektorze rolnictwa będzie wiązało się z dużym wyzwaniem. Wyzwania te mają charakter merytoryczny, administracyjno-prawny, społeczny, finansowy i geopolityczny.

SŁOWA KLUCZOWE: Europejski Zielony Ład, rolnictwo, zmiana klimatu, wspólna polityka rolna, Polska

Anna PIOTROWSKA, Dariusz BORUSZKO

ANALIZA POTENCJAŁU EFEKTYWNYCH MIKROORGANIZMÓW W PRODUKCJI ROŚLINNEJ

STRESZCZENIE: Środowisko naturalne zmienia się pod wpływem działalności człowieka i rozwoju nowych technologii. Jednym ze sposobów przywrócenia równowagi środowiska naturalnego jest ograniczenie rolnictwa konwencjonalnego na korzyść gospodarowania metodami ekologicznymi, opartych na stosowaniu nawozów organicznych i naturalnych, z wyłączeniem stosowania chemicznych środków produkcji. Takie działanie przyczyni się w znacznej mierze do poprawy bioróżnorodności i bogactwa zasobów naturalnych. Nawożenie we współczesnym rolnictwie jest jednym z najważniejszych zabiegów agrotechnicznych decydujących o wielkości i jakości uzyskiwanych plonów. W rolnictwie ekologicznym mikroorganizmy glebowe odgrywają ważną rolę, ponieważ wpływają na mineralizację węgla organicznego i humifikację materii organicznej, dzięki czemu składniki pokarmowe są łatwiej przyswajalne przez roślin. Nawozy organiczne jakimi są Efektywne Mikroorganizmy, produkowane są przy użyciu żywych mikroorganizmów, które nie tylko dostarczają do gleby składniki odżywcze, ale również pozwalają na udostępnienie nieaktywnych. Dzięki lepszemu przyswajaniu składników pokarmowych rośliny lepiej się rozwijają i rosną, zapewniając najlepsze plony, których ceny skupu z upraw ekologicznych są bardzo często znacznie wyższe, niż w przypadku tradycyjnych upraw. Celem pracy było przedstawienie możliwości wykorzystania Efektywnych Mikroorganizmów jako ekologicznej i ekonomicznej alternatywy dla konwencjonalnych systemów produkcji roślinnej wykorzystujących nawozy sztuczne.

SŁOWA KLUCZOWE: zrównoważony rozwój, rolnictwo, Efektywne Mikroorganizmy

Agnieszka BRELIK, Wojciech LEWICKI, Milena BERA, Monika ŚPIEWAK-SZYJKA

ISTOTA POTENCJAŁU RYNKU BIOGAZU ROLNICZEGO W POLSCE – STUDIUM PRZYPADKU PROJEKT BIOGAZOWNI

STRESZCZENIE: W ostatnich latach jednym z kluczowych postulatów w polityce Unii Europejskiej stał się rozwój odnawialnych źródeł energii. W Polsce pojawiła się idea, że potencjał energetyczny krajowego rolnictwa może stanowić szansę na szersze wykorzystanie dostępnej biomasy rolniczej. Biorąc pod uwagę fakt, że biogaz rolniczy od dawna postrzegany jest jako jeden z najbardziej obiecujących kierunków transformacji energetycznej, celem artykułu była ocena potencjału rynku biogazu rolniczego w Polsce. Metodologia badań została oparta na miarach statystycznych związanych z analizą struktury i zmian w czasie w poszczególnych latach. Analizę struktury przeprowadzono dla wybranych województw Polski, dla których zbudowano rozkłady empiryczne i obliczono wybrane parametry opisowe. Podobnej analizy dokonano w stosunku do wybranych krajów unijnych. Ponadto zgodnie z Krajowym Planem Działań w zakresie energii ze źródeł odnawialnych w każdej polskiej gminie powinna powstać co najmniej jedna biogazownia rolnicza. Na tej podstawie w artykule dokonano oceny efektu ekologicznego projektu biogazowi rolniczej w miejscowości Marcinkowice, w województwie zachodniopomorskim. Przedstawione symulacje pozwoliły na stwierdzenie, że biogazownia rolnicza może stanowić potencjał ekologiczny w postaci ograniczenia zużycia paliw kopalnych poprzez zmniejszenie emisji zanieczyszczeń i gazów cieplarnianych do atmosfery, przy jednoczesnym ograniczeniu zużycia paliw kopalnych. Istotnym dla praktyki było potwierdzenie, że inwestowanie w zakresie odnawialnych źródeł energii, w tym wykorzystanie biogazu, wpisuje się w cele i kierunki rozwoju związane ze zrównoważonym gospodarowaniem zasobami środowiska i rozwojem odnawialnych źródeł energii.

