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Orginal Article

Methods of revitalisation of former mining areas as exemplified by architectural objects worldwide and own studies

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Abstract: Post-mining grounds and spoil tips frequently render landscapes permanently flawed. As a result of mining activity, considerable stretches of land are often permanently excluded from further use. Due to the extensively transformed landscape, it is necessary to implement revitalisation processes. Relevant design and investment activities, coupled with the cooperation of specialists such as architects, civil engineers, geotechnicians, hydrotechnicians and environmental engineers, along with local authorities, can offer a comprehensive functional programme for areas degraded by mining and provide local residents with an attractive leisure area. This article discusses the current state of knowledge on the revitalisation of former mining areas, with special regard to architectural, environmental, social, and economic aspects. The aim of the study is to review and promote design solutions which permanently restore previously degraded areas to local communities. Various concepts of revitalisation of degraded areas are presented, based on examples of landscape architecture at home and abroad. The selected examples comprise natural regeneration, reclamation, and ecological engineering. These are examples of a holistic and modern approach to the development of tourist and environmentally active areas in post-mining sites and spoil tips. Furthermore, the study presents the authors' proposal concerning the revitalisation of a spoil tip area at LW Bogdanka mine for winter sport purposes and other activities, for which the demand was signalled by their management. The discussed examples can serve as an inspiration for future actions and executive projects, undertaken in accordance with the guidelines of Agenda 2030 and Fit for 55 policies.

Keywords: revitalisation, landscape architecture, mining, sustainable development

1. Introduction

Revitalisation of former mining areas is a critical challenge that has to be faced by many regions worldwide. Although mining was the main driving force behind economic growth and industrial development, it has also exerted a substantial adverse impact on the environment. Disused mines, transformed landscapes and, as a result, areas excluded from human activity, are just some of the challenges that need to be addressed. However, there are ways to restore areas to a vital role, serving a local or even regional community, through effective revitalisation strategies.

The starting point for discussion on the possibility and necessity of undertaking revitalisation works is the gradual and continuous process of phasing out mines in Europe. This process is largely influenced by the directives of the European Union and the United Nations, aimed at improvement in the human environment and the implementation of sustainable development principles, which also encompass revitalisation processes discussed in the article. Agenda 2030 [1], also signed by Poland [2], is a crucially important initiative that defines sustainable development guidelines for the world. Another key policy is the European Green Deal with the "Fit for 55" package. Quoting the directive, it is: "a set of legislative proposals to amend and update EU legislation and introduce new initiatives with the aim of ensuring that EU policy is in line with the climate goals agreed by the Council and the European Parliament" [3].

Sustainable development encompasses stopping environmental degradation, as well as rational use and protection of natural resources. It is associated with a need to increase the utilisation of renewable energy sources and to phase out power plants based on fossil fuels. These measures lead to significant landscape, economic and social changes in industrial areas [4]. It is a complicated process connected not only with the transformation of the landscape but also closely related to spatial development, urban planning, housing, transport, social issues, the economy, and employment structure. Thus, the final phase of mining, that is closing mines down, is not the ultimate stage on the way to achieving the goals of the Green Deal, but just a step towards restoring full functionality to a given region [5]. Before it produces an intended effect, the revitalisation process of former mine areas can last for years and encounter numerous problems [6]. The issues of closing mines down are discussed not only in Poland but also in other European countries. Relevant strategies and plans are implemented in, e.g., Germany, the Czech Republic, and Scandinavian states [7-9]. Germany was the first to deal with the closure of coal mines, beginning with the replacement of a part of its own output with the import of fuels. In the course of time, social and environmental issues connected with the degradation of former mining areas started to be addressed [7]. The German example demonstrates that challenges related to energy transition, as well as gradual restoration of functional value to post-mining areas, are the right and attainable policies which, however, demand the involvement of many sectors and institutions, as well as a broad and holistic approach to the problem [10].

This study analyses the key issues and challenges connected with the revitalisation of former mining grounds from the perspective of an architect whose task is to bring the areas in question back to their function serving local residents' needs, their social development, job keeping, and reducing the adverse impact of the phased-out mining activity on the landscape. The article examines solutions to environmental, social and economic problems in post-industrial areas, based on case studies from various regions of Poland and Europe. Furthermore, it presents an overview of methods applied in the revitalisation of post-mining grounds, based on case studies and authors' own works. The authors point both to passive methods of revitalisation, that is the natural regeneration of former mining areas, and active

ones, consisting of the development of relevant infrastructure in order to adapt an area to its new functions. By examining international case studies, the article provides a holistic view of different strategies and architectural interventions implemented in various cultural and geographical contexts. This global perspective allows for a more nuanced understanding of the challenges and opportunities associated with the revitalisation of former mining areas.

The primary objective of the article is to analyse challenges and opportunities connected with the revitalisation of former mining grounds. The article comprises a case study, an examination of established solutions, and the author's recommendation, which is founded on analyses and conceptual designs applied to the surveyed area of LW Bogdanka. These solutions have been developed in alignment with the latest European environmental initiatives and the principles of sustainable development. The article aims to contribute to the dissemination of knowledge in this important field and to provide a theoretical and conceptual basis for further practical actions.

