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Implementation of Ecological Sustainability Goals in Public Industrial Heritage Facilities in Europe

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Abstract: Industrial heritage tourism has been subject to increasing visitor interest, making Europe's old factories, mines, and steelworks into attractive tourist installations. However, these facilities, like all other market players, impact the environment, and, therefore, their management should take into account achieving sustainable development goals. The purpose of this article is to identify key sustainability measures taken by public industrial heritage tourism facilities in Europe to protect the environment. This article discusses the results of a survey of administrators of public industrial heritage facilities in Europe. This research was carried out using the Computer Assisted Web Interview technique, sending a research questionnaire to facilities associated with the European Route of Industrial Heritage. The results indicate that these entities are taking numerous measures to implement environmental sustainability patterns, particularly in the areas of waste segregation, pollution and waste generation reduction, and low energy consumption in equipment purchases. Unfortunately, the survey shows that many of the stated actions are not being implemented, as only one in four managers has implemented a formal program related to the implementation of at least some sustainability principles or training conducted in this regard. Managers of industrial heritage sites also advocate for increased national and international cooperation between sites. The author also draws attention to the need to acquire green technologies and communicate the effects of these activities to stakeholders.

Keywords: sustainable development; management; public facilities; post-industrial heritage; heritage tourism; Europe

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1. Introduction

The demise of a small industrial plant, factory, or even an entire industrial area is associated with difficult changes affecting both the owners and employees of these facilities, as well as all other stakeholders in these entities. Nevertheless, history proves that a sad post-industrial landscape does not at all have to mean the complete collapse of the business in operation, but, on the contrary, it can be an opportunity to start another life cycle for a defunct industrial facility, giving benefits to its heirs. Most often, these heirs are the next generation of residents of the post-industrial area, reacquainting themselves with the ways of their ancestors.

Notably, the growing number of facilities and even post-industrial tourism routes in the 21st century proves that industrial heritage continues to arouse great interest among tourists and residents of post-industrial areas. As an example, data from the Guido Mine and Coal Mining Museum in Zabrze, Poland, show that the number of tourists and

visitors to the Industrial Monuments Route in Silesia from 2009 to 2022 is marked by an ever-increasing development trend, increasing the number of visitors each year by an average of 82,000 people [1,2]. Projections for the coming years are also promising. The tourist motivations that drive visitors to visit such facilities vary, as the attributes of objects, installations, or intangible heritage are perceived differently by residents of a particular region who identify with the local culture and by tourists coming from outside the visited cultural area. W. Dragan and D. Gierczak [3] also draw attention to the negative emotions of residents who encounter monuments that remind them of their difficult history. R.P. Drianda et al. [4] mention primarily personal motivations, the search for authenticity, and nostalgia, but Y. Poira et al. [5] add landscape aspects to this set. Nevertheless, no matter for what reasons they visit the facilities, they experience a great deal of cultural value that not only expands their historical knowledge but also strengthens or realizes their cultural identity [6–8]. Awareness of this immense value of industrial heritage has often been the reason that authorities of post-industrial cities and regions have decided to undertake investments in the revitalization of facilities, installations, and even entire factories [9]. However, this is still an uncommon practice [10]. As evidenced by the history of many facilities on post-industrial tourism routes [11], some of them belonged to private owners, who often decided to sell the inherited plant rather than undertake costly revitalization investments. The resulting post-industrial facilities, revitalized with city and regional budgets, have the character of public entities.

Public post-industrial heritage tourism facilities in Europe are most often subject to public administration at various levels of local government, and, as their activities are subsidized or completely financed from municipal and provincial budgets, they do not have the character of economic entities like private facilities. Consequently, they do not have to carry out competitive activities in order to make their operations profitable, as these are subject to local government funding. They are not exempt, however, from the other social goals adopted by the local governments that oversee them, including environmental management practices.

The purpose of this article is to identify key sustainability measures taken by public industrial heritage tourism facilities in Europe to protect the environment. Realization of this article's purpose required conducting its own research in key European industrial heritage facilities, interviewing their administrators and managers. The course of this research therefore undertook to answer three research questions:

1. What are the extent and ways of implementing ecological sustainability goals in public industrial heritage tourism facilities in Europe?
2. How are employees of such facilities involved in the policy of implementing sustainability principles?
3. What are the needs of European industrial heritage sites in terms of (a) investment needs related to ecological principles of sustainable development and (b) the need for mutual cooperation?

It was also important to determine the authenticity of the facilities and their exhibits and displays.

The answer to the research questions posed fills the research gap resulting from the insufficient representation of research on the implementation of the principles of sustainable development within the activities of public industrial heritage sites. The lack of knowledge in this area may significantly reduce the quality of management of these sites, because external financing received by public heritage tourism sites does not oblige their managers to build a competitive advantage by implementing savings and is often only an image factor. From a theoretical point of view, it seems reasonable to identify a new point of balance of the conducted activities, taking into account both the goals of continuous development of the tourist activity of industrial heritage sites while

maintaining a high level of authenticity of sites and exhibits and the implementation of sustainable development assumptions.

The research process, however, first includes a review of recent literature addressing the topic of cultural heritage in terms of its preservation, value estimation, and management and then narrows the issue to the provision of industrial heritage and the key principles of sustainability for this activity.

2. Literature Review

Due to the limited volume of this article, the scope of the literature discussed is limited to the most recent works on cultural heritage and the principles of sustainable development that can be implemented by providing access to heritage, so, except for a few instances of pre-2024 works clarifying the necessary issues, the literature review is based on recent works. Research on cultural heritage, especially post-industrial heritage, will be discussed first, and then the issue of sustainability in relation to ecological and social assumptions in the field of cultural heritage preservation is considered. The literature review adopts a thematic criterion for selecting literature published in the Elsevier database mainly in 2024 and early 2025. Significant scientific works explaining the origins of the research problems undertaken are also considered.

2.1. Post-Industrial Heritage

Cultural heritage is one of the extremely important issues of modern societies, as it not only makes it possible to learn about the cultural achievements of a certain collective of people but also defines the cultural identity of the indigenous inhabitants of the areas where both the values and valuable resources of the local culture are passed on from generation to generation.

Heritage tourism is defined in a variety of ways, usually in terms of the value it provides to tourists. The World Tourism Organization [12,13] defines it as the movement of people for cultural purposes, such as study tours, artistic and cultural tours, and travel to festivals and other related events. Some define it as travel based on a longing for the past and a desire to experience the cultural diversity of landscapes and forms [14]. There is also a literature on heritage tourism as a process of giving anthropogenic meaning to artifacts in the form of stones, mud, metal, or wood, creating a form of cultural heritage from them [15]. Still others mention two types of heritage tourism [4]. The first concerns the material components of culture and cultural heritage, and the second is based on the experience of consuming heritage resources and deriving unique personal value from it.