SŁOWA KLUCZOWE: odnawialne źródła energii, rynek biogazu, analizy, rolnictwo, studium przypadku, efekty ekologiczno-energetyczne

Melania BĄK, Marzena STROJEK-FILUS

ZARZĄDZANIE WRAŻENIEM W RAPORTOWANIU INFORMACJI ŚRODOWISKOWYCH W GRUPACH KAPITAŁOWYCH BRANŻ ENERGETYCZNEJ, SUROWCOWEJ I PALIWOWEJ. WYNIKI Z POLSKI

STRESZCZENIE: Zarządzanie wrażeniem odgrywa istotną rolę w kształtowaniu i ujawnianiu informacji niefinansowych, w tym środowiskowych, w raportowaniu zintegrowanym. Celem opracowania jest identyfikacja i ocena skutków stosowania strategii zarządzania wrażeniem w prezentacji informacji środowiskowych o charakterze niefinansowym w zintegrowanych raportach grup kapitałowych branż energetycznej, surowcowej i paliwowej, które od wielu lat mają znaczący udział w degradacji środowiska naturalnego. Badania zostały przeprowadzone dwuetapowo: w pierwszym etapie – w ramach strategii zarządzania wrażeniem – przeprowadzono analizę tekstu w celu identyfikacji strategii manipulacji tematycznej oraz manipulacji wizualnej i strukturalnej, w drugim etapie – w ramach strategii manipulacji syntaktycznej – przeprowadzono analizę stopnia zrozumiałości tekstu za pomocą aplikacji Jasnopis, w ramach której wykorzystywane są m.in. wskaźniki FOG i Pisarka. Wyniki badań wybranych podmiotów będących tzw. „trucicielami” środowiska naturalnego potwierdzają stosowanie zróżnicowanych narzędzi w ramach strategii zarządzania wrażeniem interesariuszy, m. in. manipulowania słowami, kolorem, obrazem i tekstem.

SŁOWA KLUCZOWE: zrównoważony rozwój, zielona rachunkowość, informacje środowiskowe, zintegrowane raporty, zarządzanie wrażeniem

Piotr BOŁTRYK

WPŁYW UZGODNIENIA REGIONALNEGO DYREKTORA OCHRONY ŚRODOWISKA NA DECYZJĘ W SPRAWIE ŚRODOWISKOWYCH UWARUNKOWAŃ REALIZACJI INWESTYCJI W POLSCE

STRESZCZENIE: Celem niniejszego opracowania jest próba udzielenia odpowiedzi na pytanie dotyczące wpływu uzgodnienia Regionalnego Dyrektora Ochrony Środowiska na decyzję w sprawie środowiskowych uwarunkowań w Polsce. Dotychczas w literaturze tematu ukształtowały się dwa stanowiska. Zgodnie z pierwszym uzgodnienie takie jest dla organu wydającego decyzję wiążące. Przeciwnicy takiego podejścia przekonują natomiast, że organ administracyjny jest w tym zakresie samodzielny. Autor dokonując pogłębionej analizy obydwu podejść opowiada się po pierwszej ze stron, biorąc dodatkowo pod uwagę argumenty natury jurydycznej, funkcjonalnej oraz celowościowej. Studium przypadku dotyczyło budowy pięciu budynków do hodowli brojlerów kurzych lub indyków wraz z infrastrukturą towarzyszącą na nieruchomości położonej w obrębie Solniki, gm. Zabłudów.