2. State of the art

Revitalisation of former mining areas is a broad and complex issue that needs to be examined in many aspects. As it has already been mentioned in the introduction, only a holistic and long-term approach to the problem can help choose the right directions in the restoration of areas degraded by mining to the community. Hence, the research has to address numerous aspects, such as ecology, legal circumstances, as well as socio-economic, technological, and architectural issues (the latter being the main focus of this study), and many others. The issues associated with the energy policy of Poland and Europe, and related legal regulations (especially the European Green Deal and plans for 2030) are discussed by A. Tajduś and S. Tokarski [11]. They highlight the potential significant decrease in coal production post-2030, primarily due to the depletion of coal deposits. Additionally, the authors emphasise that Poland could potentially benefit from European funding for energy transition. This is of particular relevance to the present study as it helps establish the timeframe for the future revitalisation work examined in this article. A similar subject is also explored by M. Malec, J. Kamiński, and P. Kaszyński [12], as well as F. Green and A. Gambhir [13]. These authors underscore the diminishing demand for fossil fuels and the necessity for mining management to embrace new development strategies. This is helpful in planning a schedule of further revitalisation activities coordinated with the process of closing mines down.

The issues broadly connected with mining phase-out and revitalisation of former mining areas are frequently discussed in scientific literature, which may attest to the topicality of the problem. The focus is on challenges related to the aforementioned issues and on examples of solutions undertaken. This subject is explored in scientific works both in Poland and abroad. Domestic problems concerning possible adaptation of working mines to produce green energy and using the infrastructure that has remained after their mining activity, are discussed by, among others: J. Duda, A. Frejowski [5], J. Bondaruk [5, 14]. Furthermore, A. Harat et al. [6] explore the opportunities for limiting the adverse impact of mines on the environment after they are closed down. Moreover, the authors analyse related economic aspects. They examine various aspects, including the potential for repurposing mines for renewable energy generation and alternative utilisation of post-mining sites. These aspects align with the scope of analysis undertaken in this article. The study also highlights the practical challenges associated with mine decommissioning and underscores the intricacies of the processes involved.

Similar problems occurring in European countries are discussed e.g. by: M. Gosar et al. [5], H. Gerbelowa et al. [4], L. Lehotsky and M. Černík [8], M. Fermeglia et al. [16], as well as P. Oei, H. Brauers and P. Herpich [17]. The studies investigate the domains encompassing closed and abandoned mines, exploring their environmental implications. They also delve into the planning challenges that emerge due to the presence of such areas, offering valuable insights pertinent to the subject matter examined in this article. Furthermore, these referenced works offer an examination of development strategies aimed at bolstering mining regions. These works are case studies which deal with examples of energy transitions, completed or ongoing in various European regions. This testifies to the coherence and topicality of these issues both at the national level and in Europe.

Information concerning documents, resolutions, and agendas connected with the energy transition and related activities can be found in [1-3,18]. The guidelines presented in the aforementioned documents are interpreted e.g. by P. Czyżak and M. Hetmański in their scientific works [19]. Understanding the foundational principles of strategies connected to the European energy transition is paramount when it comes to formulating plans for the utilisation of post-mining areas in alignment with the recommendations outlined in the previously mentioned documents. The authors are committed to ensuring that the planned and suggested revitalisation solutions are executed in accordance with the principles of sustainable development.

The issues being the focus of this study, that is revitalisation of former mining areas, are also explored thoroughly in scientific literature. It is worth paying special attention to studies by A. Ostręga [20-25], R. Uberman [10, 23-27] and M. Cała [21] who, in a series of scientific studies, present results of research on methods and national experiences of land reclamation after mining. The researchers mentioned here delineate the evolution of reclamation and revitalisation concepts in Poland. They not only analyse but also highlight effective practices and strategies that contribute to social and economic progress. These studies represent a comprehensive case study, offering valuable insights into the most pertinent factors involved in the revitalisation of post-mining areas. They highlight the problems connected with spatial management, land ownership, and legislative processes which could enable or facilitate the effective revitalisation of post-industrial areas. These issues are also explored in other Polish scientific works authored by U. Myga-Piątek [28], R. Prusak [29], M. Bruchal and M. Kacprzak [30], S. Sypniowski and Z. Kasztelewicz [31], H. Wirth and W. Bujakowski [32], P. Czaja et al. [26], T. Wieja, J. Chmura and M. Bartos [33] and many others. The study underscores the challenges that stem from legal obstacles associated with developing post-mining areas as significant landscape features. It also emphasises the crucial roles played by architects and landscape architects in the revitalisation process. Additionally, it introduces the notion of performing a landscape audit, which serves as a valuable tool for establishing principles for protecting the landscape of the sites under investigation.

In their study, J. Bondaruk, J. Łączny and A. Janik [14] discuss the subject of restoring spoil tips to social function, focusing on the description of the problem and on socio-economic issues (including cost analysis). The work provides important guidelines for taking correct decisions in the design study presented in this article.

The issues connected with revitalisation of degraded areas are topical not only in Poland, but also in Europe and other parts of the world. Research on this subject is discussed in the scientific literature in Germany (P. Wirth, B. Černík-Mali and W. Fischer [34]), Slovakia and other countries (B. Gregorova et al. [35], H. Pavlova, L. Domaracka and N. Mitterpachova [36]). Within their research, the authors emphasise the tourism prospects associated with rejuvenated post-mining regions, recognising it as a pivotal element in the

local economy. They also underscore the necessity of involving local communities in the planning phase, in addition to advocating for systematic financial support from the government.

Global examples of revitalisation of former mining areas are discussed e.g. on the basis of Canada (R. C. Rooney and S. E. Bayley [37]) and USA (J. Hollander, N. Kirkwood and J. Gold [38]). The aforementioned works present cases of successful revitalisation, with special emphasis on good practices and effective solutions which contributed to restoring the degraded areas to a socially useful function.

Local circumstances, typical of the area where LW Bogdanka mine operates, are presented in the works by L. Kolanowski [39], M. Dmitruk [40], J. Kicki et al. [41]. The authors describe spatial development of the area in question, specify the reasons for such oriented expansion and point out problems connected with the site's further functioning in the future. These issues offer an important context for project decisions taken as part of the studies carried out.