There is also no shortage of characteristics of cultural heritage tourism through the prism of direct material means that the tourist finds attractive for tourism [16]. They can take on a material dimension, in the form of buildings, installations, and even places and settlements, and an intangible dimension in the form of artistic creation, tradition, and other attributes of local culture.

In the case of industrial tourism, the material dimension will therefore concern, for example, an object (building, settlement) or a workplace, machines, and work tools, while, in the intangible dimension, it may refer to the method of work, the history of the plant, or even entire branches of industry, as well as the culture of work and cultural elements of the local or regional community associated with a specific industry. N.C. Johnson [17] saw yet another value in heritage tourism. He saw it as a set of commercial transactions that simultaneously create an ideological framework for history and identity. D. Zhong et al. [18], based on a review of the literature, remind us that cultural heritage, including industrial heritage, is an important factor in creating and maintaining the cultural identity of local society. It transmits not only memories and emotions resulting from contact with cultural resources but also creates a space for local collective memory, describing the

development of manufacturing activities from the dawn until the collapse of industrial civilization. It is also a component that strengthens trust in local culture, and, thus, also improves the ability of societies to integrate despite globalized cultural patterns. Interestingly, D. Zhong et al. [18] not only support these theses with the advantages of implementing cultural asset revitalization practices but also point out the consequences of abandoning heritage revitalization. Such activity can lead to the destruction of historical industrial resources and the loss of unique regional and local cultural features.

On the other hand, Q. Gu et al. [19] discuss various aspects of the impact of the revitalization of industrial areas and facilities on society. They cite interesting examples of how the revitalization of industrial heritage has influenced the revitalization and regeneration of cities such as London, where gas tanks in the King's Cross district have been transformed into residential apartments and offices, giving the area an attractive appeal. Or they cite the example of the revitalization of the Oberhausen Gasometer in Germany, turning a massive 1927 gas tank, which disfigured the landscape, into an exhibition space and art galleries, which at the same time affected the city's social identity.

Q. Gu et al. [19] also emphasize the value of strengthening the educational and cultural components of facilities undergoing revitalization focused on industrial history, as exemplified by Gasholder No. 8 in Prague. Finally, they refer to the economic dimension of heritage revitalization, stimulating the development of tourism, and cite as an example the transformation of yet other gasometers—the 1920s Gasometer Duisburg (Germany) functioning as a diving center and the 1950s King's Lynn Gasholder (England) now serving as a park. The final argument by Q. Gu et al. [19] is the impact of the reuse of post-industrial infrastructure on the realization of sustainable development principles. At the same time, the aforementioned examples point to numerous practices for promoting green spaces and reducing the impact of the construction of buildings on the environment, reducing waste emissions from eventual demolition and many other environmental savings.

C. Balcan et al. [20] proposed an interesting optimization model based on values and attributes to support the design of cultural routes. The model was applied to the design of the route of ancient water supply facilities in Istanbul (Turkey). Its usefulness is based on the tool's use in designing trails, providing an opportunity to regulate economic income and reducing the negative effects of excessive tourism.

In contrast, Li M. et al. [21] focused their research on intangible cultural heritage, proposing a new narrative structure for message enrichment and a process model for constructing narrative texts of intangible craft heritage. This allowed the researchers to reduce the bias of cultural trait transmission in narratives of intangible cultural heritage.

Another work referring to natural language, this time in the evaluation of local environmental texts, is the article by Y. Chen et al. [22]. In their study of 624 documents from 303 world heritage cities, they point out how differences in income and levels of scientific and educational development contribute to the quality of document preservation at the local level.

The literature also offers ideas for activating the local community through various forms of contact with cultural heritage. An interesting study on the evaluation of digital participatory practices in cultural heritage management was conducted by Y. Zhang et al. [23]. They have developed a framework for assessing the digital participation of youth in the dissemination of cultural heritage.

Many research papers involve the use of modern technologies in cultural heritage preservation. For example, F. Wang et al. [24] use convolutional neural networks (CNNs) to diagnose moisture damage in heritage buildings. On the other hand, Y. Hu et al. [25] propose using polyacrylonitrile–nano silver–oregano oil electrospun fiber membrane in the analysis of microbial deterioration of cultural heritage, while Y. Qian et al. [26] study

stone cultural heritage using the metabolic potentials of microbial-driven carbon, nitrogen and sulfur cycling. In contrast, A. Towarek et al. [27] utilize artificial intelligence (AI), or machine learning, in analytical chemistry, using them as exhibits in cultural heritage.

Some of the recently published scientific works concern the application of engineering achievements in the protection of cultural heritage. Among them, interesting ideas are presented by X. Bai et al. [28], C.C. Barbaro et al. [29], X. Li et al. [30], and S. Mandal et al. [31], as well as B. D'Orsi et al. [32], T.K. Gireesh Kumar et al. [33], Q. Hu et al. [34], or P. Zhao et al. [35].

Another interesting scientific solution in the study of cultural heritage facilities is the methodology of G. Wei et al. [36], based on remote sensing (RS) and geographic information systems (GISs) in understanding disaster risk, or the literature review of G. F. Salazar et al. [37], who also referred to vulnerability of cultural heritage facilities to flooding, indicating a set of 22 indicators of vulnerability to flooding.

In contrast, N. Bai et al. [38] are using spatial and temporal mapping of public risk perception to cultural heritage during radical events. Interesting examples they use are events such as the Notre Dame Cathedral fire in Paris and the 2019 flood in Venice. The spatial and temporal mapping they propose can be effectively used, among other things, in surveys of public opinion on events also related to heritage and to test algorithms for their spatial and temporal clustering.

H. Wang et al. [39] take up the interesting topic of heritage gamification, that is, the use of game mechanisms in cultural heritage for visitors' understanding of the historical and cultural significance of exhibits. They envision that interactive technologies will be involved for this, using augmented and virtual reality or 3D reconstruction or other artificial intelligence capabilities.

C. Breen et al. [40] focused on the development of an integrated model for the management of maritime cultural heritage, through a program for mapping and documenting endangered cultural heritage facilities and landscapes. The authors refer to the implementation of the UN Sustainable Development Goals, specifically Goal 14, focusing on the protection and sustainability of oceans, seas, and marine resources for sustainable development. Similarly, M. J. Andrade et al. [41] focus on two examples of good practice in intervening in a port's industrial heritage. The focus of their research is shipyards, which are an extremely valuable but endangered element of industrial heritage.

Much of the scholarly work addressing the topic of heritage directly addresses industrial heritage [42] and its technical issues. Often, however, these works are in the nature of technical protection of heritage facilities or facilities. For example, I. Tissot et al. [43] focus on the study of industrial heritage machines, evaluating their technical elements (substrates, coatings, lubricants, and operating mechanisms).