SŁOWA KLUCZOWE: decyzja, środowisko, uzgodnienie, ocena

Łukasz ZBUCKI

WPŁYW PANDEMII KORONAWIRUSA SARS-COV-2 NA DYNAMIKĘ RUCHU TURYSTYCZNEGO W WYBRANYCH PARKACH NARODOWYCH W POLSCE

STRESZCZENIE: Pandemia SARS-CoV-2, rozpoczęta w 2020 roku, bardzo dotkliwie dotknęła sektor usług turystycznych. Celem niniejszego artykułu jest określenie wpływu pandemii koronawirusa i konsekwencji z nią związanych na dynamikę ruchu turystycznego w dziewięciu polskich parkach narodowych. Posłużono się metodą analizy statystycznej (opisowej) na podstawie danych dotyczących sprzedaży biletów do parków w 2019 i 2020 roku. Przeprowadzone badania dowiodły, że mimo obaw o zdrowie oraz szeregu ograniczeń, liczba turystów we wszystkich parkach, wyrażona sprzedażą biletów w roku 2020 spadła tylko o 0,06%. Polskie parki narodowe, które są mniej popularne, zanotowały wzrosty odwiedzjących nawet o 66%, natomiast w parkach o dużej zwykle frekwencji nastąpiły spadki, szczególnie podczas wiosennego lockdownu. Uzyskane analizy pozwalają na opracowanie wzorców mobilności turystów w sytuacjach wyjątkowych.

SŁOWA KLUCZOWE: dynamika ruchu turystycznego, koronawirus, SARS-CoV-2, COVID-19, parki narodowe

Izabela WIELEWSKA, Marzena KACPRZAK, Agnieszka KRÓL, Artur CZECH,
Dagmara K. ZUZEK, Katarzyna GRALAK, Renata MARKS-BIELSKA

ZIELONE ZARZĄDZANIE ZASOBAMI LUDZKIMI

STRESZCZENIE: Zielone zarządzanie zasobami ludzkimi to podejmowanie działań oraz kształtowanie i promowanie postaw proekologicznych w środowisku pracowniczym. Celem niniejszego opracowania jest zbadanie roli zielonego Human Resource Management (HRM) oraz ekologicznych polityk firm w zakresie zrównoważonego rozwoju środowiska. Badania w tym zakresie przeprowadzono wśród 346 pracowników zatrudnionych w przedsiębiorstwach z różnych branż zlokalizowanych na terenie Polski w 2021 roku. W badaniu wykorzystano internetowy kwestionariusz ankiety. Uzyskane wyniki poddano analizie statystycznej, zastosowano model regresji logistycznej z wykorzystaniem m.in. pakietu komputerowego ***Statistica***. Przeprowadzona analiza wykazała, że świadomość pracowników w zakresie zielonych kompetencji, jaki i działania pracodawcy w zakresie szkoleń i edukacji ekologicznej są statystycznie istotne, ale pracodawcy większy nacisk powinni kłaść na edukację ekologiczną zatrudnionego personelu w powiązaniu z zajmowanym przez nich stanowiskiem pracy.

SŁOWA KLUCZOWE: zielone zarządzanie zasobami ludzkimi, działania prośrodowiskowe przedsiębiorstw, ekologiczny kontekst HR, model regresji logistycznej, zielone miejsca pracy i zielone kompetencje

Beata SKUBIAK

IDENTYFIKACJA I DELIMITACJA OBSZARÓW PROBLEMOWYCH NA PRZYKŁADZIE WOJEWÓDZTWA ZACHODNIOPOMORSKIEGO

STRESZCZENIE: W Polsce, mimo tego, że istnieje już coraz bogatsza literatura poświęcona gospodarce regionalnej, wciąż jest zapotrzebowanie na wiedzę zakresie różnych wymiarów i aspektów rozwoju obszarów problemowych. Przyczyną tego stanu jest szukanie sposobów na zdynamizowanie rozwoju kraju, znalezienie nowych możliwości aktywizacji zarówno ośrodków wzrostu, jak również, a może przede wszystkim, obszarów słabo rozwiniętych, zacofanych, obciążonych ukrytym bezrobociem w rolnictwie i pozbawionych cech, jakie sprzyjają rozwojowi nowoczesnej, opartej o wiedzę, gospodarki właściwej XXI stuleciu. Kluczowy problem, który został podjęty w niniejszym artykule, dotyczy tego, jakie kryteria powinny być brane pod uwagę przy delimitacji obszaru problemowego, aby interwencja publiczna była skuteczna i przyczyniała się do pożądanych zmian?