Even though the issues of revitalisation of former mining areas in the context of possible architectural arrangement are not discussed thoroughly in scientific literature, such studies are conducted. The design approach to the arrangement of post-mining areas is explored by, among others: Z. Myczkowski et al. [42]. They describe the design method for architectural and landscape units and interiors (JARK-WAK) which consists in the analysis of the present condition and synthesis, that is drawing up development plans. A similar approach was attempted in the development of the presented concept.

In scientific literature, there are few analyses and design studies concerning revitalisation of post-mining areas in terms of architectural solutions. Hence, it creates a kind of a research gap that the authors try to fill in; however, leaving much room for further exploration and studies. The aforementioned research fields are just some selected issues related to the discussed subject. The authors are aware of the complex and multifaceted character of the explored topic which cannot be exhausted in a single article. The extensive research area of post-mining land revitalisation issues, demands comprehensive interdisciplinary research and analysis. The authors concentrate on matters associated with architectural design to encourage the utilisation of post-mining land and its restoration for the benefit of the local community following the cessation of mining activities. The analytical and conceptual works undertaken are intended to draw attention to the topicality of the issues discussed and highlight still existing functional potential of the degraded areas. The works collected and explored provide the theoretical background for proper interpretation of social needs, accurate definition of the time framework, as well as analysis of opportunities and threats, which are the basis for the presented and further discussions on design solutions.

3. Research methods

The objective of the research presented in the article is to provide an overview of challenges and opportunities connected with the revitalisation of post-mining areas and to offer insight into effective strategies and approaches to ensure sustainable development of such areas. The research methods applied comprise theoretical and practical studies – a conceptual design study prepared by the authors.

The theoretical research includes literature analysis of scientific articles, planning documents, existing design studies, as well as development plans, issued by LW Bogdanka company. This analysis provides insights into the directions of mining activities both domestically and internationally, as well as into plans and methods of post-mining land management. Furthermore, the category of theoretical research includes qualitative studies

based on a non-interactive technique, which consists of analyses of view, composition, function, and others, providing theoretical grounds for design studies in the field of architecture and landscape architecture. Moreover, theoretical research includes qualitative studies in the form of free interviews and written correspondence conducted with LW Bogdanka representatives for the purpose of gathering information about further development plans of the mine and explaining the materials received. Letters, publications, and other materials were received from the mine's management, containing previous project plans, defining further development strategies, and providing a basis for setting a direction for conceptual architectural designs presented later in the manuscript [39, 41, 43]. The method of comparative and evaluative research is applied by juxtaposing global examples of revitalisation of post-industrial areas of a similar type, influencing the solutions adopted in the authors' design study and serving as a reference model for it.

The practical research – a design study, is an example of conceptual solutions that may serve to indicate a direction for actual works carried out in the future. The presented conceptual project of dealing with a spoil tip explores technological capacities for land management in a way that takes into account the needs of local residents, respects landscape issues, examines technical opportunities, and complies with sustainable development principles.

The authors are aware of the need for much deeper technical, economic, and environmental analyses (and many more) at the pre-design stage. The presented architectural study was preceded only by the analyses necessary for the preparation of the design concept. Full studies and analyses will be continued in the future.

4. Example solutions – a case study

The presence of industry in the cultural landscape has become appreciated only recently. Proper revitalisation of an area begins with appropriate protection. Hence, it must harmonise with the society's high awareness of the legacy left by the industry. The perception of mine areas by the society is changing, but it is still ambiguous. What used to be seen as environmental pollution, devastating the landscape and non-ecological, has now started to be treated as a joint work of a human and nature, and an element of cultural heritage. Public awareness is growing, both in Poland and all over Europe. The recognition of the importance of cultural heritage in industrial zones is evident through the inclusion of these areas on the UNESCO World Heritage List. A prominent case, particularly important for this study, is the inclusion of the French Nord-Pas de Calais Mining Basin in the UNESCO list in 2012. This event left a lasting impression on all experts involved in the promotion and recognition of industrial landscapes [44]. The list now comprises over 100 sites from the basin, surpassing the number in Cornwall, previously recognised as one of the examples on the UNESCO-listed mining landscape.

The potential of coal mine sites is also getting recognised, although not solely on the basis of heritage awareness, but also by motivation to use the vast areas of spoil tips for revitalisation and commercialisation. In the case of a coal mine, extensive heaps of waste from coal processing are typically formed. An example of a good attitude towards the revitalisation process is the area of Rydułtowy Mine in the Silesian Province where, similarly as in Bogdanka, there is a significant spoil tip [21]. A design study has been undertaken and is gradually implemented in this locality. According to the study, revitalisation of a post-mining object should not be planned without considering such a significant context as analyses, field research and community interviews. A detailed study of the site (also historical) and of the local community's needs provides the basis for further projects. Both

historical and contemporary value of the mining landscape should be evaluated, and then directions of work and further actions should be planned accordingly.