There are also works that undertake economic valuation of industrial heritage. E. Bertacchini and V. Frontuto [44] note that the two most important attributes worth preserving are the preservation of significant landmarks and the intangible component of an industrial facility. In their article, they evaluate the economic valuation of the Baosteel steel factory (Shanghai). Their experiment expands the knowledge of valuing post-industrial heritage in the context of its revitalization. The valuation of industrial heritage under uncertainty has also been addressed by Q. Zhao et al. [45]. They, however, used cloud theory and Dempster–Shafer theory.

The extremely diverse range of heritage issues can be seen if only by looking at the research of Q. Gu et al. [19], who focus on alcohol and wine heritage. The authors consider the impact of stimuli associated with this heritage on the experiential value and behavioral intentions of tourists. In doing so, they provided insights into how to design and enhance tourists' incentives at heritage facilities and their brand loyalty.

An interesting example of industrial heritage research is the work of G. E. Gürcanlı et al. [46], who analyzed the impact of industrial heritage revitalization projects on the community. They highlighted the economic benefits and the transmission of the memory of local history in the local community that the revitalization of post-industrial facilities brings. Their goal was to focus on revitalization projects that can have an even broader impact than discussed in most academic works. It addresses both social impact management and sustainability in heritage facilities.

D. Zhong et al. [18], in turn, relied on place theory to reveal seven combinations of strategies for revitalizing industrial heritage. These strategies may relate to artistic expression, landscape and space, history and culture, humanistic references, industrial construction, and architectural features and construction skills.

Interesting research results on the relationship between perceived value, satisfaction, and loyalty of tourists at industrial heritage facilities were obtained by the team of N. Qiu et al. [47]. The results show that perceived value has a positive effect on both tourist satisfaction and persistence. It turns out that satisfaction has mediating roles between perceived value and tourist persistence, while gender has a moderating role in various aspects of the model. The authors also note that the attractiveness of industrial heritage tourism continues to assume an upward trend, so caring for industrial heritage resources enables the harmonious integration of industrial spaces but also contributes to the development of the tourism sector.

On the other hand, F. Scaffidi [48] undertook an assessment of the impact of social and territorial innovation on the revitalization of industrial heritage in European cities. The results described show a correlation between social innovation and the level of territorial innovation and confirm that innovation depends on location, new uses, and the revitalization model.

In his research, L. You [49] focused his research on energy savings in buildings by providing knowledge on optimizing the thermal environment of buildings. These efforts can help promote some of the principles of sustainability in industrial heritage buildings.

H. Yue et al. [50] showed how smart city development is revitalizing the city's industrial heritage. In doing so, they recognized that such revitalization increases public trust in government. The researchers advocated a holistic approach to urban revitalization, encompassing both the social/economic and ecological aspects, which, in consensus, leads to the sustainability of these spheres of the city. In connection with the fact that the process of recreating cultural heritage is also an important element of heritage [51], it is worth noting the advantages of original objects and installations. In this respect, the literature indicates the concept of authenticity as a measure of interference in authentic heritage. It is worth adding that authenticity in heritage tourism, on the other hand, is subject to personal evaluation. Therefore, it is assessed through the prism of the memory, experience, and cultural background of the tourist [52].

It is also necessary to emphasize works that directly relate to the goals of sustainable development. An example is the model of restructuring an agro-cultural heritage facility by Y. Zhang et al. [53], oriented towards the realization of the goals of sustainable development. On the other hand, Z.-Y. Yin et al. [54] emphasize the importance of heritage tourism in achieving sustainable development goals. A.J. Rios et al. [55] confront the presence of sustainability with resilience and anthropocentrism in the face of Industry 5.0 assumptions, while L. D. Thuc et al. [56] relate to climate change by contributing to the development of policies for sustainable heritage conservation. C. Galluccio and F. Giambona [57] have even undertaken to measure sustainability over time. Due to the importance of the issues addressed, the works mentioned will be discussed in more depth.

2.2. Issues of Sustainable Development

The issues of sustainable development elaborated in the findings of the United Nations (UN) and achieved in many scientific works published since the 1970s are no longer only a way to reduce the negative impact of humans on the environment, but, over time, have become a standard for conducting economic and social activities.

Today, the most recent document shaping the tenets of sustainable development is the 2030 Agenda for Sustainable Development [58], adopted in 2015 by all UN member states. Despite being controversial due to its inclusion of many left-wing demands that contradict the attitudes of conservative circles, it represents a common plan to achieve peace and prosperity both for people and for the planet, in the present and future. The 2030 Agenda includes 17 Sustainable Development Goals and 169 tasks aimed at taking care of the three dimensions of sustainable development—economic, social, and environmental. Therefore, it is worth emphasizing that sustainable development is an idea that is important to increase the sustainability of human impacts on the environment, economic activity, and the quality of life of societies, but, at the same time, it is a way to save indigenous cultures and traditions, which are elements of cultural heritage. Thus, the protection of heritage, especially cultural heritage, becomes the fulfillment of the goals that sustainable development adopts in the developed agendas.

Sustainable development is an idea that has been worked out for half a century by diverse social circles and directed towards increasingly precise goals. Interestingly, Agenda 21 [59], adopted in 1992 in Rio de Janeiro, included measures to build a global partnership to improve people's lives and protect the environment. Also, as part of the Millennium Declaration [60] in 2000 in New York, eight millennial goals were developed aimed at reducing extreme poverty. In 2002, in Johannesburg, poverty eradication and environmental protection were again declared but already within the framework of a multilateral partnership. Further actions were included at the United Nations Conference on Sustainable Development, held in Rio de Janeiro in 2012. The resulting document pledged to develop a set of Sustainable Development Goals (SDGs), resulting in the 2030 Agenda for Sustainable Development (the so-called 2030 Agenda), announced in 2015, which includes 17 goals that should be achieved over the next 15 years, i.e., by 2030. Work on these documents continues as the needs of various countries and communities, identified over time, are incorporated into the idea of sustainable development. They are currently addressed by the Division of Sustainable Development Goals (DSDG) in the United Nations Department of Economic and Social Affairs (UNDESA).

While sustainable development is an idea understood and accepted by most of the world's communities, it is not always understood in the same way. The main objection to the wording of Agenda 2030 is the use of undefined terms, which are interpreted by different communities according to the political and moral views they promote. The extremely capacious concepts of procreative health protection and procreative rights included in some of the Agenda's goals are examples of concepts that are interpreted ambiguously. Inaccuracies in the measures taken to achieve the goals of sustainable development in certain situations distort this valuable idea by using it to promote certain ideologies that contradict the values of parts of society. This poses a huge threat to the realization of the Sustainable Development Goals for such societies, as their rejection of even a few practices that contradict their values can lead to the rejection of, or at least distancing from, the entire agenda. It is also critical to continually expand the Sustainable Development Goals with further aspirations and obligations. Meanwhile, any system of rights and obligations overloaded with their number over time becomes a useless set of unfulfillable assumptions, and, thus, the whole, even the most legitimate idea, loses its meaning.