W artykule zaprezentowano metodę delimitacji obszarów problemowych na przykładzie modelu pięciu kapitałów. Studium przypadku stanowi województwo zachodniopomorskie.

SŁOWA KLUCZOWE: obszar problemowy, delimitacja

Elżbieta LOREK, Paweł LOREK

POSTAWY SPOŁECZNE WOBEC ELEKTROODPADÓW A REALIZACJA ZASAD GOSPODARKI OBIEGU ZAMKNIĘTEGO

STRESZCZENIE: Artykuł porusza kwestię elektroodpadów i roli konsumenta urządzeń elektrycznych i elektronicznych w organizacji gospodarki obiegu zamkniętego. Celem artykułu jest (i) identyfikacja podejść badanych konsumentów do nieużytkowanego sprzętu elektrycznego i elektronicznego, (ii) ocena spójności wykazywanych postaw z zasadami gospodarki obiegu zamkniętego oraz (iii) identyfikacja najważniejszych czynników wpływających na te postawy. W części teoretycznej odniesiono się do kwestii takich jak: subiektywność postrzegania elektroodpadów przez konsumentów, rosnącej ilości elektroodpadów w skali globalnej i problemów związanych z ograniczonymi możliwościami recyklingu. Przeprowadzone badania ujawniły potencjał badanych konsumentów dla organizacji gospodarki obiegu zamkniętego w zakresie zagospodarowania elektroodpadów, jak również czynniki zagrażające w postaci deponowania elektroodpadów do strumienia odpadów komunalnych. Analiza wykazała również korelację postaw wobec elektroodpadów z czynnikami takimi jak wiek, płeć i wykształcenie. W podsumowaniu usystematyzowano najważniejsze problemy konsumentów związane z zagospodarowywaniem elektroodpadów i zasygnalizowano przeprowadzenie dokładniejszych badań w tym zakresie.

SŁOWA KLUCZOWE: gospodarka obiegu zamkniętego, elektroodpady, zachowania konsumenckie

Elżbieta BRONIEWICZ, Mirosław BRONIEWICZ, Beata SKUBIAK, Artur BRYLIŃSKI, Paulina GRABOWSKA

ADAPTACJA ISTNIEJĄCYCH OBIEKTÓW BUDOWLANYCH DO NOWYCH WARUNKÓW UŻYTKOWANIA

STRESZCZENIE: Celem artykułu jest ocena kryteriów, które są brane pod uwagę przy podejmowaniu decyzji o adaptacyjnym, ponownym wykorzystaniu istniejących budynków. Ponowne wykorzystanie istniejących obiektów budowlanych poprzez ich modernizację i przystosowanie do nowych warunków użytkowania jest zgodne z koncepcją zrównoważonego rozwoju, ponieważ umożliwia przedłużenie okresu ich użytkowania bez ponoszenia znacznych nakładów finansowych. Koncepcja adaptacyjnego wykorzystania istniejących budynków związana jest z teorią gospodarki o obiegu zamkniętym, według której obiekty budowlane należy projektować i budować uwzględniając procesy, w którym odpady z jednego procesu są wykorzystywane jako surowiec do innego. Ogranicza się wówczas zużycie surowców, zmniejsza ilość odpadów i minimalizuje zużycie energii. W artykule omówiono kryteria, którymi powinny kierować się samorządy, architekci i projektanci przy podejmowaniu decyzji o ponownym wykorzystaniu budynku. Kryteria zostały sklasyfikowane jako kryteria techniczne, ekonomiczne, społeczne i środowiskowe. W artykule przedstawiono, zweryfikowane metodą ankietową, preferencje obecnych i przyszłych decydentów, którzy są zaangażowani w adaptacyjne ponowne wykorzystanie obiektów budowalnych.

SŁOWA KLUCZOWE: adaptacja budynków do nowych warunków użytkowania, renowacja, obiekty budowlane, kryteria

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