In Poland, there are ca 150 mine spoil tips with a total area around 4000 ha. The majority of them (101) are located in the Silesia region: 78% have been reclaimed for forestry; 10% for recreation, while 12% for further industrial purposes [21]. It is worth noting that an important aspect determining possible management of a spoil tip is its shape. In the 1990s so-called cones were erected. They were formed by spot disposal with a field and line drive, which gave them considerable height and steep slopes. This technology was discontinued in the 1990s, but in KWK Rydułtowy mine there is still a cone built in this way, now called "Szarlota". Due to the steepness of hills, the only option for reclamation was to let the spoil tip overgrow. Thus, for a spoil tip to be properly revitalised, its shape should be planned at an early stage, before the beginning of storage and formation. At the same time, despite its troublesome cone shape, Szarlota has provided an inspiration for the form of a new spoil tip that is under construction nearby, with the latest technologies. Theoretically, it is also a cone but, more precisely, built of terrace layers of decreasing fields, stacked on top of each other, visually referring to the neighbouring heap. Such a structure of the spoil tip is possible due to proper transport and compression of gangue with bulldozers and rollers. The planned cone was intended to be the highest heap of this type in Europe. Only when it reaches the target shape, the spoil tip shall be transformed into a green area. Revitalisation of this space comprises the creation of parks and gardens with footpaths and cycling routes; while accompanying waste ponds, necessary for the previous operation of the mine, shall be sealed and converted into fish ponds. The whole area is to cover 45 ha [21]. This case analysis demonstrates the significance of the described spoil tips for the space where they are located. The Szarlota cone, despite being an artificial creation, has become an indispensable and important element of the landscape, penetrating and shaping the identity of the place. Local residents regard the spoil tip as the local pyramid, an element distinguishing the town, an icon or a legacy, and they see a huge recreational potential in it; hardly anyone considers it destructive to the environment. Therefore, the historical value of the entire mine surroundings was estimated. It was concluded that this value was high not only for the spoil tip but also, considering the mine buildings as a whole, for architecture of pit shafts, chimneys and office buildings which could be adapted to the museum function.

A very important example of adapting post-mining areas to new functions is the General Jerzy Ziętek Regional Park of Culture and Recreation, today known as the Silesian Park [45]. It was one of the largest ecological investments in Upper Silesia. The construction of the park was commenced in 1951 and its main initiator was Jerzy Ziętek. The 75% of its area is post-mining grounds, such as spoil tips, shafts, sinkholes and swamps, with a total area of about 640 ha covering Chorzów and Katowice. The design was created by a team of architects headed by Prof. Władysław Niemirski. The idea was to divide the area into two functional spheres. The central, forest area, crossed with alleys and footpaths, was intended for passive leisure, relaxation or physical activity, while the remaining area of ca 13 ha was designed as a place for culture and recreation. A stadium, a planetarium, a zoo and an amusement park were soon built. Local residents took part in the afforestation of the Park: about 3.5 million seedlings of trees and shrubs, of 70 varieties, were planted. The Silesian Park was growing quickly. In 1957 a 5-km narrow gauge railway was launched and in 1967 "Elka" cable car started operating. Next, in 1968, a camping site and a sport shooting range were opened in connection with the launching of a PTTK branch (Polish Tourist and Sightseeing Society) and a scout centre later. Furthermore, "Fala" swimming pool was opened in 1966, followed by "Kapelusz" exhibition hall in 1968, and a tower greenhouse, no longer existing, the highest in the world at that time. Moreover, a rope park was created in 2007. More plants were grown and currently the area boasts one of the most interesting

collections of flora in Europe. An integral element of the Silesian Park is the Rosarium which is the largest garden of this type in Poland. It has over 35,000 roses in 300 varieties. Currently, other plant species grow there, as well, and the garden covers 1.6 ha [46].

Moreover, the Industrial Monument Route of the Silesian Province was established, which comprises 40 objects associated with the mining heritage of Silesia [47]. There are also examples of adaptation of above-ground post-mining objects to cultural functions, such as an engine hall of Jerzy Shaft of Gottwald mine, which was adapted to the function of a chapel, or a former mine in Gorlice converted to the function of "Magdalena" Oil Industry Open-Air Museum. Other examples include the conversion of "Wilson" shaft top of "Wieczorek" mine into an exhibition hall, incorporation of "Gottwald" mine into Silesia City Center shopping mall, etc. (Gasidło). A valuable example is the adaptation of the entire group of buildings of "Gliwice" coal mine to be used by the Gliwice Entrepreneurship College, the Artistic Casting Department of the City Museum and many NGOs. What is important, these buildings previously housed meeting rooms, changing rooms and miners' baths, together with the machine room. The adapted objects were put into use already 10 years after the closure of the mine [45].

A noteworthy example of post-industrial area management is the "Alpin Center" ski slope in Bottrop, Germany, open all year. It was built on a mine spoil tip in 2001 and it is one of the longest indoor ski slopes in Europe (640 m long and 30 m wide) [47]. It is accompanied by a restaurant, "Revier" beer garden and other attractions. Moreover, it is not the only example of putting spoil tips to recreational use in Germany – the identical function was introduced on the municipal spoil tip in Neuss. Here, the ski slope is 300 m long and 60 m wide, and offers appropriate temperature conditions.

Another example of solutions similar to those proposed for the LW Bogdanka site is the revitalisation of the Bełchatów mine area. Numerous revitalisation concepts have been devised for this locale, one of which has already materialised in the form of a ski slope [47]. This ski slope, complete with artificial snowmaking capabilities, a four-person chairlift, and two additional platter lifts, has been erected on *Góra Kamieńska* (Fig. 1). The ski slope and its associated infrastructure span approximately 10 hectares. Additionally, there's a summer toboggan run, bike paths, as well as hotel and dining facilities at the mountain's base, along with equipment rental services and 400 parking spaces. In 2019, the reclamation of an overburden dump from the Bełchatów mine was successfully concluded. There is an ongoing debate for its potential future use for recreational activities[1].

The provided examples, although originally posing challenges, are highly suitable for conversion and social integration. When appropriately developed, they frequently yield numerous advantages and can serve as investment opportunities. Ultimately, they blend seamlessly with naturally occurring hills and play a vital role in terms of landscape, tourism, and recreational activities. What were once inaccessible mine spoil tips have now been transformed into gathering spots and appealing recreational areas for the public. This proves that similar solutions can also be applicable in the case of other mines, including LW Bogdanka discussed below.