It should also be acknowledged that even the elements of protection of cultural heritage were not originally included in the assumption of sustainable development, since the efforts made were limited to improving the quality of life and ecological activities, i.e., protecting the environment (air, water, flora, and fauna). The UN conference held in Stockholm in 1972 focused on environmental threats. Thus, care for the environment was included among the primary tasks of states, and the Declaration of the United Nations Conference on the Human Environment [61] was drafted, including 26 principles, of which the only heritage that was included was that of wildlife (Principle 4). Nevertheless, this was a document initially formulating the principles of sustainable development. It was only in subsequent documents formulating the principles of sustainable development that attention was paid to cultural heritage.

Thus, the protection of cultural heritage took a form coordinated with the protection of the environment under Goal 11 of Agenda 2030 (Goal 11, Make cities and human settlements inclusive, safe, resilient and sustainable). This goal is detailed in the fourth task of its implementation (11.4), namely, by emphasizing the need to strengthen efforts to protect and safeguard the world's cultural and natural heritage. Furthermore, reference to the promotion of culture can be found in the implementation of Goal 4, which is to provide quality education for all and promote lifelong learning. The Seventh Action (4.7) taken to achieve this goal sets the horizon of 2030 as the intended moment to achieve the acquisition of knowledge and skills needed to appreciate the contribution of culture to sustainable development. Also relevant to the topic at hand is Goal 8 aimed at promoting stable, sustainable, and inclusive economic growth, to be achieved, among other things, through (8.9) the development and implementation of policies that promote sustainable tourism that promotes local culture and products. Goal 12, on the other hand, to ensure the achievement of sustainable consumption and production patterns, should seek to develop and implement tools to monitor the impact of sustainable development on sustainable tourism that creates jobs and promotes local culture and products. Thus, these are goals that directly relate to the protection of cultural heritage, especially local communities.

3. Materials and Methods

To determine the determinants of the implementation of sustainability principles at post-industrial heritage tourism facilities, scientific research was performed. In the implementation of this study, a database of tourist facilities associated with the European Route of Industrial Heritage (ERIH) association was used, which is a tourist information network about industrial heritage in Europe. It includes over 2200 facilities from all European countries, represented by 316 members (owners and administrative institutions). As a result, they created 16 systematic thematic routes, making the heritage of European industry available [62]. In total, 73 industrial heritage sites participated in this research, but only 36 of them had the status of public entities, and it is to this group that the discussion of this research was narrowed down.

This research was conducted through interviews with managers and administrators of the facilities in December 2021 and January 2022. The interview form included eight thematic groups, including questions on sustainability activities, implementation of open innovation in post-industrial tourism, and implemented business models at the facilities. This research was conducted using the CAWI (Computer Assisted Web Interview). The link to the survey was sent directly to the emails of all facilities associated with ERIH, along with a letter of recommendation from the association. Facility administrators and managers completed the survey in accordance with the instructions and comments included in the questionnaire. This research was carried out as part of the research work

conducted by the Institute of Economics and Computer Science of the Silesian University of Technology.

The database of ERIH-affiliated facilities during the research period included 316 heritage tourism facilities operating throughout Europe. The thematic scope of cultural heritage provided by most ERIH-affiliated facilities relates to production and manufacturing, mining (including salt mines), iron and steel making, transportation, textile and paper industries, landscape, and housing and architecture. They also include those on communications (radio and telephone), water installations, and services and leisure industries, as well as war and other events relevant to cultural heritage.

Nearly one in four ERIH-affiliated facilities (23%) agreed to participate in the survey, but only 36 facilities were public (the rest were in the form of private entities or NGOs). In this analysis, the discussion of the results is limited to only those facilities that were public in nature. These facilities were located in 11 European countries (Portugal, Spain, Finland, the United Kingdom, Slovenia, Croatia, Germany, Ireland, Poland, France, Belgium) (Figure 1).

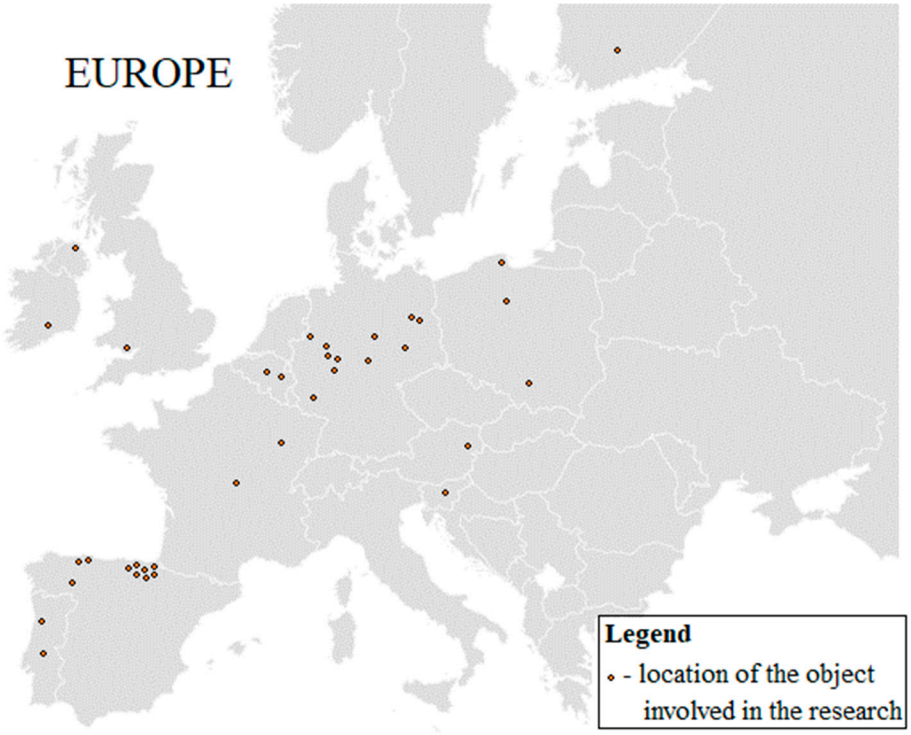

Figure 1. Map of the locations of the facilities involved in this research. Source: own study.

Among the facilities surveyed, 16.7% operated for a full year, 36.1% for more than six months, and the same number for less than six months. Only one in ten facilities (11.1%) were not open to the public and only had other public functions.

The surveyed facilities varied greatly in terms of the number of tourists visiting them, as among them there were both those that did not receive tourists (two facilities) and those that served more than 700,000 tourists (two facilities). Thus, the empirical area of variation in the number of tourists at the surveyed facilities ranged from zero to 10.1 thousand tourists per year, with a median of 4.2 thousand visitors. The data were collected in the form of a database and subjected to statistical analysis using MS Excel and STATISTICA 10.0 spreadsheets.

Managers of the facilities surveyed were asked to rate the authenticity of the heritage displayed in or by their facilities (on a scale of 1 to 5). The scale used was a stepped stimulus (Likert scale), where a rating of 1 was assigned to objects and displays lacking

authenticity (reconstructed), and five to original objects and displays (totally authentic). It was the only quasi-quantitative variable. All other variables were qualitative. Due to the obtained data structure, statistical analysis was limited to qualitative analysis, taking into account the structure index and possibly the level of significance of differences between fractions estimated using the nonparametric Chi-square test. Dichotomous or multivariate variables reduced to dichotomous also enabled the use of the Yule coefficient (φ) for 2 × 2 contingency tables.

4. Results

In this part of this work, the results of the conducted research on the implementation of the principles of sustainable development in facilities promoting post-industrial heritage will be discussed. Before this happens, however, it is worth mentioning the important issue of assessing the authenticity of facilities and their exhibits and exhibitions.

As the analyses showed, the average authenticity rating of the cultural heritage on display at the surveyed facilities was 3.86 ± 0.96 (Me = 4), which indicates the high authenticity of the cultural heritage on display. The predominant ratings were 4 (47.2%) and 5 (25.0%). This means that almost three out of four managers (72.2%) have cultural heritage values of the highest quality, and, as such, they realize one of the essential sustainability goals for this activity.

4.1. Ways to Achieve Sustainability Goals in Industrial Facilities and Their Impact on the Environment

The implementation of the principles of sustainable development involves many considerations. Each action or procedure taken to protect the natural or cultural environment requires a prior analysis of the situation against which the next steps are taken. Introducing any rules without analyzing and thinking through the consequences is risky, to say the least, for the system being interfered with. Solutions implemented unthinkingly, for example, in the name of fashion or popular ideology, can be counterproductive. Therefore, it is indispensable to properly analyze the process. This is no different in facilities promoting post-industrial heritage in Europe.

In the research conducted, managers and administrators were asked many questions only indirectly related to sustainable development. In doing so, they supplement knowledge about the facilities, giving it context. One such question is the issue of managers' perceptions of changes in the popularity of their facility, which is related to an attempt to determine the general trend of popularity of this issue among visitors and especially among young people. It turns out that 16.7% of managers perceive that interest in cultural tourism is declining from year to year at their facility, and 22.2% have no opinion in this regard, but as many as 61.1% of respondents disagree. The difference between the fractions concerning extreme opinions with the obtained number of responses is statistically insignificant ($p = 0.053$) at the adopted p-value ($p < 0.05$) but close to this limit. This emphasizes the maintenance of an upward trend in the popularity of facilities promoting post-industrial heritage.

Determining the direct impact of the activities undertaken on the environment was also deemed essential. The basis here was the subjective assessment of the managers, treated as experts who know their own facility best. Clearly, each facility is important in spreading the cultural heritage it represents, but it is worth determining whether, in doing so, it is impacting the environment, and, if so, how. According to their managers, every other facility surveyed shows a positive (44.4%) or very positive impact on the environment (5.6%), and only one in ten facilities assesses this impact as negative (11.1%). As many as 38.9% of respondents indicated that their facility's activities had no impact on the environment in which it is located. This means that at least a neutral impact on the

environment is declared by 88.9% of the surveyed facilities (Figure 2). Also, in this case there is a statistically insignificant difference between the extreme fractions ($p = 0.155$). A statistically significant difference occurs only when comparing the percentage of objects indicating a negative and at least neutral impact ($p < 001$).

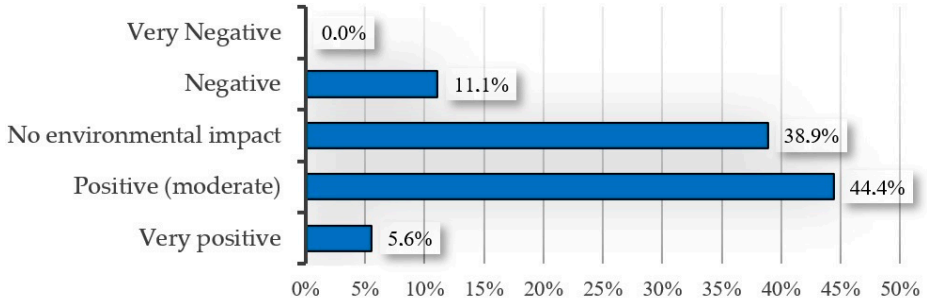

Figure 2. Assessment of the impact of the facility on the natural environment. Source: own study.

The respondents were asked about the facility's implementation of environmental sustainability principles. The vast majority of responses were related to waste separation, a practice that 55.6% of the surveyed facilities followed. A significant number of facilities (41.7%) also introduced measures to reduce pollution and waste generation, and one in three facilities (33.3%) takes into account the criterion of low energy consumption when making purchases. Slightly fewer facilities (27.8%) are eliminating plastic utensils in their food service operations by replacing them with biodegradable or reusable ones. The same number of facilities obtain energy from renewable sources and reduce the facility's water consumption. Other measures are declared by few facilities (Table 1).

Table 1. Activities undertaken by facilities for the sustainable development of their promotional activities.

Actions Taken by Objects	% Answers	% of Objects
Segregation of garbage	18.9%	55.6%
Reduction of pollution and waste generated	14.2%	41.7%
When purchasing electrical devices, the parameter of the energy class of the device is an important parameter taken into account	11.3%	33.3%
In the case of a gastronomic offer, the use of reusable or disposable dishes and cutlery made of biodegradable materials	9.4%	27.8%
The use of energy from renewable sources	9.4%	27.8%
The use of solutions limiting water consumption in the facility	7.5%	22.2%
None of the above	6.6%	19.4%
Selling souvenirs and issuing materials made of recycled materials	6.6%	19.4%
Generation of own renewable energy	5.7%	16.7%
Reduction in transport requirements	5.7%	16.7%
Participation in programs to reduce greenhouse gas emissions	4.7%	13.9%

Source: own study.

4.2. Employee Involvement in the Policy of Implementing the Principles of Sustainable Development

When considering the questions directly related to the issue addressed in this article, it was noted that the managers of the surveyed facilities generally stop at sustainability measures, limiting themselves to promoting the heritage they represent, and some, even if they implement relevant formal measures, are only declarative. Our research showed that only one in four managers has implemented a formal program related to

sustainability principles (27.8%), and the rest have either not done so at all (52.8%) or are unaware whether such procedures exist at the facility (19.4%).

In all facilities where the implementation of such principles was declared, the involvement of employees in taking environmentally friendly actions was indicated. Employee awareness in this regard was carried out through training on roles and responsibilities towards sustainability. More proactive activities were performed by 80% of the facilities, as they communicated the adopted sustainability policy to both customers and contractors. Only one in three facilities (30%) took measures to monitor customer satisfaction with the facility's sustainability efforts (Figure 3).