[1] Following: PGE Górnictwo i Energetyka Konwencjonalna S.A. [48]

Fig. 1. Góra Kamieńska – chairlift and ski slope. Author: Adam Chamczyk (CC)

5. The concept of development of LW Bogdanka spoil tip – a case study, as the basis for the authors' solutions.

In the original development plans for the Central Coal Region – the Lublin Coal Basin (CRW-LZW) from 1979, the functional area was supposed to be much larger than it is now and cover 9 districts: Łęczna, Ludwin, Milejów, Spiczyn, Puchaczów, Cyców, Siedliszcze, Wierzbica, and Urszulin. The total area of CRW was planned to be 1105 km², including 240 km² of strictly mining field [49]. The functional area was to comprise the whole settlement structure; it was assumed that Łęczna would reach 70,000 – 110,000 citizens (nowadays there are just under 20,000) [40]. Out of concern both for the proper living conditions of the inhabitants of this area and for environmental issues, there were plans to protect the mining areas. As early as in the 1970s, it was planned to: secure environmental conditions, protect against noise by appropriately mapping out communication routes and their isolation, increase air purity norms by relevant protection zones, raise the share of green areas, also in miners' housing estates, as well as construct the Lublin Water Channel joining the Wieprz and Vistula rivers. Despite the limited spatial development of CRW-LZW, the impact of the mining industry on the local environment has been much more profound than anticipated [40]. Accumulation of coal stone waste led to the formation of a hill which is unnaturally large for the landscape of the Łęczyńsko-Włodawskie Lake District. The population density in the area is much lower than envisaged in the plans. The mine has been the major factor attracting potential residents. Once it is closed, the socioeconomic situation of the region shall change profoundly. However, the examined area has considerable tourist potential. The Poleski National Park, adjacent to the industrial area, already attracts a significant number of tourists. It means that these areas are attractive and should be taken care of, including mining

damage sites which, appropriately transformed, could become an attraction. In accordance with the plan to reach climate neutrality in the European Union, the aim is to give up coal in Poland by 2050 [11]. Despite the fact that the yearly output is much smaller than planned (ca 25 million tons per year were expected – currently, the output is about 10 tons) [40], the present extent of the spoil tip is 40% of the target area which is predicted at 230 ha. The spoil tip is visible from a 10 km distance today. Its north-western part has already been shaped, but it is still undeveloped as a whole.

In 2008, a design study was undertaken for the development of a spoil tip in Bogdanka [43]. A detailed analysis of the site was carried out and appropriate solutions were suggested. First of all, the target size of the heap was designed: it was supposed to resemble a naturally formed hill as much as possible – irregular, with two peaks, one 250 m above sea level and the other 10 m higher. Owing to the lie of the land, imitating the natural one, it was possible to design footpaths on the hill and an open-air museum, and to introduce a variety of plants. Another element included in the project was a ski slope. The site of the station, the chairlift, and two ski runs on the north-eastern slope were proposed (Fig. 2).

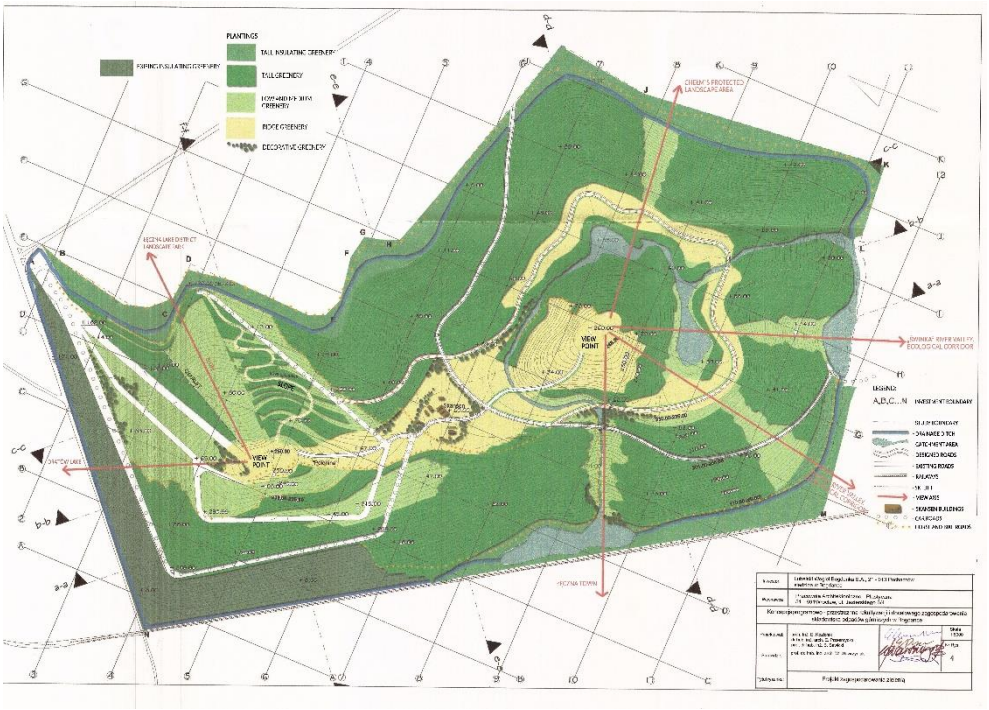

Fig. 2. Greenery development project, source: [43]

This example represents the most pertinent case study, serving as the foundation for the author's vision of spoil tip development in Bogdanka. It played a crucial role in forming the desired hill shape and size and offered guidance on development directions that align with the company's strategy [50] and the requirements of the local community. It's also worth highlighting the versatility of the solutions adopted, which are applicable irrespective of the season or prevailing weather conditions [51]. Despite the absence of a finalized station design at this juncture, this demonstrates that the present spoil tip remains amenable to conversion into a ski slope and other tourist attractions.

6. Authors' design concept – development of the original plan

The aforementioned design studies provided the basis for the solutions presented in this article. Furthermore, new detailed field analyses were prepared, grounded in the spatial, communication, natural, and compositional conditions. The character of the explored space is also of key significance. The design provides for the sustainable introduction of a new sport and recreation function, facilitating the development of the area and attracting people from outside the region. The new concept does not stand in opposition to the previous design, but attempts to supplement and expand it: most of the key elements of the ski resort are located in the previously planned sites or in their immediate vicinity. The planned configuration of the spoil tip is tailored to accommodate ski slopes designed for both beginners and intermediate skiers [52].

The decision to pursue the ski resort project on a mine spoil tip is not accidental. Considering the above-mentioned aspects, we can notice that the recreational function in the Bogdanka region is underdeveloped. The closest ski slope is located in Bobliwo, 70.2 km from the studied area, however, it lacks the comprehensive infrastructure required to manage tourist traffic. This slope has only a drag lift which is not a comfortable way of accessing the slope, frequently making the ascent difficult for beginner skiers and snowboarders. It also does not have ski slopes of varying length and difficulty. The nearest station with a chairlift is located in Chrzanów, 91 km from Bogdanka. Lack of such infrastructure in the region may result in a decrease in interest in winter sports among local residents or in the need to travel way beyond the Bogdanka area. In consequence, the area also lacks a factor that would attract tourists from outside and encourage them to come back regularly [53].

The surroundings of LW Bogdanka mine are attractive in terms of recreation in the summer season. There is Poleski National Park nearby, as well as numerous lakes (Piaseczno, Rogóźno, Rotcze, Uściwierz) and fishing reservoirs (Bikcze, Dratów).

The area has diverse nature, but its potential is untapped in autumn and winter. It should also be noted that communication is poorly developed: the only possible means of transport from nearby towns is by national road no. 82 connected with Bogdanka by a local road. Rail transport is intended only for the transportation of mining raw materials, even though a commercial railway connection would definitely boost tourism in this area. Before formulating the design concept, various field analyses were conducted, notably the spatial-view analysis. The study area is situated in the southern segment of the overall mine complex. In the Local Land Use Plan, the land plots within and surrounding the spoil tip are designated as "Storage and warehousing areas – PS," as well as "Public utility – PS/U", indicating their primary use post-reclamation for sports and recreation services. Consequently, this allows for the placement of facilities like a ski station with essential technical infrastructure, provided that the spatial organization is maintained. It also permits commercial establishments, including retail, services, dining, and associated amenities such as an open-air museum and agritourism.

The surroundings of the developed site exhibit a diverse composition. To the northwest of the spoil tip, the landscape is determined by the presence of dense, medium-height structures comprising the main segment of the mining facility. On initial observation, the area's environs may appear somewhat disordered, lacking planned scenic and compositional axes. The buildings display irregular layouts, varying colours, and are distributed across different parts of the complex. It's crucial to consider, however, that functionality and efficient use played a pivotal role in shaping this mining facility. All the structures, along with their forms and their interrelationships, are intricately linked to the requirements of coal mining and processing. The prominent features of this space include the towering mine shaft

and the heating plant's chimney. Notable structures visible from the main street encompass the coal processing facilities, as well as the administrative, office, and welfare buildings. These are typically rectangular blocks, adorned with gently sloping roofs and predominantly finished with corrugated sheet metal, featuring narrow strip windows.

According to data from the meteorological station at Lublin-Radawiec Airport, the average temperatures in 2021 per month were as follows (Tab. 1):

Table 1. Meteorological data in Lublin province

	January 2021	February 2021	March 2021	December 2021
Avg. temp. (ºC)	-1.9	-2.9	-2.6	-1.6
Days of frost	25	22	20	23
Days of snowfall	21	25	2	14

The climatological data from past years in the region indicate that the prevailing weather conditions have proven to be conducive, thereby presenting a compelling opportunity for the establishment of a ski resort situated on the reclaimed spoil tip of the Bogdanka coal mine. However, it is essential to note that these findings should be confirmed during the potential project implementation phase.

The guiding idea behind the development of the spoil tip was to design the architecture and the entire area with respect for the site's history. Particular parts of the resort should fit properly into the spatial context but also provide comfortable functional solutions.

The designed architecture is intended to be ascetic and austere, reminiscent of the Bogdanka mine's beginnings and buildings made of steel and wood (Fig. 3). In accordance with the project guidelines for 2050, it is supposed to reflect the character of an abandoned mine where the past merges with the future.