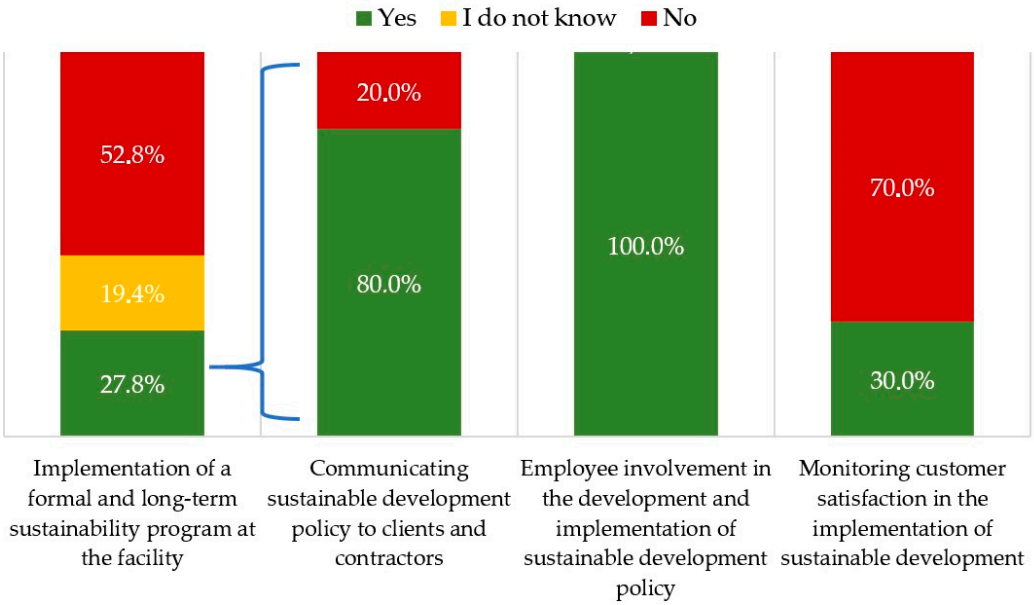

Figure 3. Implementation of sustainable development principles in a post-industrial heritage facility. Source: own study.

The question about employee involvement in the facility's sustainability implementation policy was deepened to include the topics of training provided and procedures implemented. It turned out that the primary actions taken by employees were to reduce electricity consumption in their facilities (25%) and to implement programs to save water and other natural resources (20%). Overall, 15% of facilities are selecting waste and taking climate protection measures. One in ten facilities (10%) has implemented a program to reduce air emissions and protect against infection (understandable after the post-pandemic period). Only 5% of facilities declared implementation of a recycling program in their operations (souvenirs, promotional materials) (Figure 4).

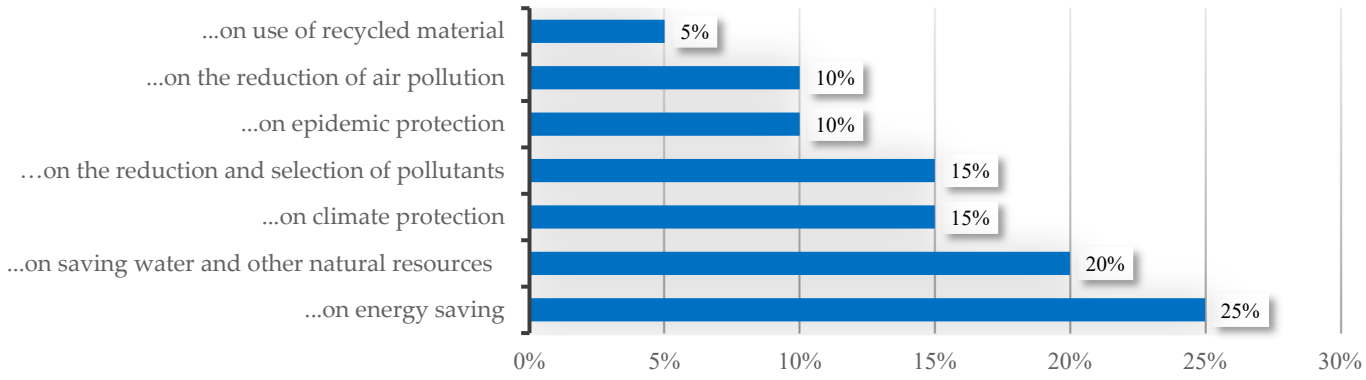

Figure 4. The primary actions taken by employees. Source: own study.

The surveyed facilities also reported some need to develop promotional activities as cooperation with other facilities. The situation also provides an overview of the current state of cooperation. Thus, one in five managers (19.4%) is satisfied with the current international cooperation between their own and other facilities. Even fewer, only 13.9% of managers, rate the current situation of domestic cooperation, or lack thereof, as adequate (sufficient). The overwhelming majority of managers show a desire to change the current situation, declaring the need to expand both domestic (86.1%) and international cooperation (58.3%). Statistical nonparametric tests confirm that the percentage of managers indicating the need to expand international cooperation is significantly higher than the percentage of managers satisfied with the current situation ($p < 0.05$). The situation is slightly different in the case of domestic cooperation ($p = 0.074$). A comparison of supporters of expanding domestic and foreign cooperation indicates a significant predominance of the opinion that it is foreign cooperation that should improve over domestic cooperation ($p = 0.023$).

Using the association measure, it was also noted that there is a moderate positive correlation ($\varphi = 0.342$) between the fact of implementing a formal sustainable development program and the declaration of impact on the natural environment. This means that in many cases, facilities with a formal program simultaneously declare a positive impact on the natural environment. In the analysis of the remaining comparisons, no significant qualitative correlations were observed.

5. Discussion

The cited review of recent references shows that the literature on cultural heritage often refers to the principles of sustainable development. An example is the work of the already-mentioned Y. Zhang et al. [53], who developed a model for restructuring an agro-cultural heritage facility. Their work captures the issue in the context of the integration of culture and tourism, especially agro-culture. The resulting restructuring model is also geared towards the realization of sustainable development. They prove that the spatial disorder in the place of making agro-cultural heritage available is due to the imbalance of physical space, fragmentation of cultural space, and complications of social space, and the answer to these problems is precisely the model of restructuring the heritage facility. Perhaps this is an interesting proposition for industrial areas, which, in the light of the obtained results, also demonstrate the need to implement a system solution that can be based on the mutual cooperation of facilities.

The issue of making cultural heritage accessible in the context of tourism is also considered by Z.-Y. Yin et al. [54], who focus on the attributes of virtual tourism in cultural heritage. They make an attempt to determine the benefits and value of this form of sightseeing, which can be a response to the sustainable development of cultural heritage facilities and objects. With this, they list 29 attributes (23 benefits and 14 values) of virtual tourism in cultural heritage facilities. On the other hand, A.J. Rios et al. [55] discuss how the architecture, engineering, construction, management, operations, and maintenance industries can prepare to adopt the new principles of Industry 5.0. The authors hope to bring about improved cultural heritage conservation practices following this approach. They note that sustainability is widely discussed, while resilience and anthropocentrism are insufficiently emphasized in research aimed at adopting Industry 5.0. Similar conclusions can be drawn from the results presented here, as the examined post-industrial tourism facilities also show deficiencies in the implementation of the fifth industrial revolution, especially in the area of environmental protection. Undoubtedly, introducing

the possibility of virtual tourism to the offer of heritage facilities can be one of the solutions supporting the implementation of the assumptions of Industry 5.0.