Fig. 3. Bogdanka coal mine – Archive photos, source: Kurier Lubelski [54]

Currently, the hill serving as a mine spoil tip is covered with undemanding and diverse self-sown vegetation, primarily consisting of birches and various grasses (Fig. 4). The matter of introducing vegetation plantings in the spoil tip area has been previously addressed and described in the "Programmatic and Spatial Concept for the Reclamation and Targeted Management of the Bogdanka Mine Spoil Tip" in 2008. Currently, the developed area exhibits diversity in terms of development progress. The northwestern section of the landfill has already undergone partial afforestation, achieving the desired incline. The vegetation primarily comprises shrubs and medium-sized trees, predominantly birches of up to 20 years

in age. In contrast, the inner portions of the landfill – the eastern and southern sections – remain operational, undergoing expansion and shaping. As per this project, the ongoing concept entails the introduction of a range of plant species to prevent monocultures and the avoidance of linear plantings. The ground is also to be initially fortified with leguminous plants. In this proposed concept, grass plantings are suggested in place of designated trails and footpaths, while in the areas remaining after land rehabilitation, on the periphery of the ski trails, and in the vicinity of the ski buildings, it's recommended to plant coniferous trees such as common pine, Norway spruce, European larch, and white birch as part of diversification efforts. At the elevated plateaus of the site, the proposal is to maintain grasses and introduce low-lying plants such as meadow clover, dandelion, and various flowering plants. Along the slopes and cliffs, the plan includes the use of low trees and shrubs like blackthorn, hawthorn, or rowan. Additionally, contingent upon favourable conditions, it's suggested to introduce trees such as maple and hazel. These tree species, identical to those naturally occurring in the region, can also be strategically placed near the heap. Come autumn, they will contribute to creating an attractive landscape on the slopes.

Fig. 4. View of the spoil tip during formation- visible self-sown plants, source: own study

The plan suggests utilizing the paths for both walking and biking during the summer season, as well as in the winter when skiing conditions are less favourable. The entire resort is designed to serve recreational purposes throughout the year. Additionally, the dining facilities, strategically situated on a hill and offering excellent panoramic views of the surrounding area, can also be used for hosting special events in various seasons. The project provides for the construction of two station buildings: bottom and top ones, and two chairlifts. One chairlift is located in the north-eastern part of the spoil tip as originally planned [43]. It joins the beginning and end of two ski routes: a ski run of 5-10% inclination and approximately 2 km long, located along the old technical road, delineated already at the beginning of storage, and a ski run of 12-21% inclination, 550 m long, corresponding to an intermediate level of difficulty [52]. Owing to the mild slope of the first ski run, it can be used as a technical and supply route also in the future. The other lift connects sections of an advanced route, with the steepest slope of 15-34%. It runs from the cone downhill through the centre of the spoil tip and is 430 m long (Fig. 5).

The main function of the bottom station building is a rental facility with additional necessary rooms, such as sanitary facilities, a cloakroom, ticket offices, and a small café. The building is designed in such a way as to reduce the risk of any traffic collisions. Therefore, all functions are placed along one communication lane and in smaller modules of the building, separated by strips of glazing (Fig. 6).