The topic of protecting cultural heritage facilities in the context of climate change is the subject of research by L.D. Thuc et al. [56], in which they proposed a prioritized quantitative model for identifying barriers to cultural heritage preservation. Through this, they identified 22 barriers, six of which they identified as key, among them, limited human resources, lack of funds, user behavior, and limited community participation. Research by L.D. Thuc et al. [56] can contribute to the development of strategies and policies for sustainable heritage preservation also in public industrial heritage sites.

Also of interest in the context of the sustainability of heritage facilities is the work of C. Galluccio and F. Giambona [57]. They measure sustainability over time by examining the role of museums and cultural heritage in local development. They note that the link between sustainability and the preservation of cultural heritage has already been recognized by the International Council of Museums [63], and their task in this context is *to make facilities such as museums attractive to communities*. But, as they rightly point out, this is not the only role of such facilities, as they positively influence tourism employment and the quality of human and social capital in general, as well as carry out their educational mission by providing the public with knowledge connecting it to the past.

The perception of post-industrial heritage facilities has also undergone a significant change in the past five decades. An example may be the facilities that remained in Poland after the socio-economic transformation in the 1990s. The collapse of communism and the transition to a free-market economy meant that old, unprofitable industrial plants, overnight deprived of state funding, began to deteriorate, and those that were still profitable began to pass into the hands of private owners for virtually a song. Residents of the industrial areas affected by the transformation and, at the same time, by massive unemployment, were deprived of their sources of income, and the plant that had previously provided them with financial stability became a disfiguring vacant lot, reminiscent of a traumatic period of poverty. Despite the loss of stable jobs, they did not lose the cultural heritage associated with the region in which they lived and the work they did. This is evidenced by the many customs and still living traditions of heavy industry still present in areas of Upper Silesia (Poland) [64].

Nowadays, we can conclude that the area has turned from a steel belt into a rust belt, as is currently observed in some areas of the US. At the same time, the rust belt observed in the northeastern states of the US is also associated with significant internal migration of residents of cities that have ceased production of steel and related products. In Europe, the migration that took place at the turn of the 20th century was also associated with the decline or reduction of production in heavy industry plants but also with the fall of the Iron Curtain, i.e., the opening of borders to residents of Central and Eastern Europe. A large part of the population of the post-communist countries emigrated to western Europe, assimilating into the new cultures. However, most of the area's residents remained in their regions, preserving their ancestral culture and traditions. Even the few post-industrial factories were restored, while others were demolished. The significant development of post-industrial tourism made the post-industrial plants revitalized in the early 21st century not only a new source of income but also a way to save the region's post-industrial heritage. Although the revitalization efforts undertaken for post-industrial facilities were not related to the realization of the idea of sustainable development, they fit in well with it.

The contemporary outlook on the business of brownfield redevelopment is aimed at deriving income from it. Business models for post-industrial heritage facilities are being developed, as well as schemes for transforming such facilities into culturally valuable tourist attractions [65]. Numerous regional networks of post-industrial facilities in

Europe, adapted into hiking trails, i.e., automotive post-industrial tourism routes, are also experiencing a heyday [64]. These facilities, continuing to expand their exhibitions with new exhibits, and developing tourism and hospitality activities in the process, are beginning to function like any other business in the market. Thus, they bring valuable assets generated for the customer, value assumed by the enterprise, and value for the benefit of society. Yet, while bringing certain value, they also generate that which does not serve the environment and the indigenous culture of the region. Hence, too, the need for post-industrial heritage facilities to realize the principles of sustainable development. Although, in a way, it seems that at least the aspect of heritage preservation does not have to be significantly considered here, it is worth noting that some facilities, in order to expand the audience of their offerings, develop their activities so significantly that they lose the dimension of authenticity and thus contradict sustainability. Meanwhile, the authenticity of a tourist site is a universal value and, at the same time, a force motivating tourists to visit tourist destinations [66]. In this situation, it seems important to determine the authenticity of post-industrial heritage facilities in Europe and the activities they undertake to achieve sustainable development goals.

Notably, though, the post-industrial heritage facilities that are the subject of the research activities undertaken, although they have a public status, function as administrative entities that often also carry out socio-economic activities and as such have an impact on the environment. Therefore, it is reasonable to also pay attention to those environmental sustainability goals of Agenda 2030 [58] that should be implemented in post-industrial heritage facilities. These are goals such as the following:

- Goal 3, especially its Task 3.9, which mandates a reduction in deaths and illnesses caused by air, water, and soil pollution and contamination;
- Goal 6, which, in Task 6.3, mandates a reduction in water pollution and an increase in recycling and safe reuse of materials, and, in task 6.5, indicates the need to implement integrated water resource management at all levels;
- Goal 7, which, in Tasks 7.2 and 7.3, imposes the need to increase the share of renewable energy sources in the global energy mix and to double the rate of increase in global energy consumption efficiency;
- Goal 12, which endeavors to develop benchmarks for efficient use of natural resources (12.2), to manage all types of waste throughout its life cycle (12.3), to reduce waste generation through prevention, reduction, recycling, and reuse (12.4), to encourage companies to implement sustainability practices and include sustainability information in their cyclical reports (12.6), and to promote sustainable procurement practices (12.7);
- Goal 13, which emphasizes taking urgent action to address climate change and its impacts by strengthening adaptive capacity and resilience to climate risks and disasters (13.1), integrating climate change into national policies, strategies, and action plans (13.2).

Although these selected goals have the status of national and international aspirations, they must be implemented by entities at every administrative level, which, in the economic context, means that socio-economic entities, which are almost always polluters or users of natural resources, are also directly affected. Meanwhile, confronting the available knowledge with the results of the conducted research, it should be stated that, although the mentioned goals are implemented in some industrial heritage facilities, unfortunately they remain mainly in the form of declarations. Also, the ideologization of tasks aimed at sustainable development of the world may be the main threat to the realization of objectively reasonable assumptions. It also seems necessary to incur significant research and development investments aimed at the development of technologies that enable the realization of sustainable development goals, since at present

many of them do not take into account climatic differences even within Europe, nor the ability to transfer so-called clean energy.

Figure 5 presents the theoretical structure of the links between individual stakeholders in the implementation of ecological sustainable development goals in public industrial heritage sites. It shows the mutual relations between the individual elements included in the author's research, including the ecological assumptions of sustainable development, especially those resulting from the implementation of SDGs no. 3, 6, 7, 12, and 13. However, this process requires a systematic approach to the implementation of ecological strategies not only at the management level but also by all employees of the site. Another important practice is communicating the undertaken pro-ecological actions and their effects among suppliers, the financing entity, investors, and sponsors, and, above all, among the direct recipients, who are visitors to the industrial heritage site.