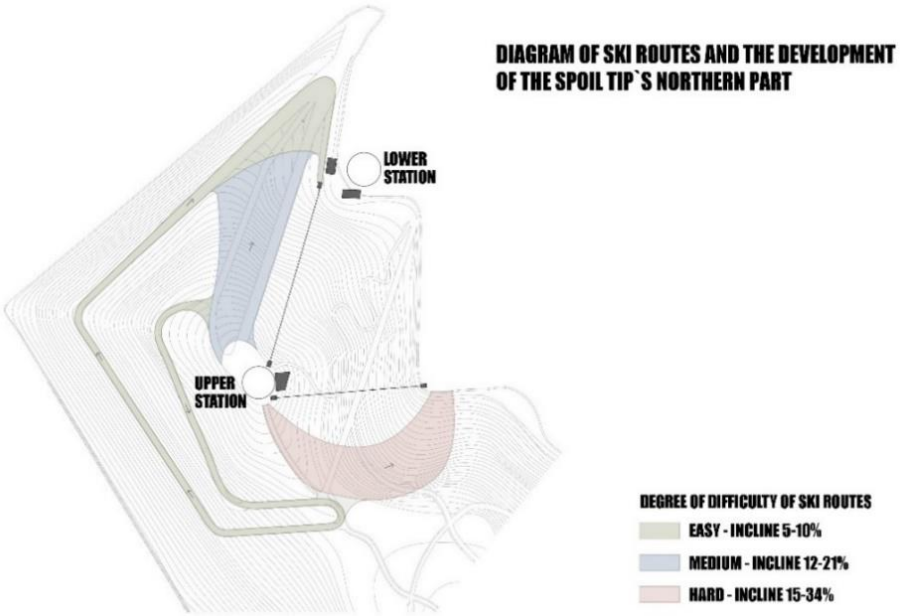

Fig. 5. Ski resort map: location of buildings and ski runs; author`s work

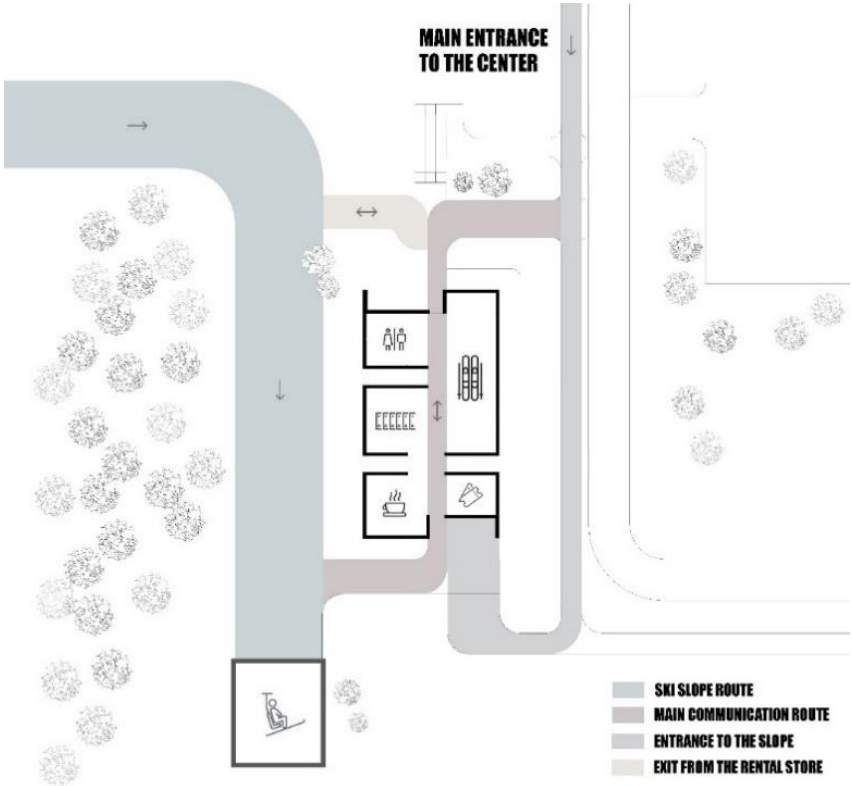

Fig. 6. Map of functions of the bottom station; author`s work

The form of the top station building is determined by its function. The building is an element of the ski slope. It emerges from the slope, bends upwards and hovers over the ski slope area. Its roof serves as a ramp from which it is possible to ski down the slope. The building is almost invisible from the hilltop: its presence is marked only by the attic walls. From the side of the slope, it stands above the ground on a crisscrossing structure reminiscent of lane overpasses entwining the spoil tip area. This structure makes the front wall of the building bend. The interior of the top station was designed without stairs, despite considerable differences in levels – it can be accessed by two ramps running from both ski lifts and meeting inside the building. The top station serves mainly as a catering facility. The proposed restaurant is designed as a bistro; there is also a separate bar with seats and an entrance to a mezzanine. The restaurant, suspended over the slope, offers an attractive view of the eastern side and the exit onto the lower terrace for open-air ski events.

Fig. 7. Visualizations of the top station building; author`s work

In terms of architecture, the appropriate selection of materials is of key importance for the design concept (Fig. 7). The black wooden façade boarding refers both to the main product of mining – coal – and to the simple wooden buildings that once existed here (Fig. 3).

Moreover, steel is the material on which the whole mining industry is based, which is why numerous steel elements are used in the buildings, e.g., truss structure or smaller elements, such as railings, that could reuse the steel left after the mine is closed.

The creation of a ski resort at the Bogdanka mine's spoil tip can have positive environmental implications. By repurposing the land for recreational use, it mitigates the negative environmental impact associated with mining activities. The ski resort also brings recreational and tourism infrastructure that can have a positive impact on the region's image. It could attract attention and visitors, potentially positioning the area as a desirable destination for winter sports enthusiasts. It also has the potential to bring in visitors from other areas, stimulating the local economy through tourism-related activities, especially when the mining function ceases to be of economic importance.

7. Discussion

Revitalisation of post-mining areas is a significant undertaking aimed at transforming former mining sites into new and functional spaces. Recreational water reservoirs, ski lifts, and tourist trails are developed in mining regions, contributing to the enhanced appeal of these areas. Many revitalised regions that have gained additional functions have experienced an increase in value. Similar solutions have been implemented in Poland and worldwide, as illustrated in the case studies presented in this article. An example from Poland is the ski slope "Góra Kamieńska" situated on the external spoil tip of the "Bełchatów" open-pit mine. In Germany, there is another ski slope created on a spoil tip called "alpincenter" in Bottrop [47]. The architectural concept proposed for the spoil tip at the LW Bogdanka site draws inspiration from established and effective solutions while also paying homage to the mining heritage through its design. Examples of architecture and engineering from various parts of the world, along with historical structures once dedicated to industrial use, can offer inspiration for the revitalisation of post-mining areas. The preservation of cultural heritage from the post-industrial era, achieved through repurposing or recycling existing infrastructure and artificial landscape features, appears indispensable for the triumph of revitalisation efforts. Essential factors, including sustainable development, multifunctionality, and tourist attraction, are also pivotal for the success of these endeavours. Further research and analysis of these examples can contribute to the development of more effective revitalisation strategies that serve not only the utilisation of these spaces but also the improvement of the quality of life for local communities.

8. Conclusions

As follows from the research, the discussed problem seems topical and socially important. According to the analysis of cases from Poland and Europe, post-mining areas, contrary to what may seem, constitute attractive cultural heritage and an element shaping the identity of a given area. Unusual and attractive industrial architecture, together with the entire infrastructure, after appropriate revitalisation processes can form an attractive, profitable, and culture-shaping recreational area for the region’s inhabitants in the future.

The article is focused on the analysis of technological and architectural solutions which would help to restore the usable functions of the discussed area. Drawing from case studies, scenic analyses, and the rich historical heritage of LW Bogdanka's industrial architecture, we have put forth spatial and architectural solutions aimed at enhancing the region's tourism offerings. These architectural proposals seek to build upon the plans and ideas developed in

previous years, taking inspiration from the form and material choices of the mine's historical buildings. The architectural concept presented here aims to promote solutions that empower local communities to reclaim areas initially impacted by mining activities. The architectural proposal for the spoil tip development also offers the opportunity to effectively shape the resulting heap, aligning it with the intended future purpose. This concept can also be implemented when there is a need for public consultation, planning activities, or political decisions. This is important in order to ensure that the needs and points of view of local communities are taken into account in the revitalisation of the explored area. The authors' design study has a conceptual character, but with significant development and implementation potential if the LW Bogdanka company includes such an intention in its economic strategy.

The article provides an overview of similar projects related to the revitalisation of former mining areas, emphasises the need for continuous interdisciplinary cooperation and innovation in order to deal successfully with environmental, social, and economic challenges associated with the discussed processes, and outlines the direction of possible future works.

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