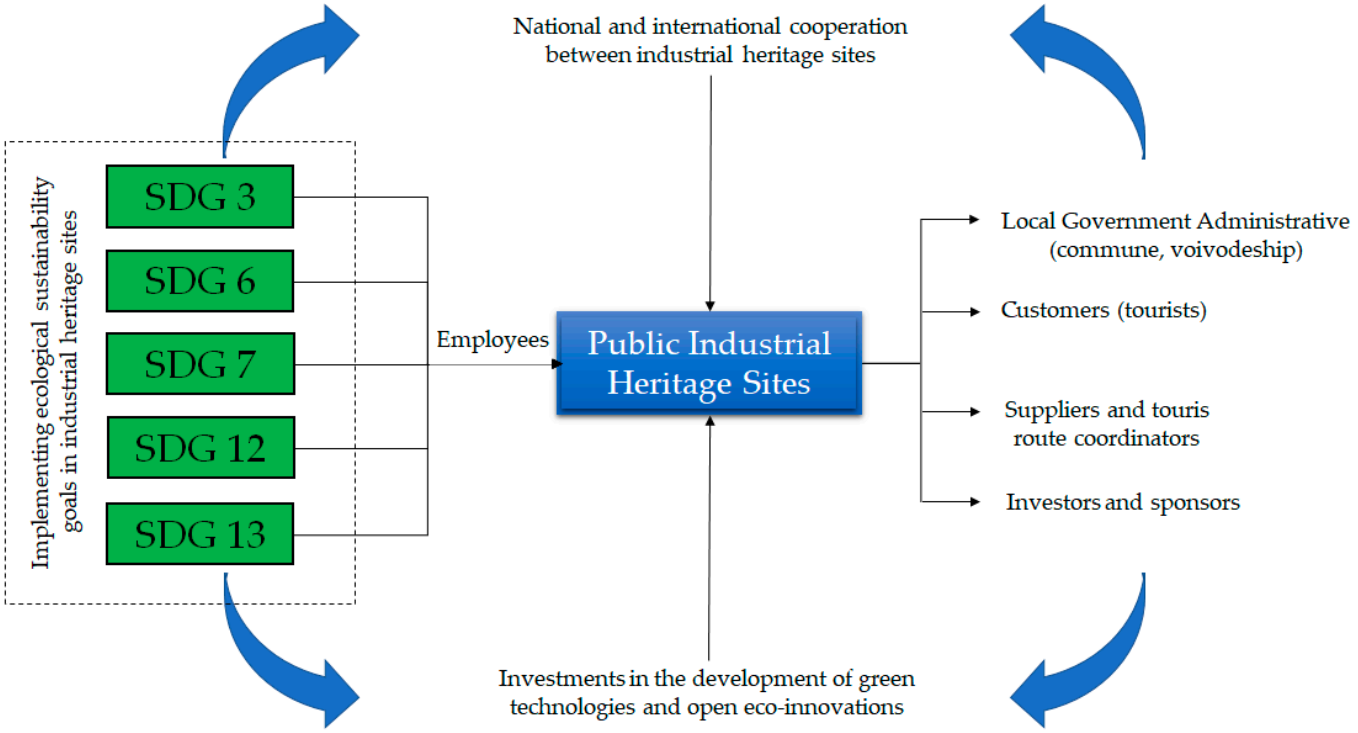

Figure 5. Scheme of relationships between stakeholders in the implementation of sustainable development strategies in public industrial heritage sites. Source: own study.

It is also important to strengthen protective actions through national and international cooperation in the exchange of experiences and the use of investment programs aimed at implementing innovative technologies. An important way of exchanging and transferring knowledge, including pro-ecological technologies, is the concept of open innovation [67], which can play an important role in managing cultural heritage tourism [68].

6. Conclusions

Research carried out in the field of post-industrial heritage, which is part of cultural heritage, in Europe is generally carried out in the form of activities of tourist facilities. Post-industrial tourism facilities established in the past few decades in Europe have become important units of cultural heritage protection. Surveys of ERIH-affiliated public post-industrial heritage facilities have shown that they have very valuable displays and facilities highly valued for their authenticity. In doing so, they implement several

principles of sustainable development, formulated in the form of goals, specifically goals 4, 8, and 11 and the recommendations of Goal 12.

Of particular importance here is the implementation of Goal 11. It defines the aspiration for cities and human settlements to be safe, stable, sustainable, and inclusive. One of its forms of implementation (11.4) is to strengthen efforts to protect and safeguard the world's cultural and natural heritage. Its tool dimension is also one of the recommendations for the implementation of Goal 12, namely, to ensure sustainable consumption and production patterns by developing and implementing tools to monitor the impact of sustainable development on sustainable tourism that creates jobs and promotes local culture and products (12b).

In terms of other goals relating to environmental protection, public post-industrial heritage facilities undertake numerous activities that implement sustainable development patterns. These include, in particular, measures to segregate waste (55.6%), reduce pollution and waste generation (41.7%), or consider low energy consumption when purchasing equipment (33.3%). A positive or highly positive impact of the facility on the environment is perceived by one in two managers (50.0%), while 38.9% rate it as neutral.

In terms of formal measures taken by managers, the situation leaves much to be desired, as many of the measures mentioned remain in the declarative layer. Only one in four managers has implemented a formal program related to the implementation of the sustainability principles being implemented (27.8%) (research question 1). In all of these facilities, training was provided, and employees were made aware of the action program (research question 2). The majority of facilities communicated the adopted sustainability policy to both customers and contractors. Measures to monitor customer satisfaction with the implementation of sustainability were introduced at one in three facilities.

The author's research also showed the need for managers to change the current situation of cooperation with other facilities. Most declare the need to expand both domestic and international cooperation (research question 3b). It is worthwhile as well to take investment measures to develop technologies for obtaining energy from natural sources or recycling waste and reducing exhaust emissions (research question 3a).

It should be emphasized that the conducted research has significant research limitations. The survey addressed individual issues based directly on the opinions of managers without verifying the declared information and in-depth interviews. Another limitation is the limitation of this research to public facilities in Europe, which, at the same time, made it impossible to compare the results for public and non-public facilities, as well as European and non-European ones. It is also important to note that studies may suffer from selection bias. This is because managers who do not implement the principles of sustainable development in their facility could avoid taking part in this study. Unfortunately, despite an attempt to avoid this drawback through the patronage of the ERIH association, only one in every four facilities took part in this study.

The obtained results indicate the need to direct future research to the perspective of developing practical solutions for the systemic implementation of ecological aspects of sustainable development. These solutions should contribute to the implementation of new practices protecting the natural environment and not only to declaring the willingness to use them. The possibility of cooperation between facilities on the principles of open innovation should also be taken into account, i.e., by exchanging knowledge in the field of green technologies and eco-innovation.

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