

Renaturalisation of local rivers in city landscape, based on Sokołówka Valley Trail design

Karol Langie*, Kinga Rybak-Niedziółka

Department of Revitalisation and Architecture, Institute of Civil Engineering, Warsaw University of Life Sciences SGGW, Warsaw, Poland, emails: karol_langie@sggw.edu.pl (K. Langie), kinga_rybak@sggw.edu.pl (K. Rybak-Niedziółka)

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ABSTRACT

Processes of restoration of water bodies in cities involve a wide spectre of social, infrastructural, spatial, and landscape factors, as a case of renaturalisation of Sokołówka River exemplifies. The research field is a mentally significant part of Łódź, contextually bound with the identity of the city structure. The main goal of the work is to present a design process that focuses on both urban and environmental aspects of transforming the project site into a sustainable area of recreational and touristic functions, at the same time improving qualities of space (comfort, accessibility, walkability, legibility, composition, etc.). Main research theses involve methods of transforming the city landscape in order to create space that is ecologically resilient while maintaining optimal social attractiveness of the site, all being subject to legal and environmental determinants. The Łódź example was compared to similar enterprises in Europe. The resulting space is a site that offers multiple cultural ecosystem services. Findings presented in the research outputs can be applied as a universal conceptual framework and inform methods of city landscape design of similar characteristics.

Keywords: City landscape; Urban planning; Green Deal; Resilience; Cultural ecosystem services

1. Introduction

The issues significant in restoration, Green Deal and the city landscape relate directly to actions resulting from the recently popular urban development strategy based on the Eco and Smart City idea [1–8]. The presented idea assumes the development of the city in a spirit that takes into account regeneration endeavors within the existing planned urban structures. The study presented here applies to various spatial scales. It can inform the urban development strategy of the whole city, but can also be implemented on a smaller fragment of the inhabited space – as presented in research by The Sokołówka Trail Valley design [3].

Renaturalisation, to which the presented study refers, is understood as actions aimed at increasing the species diversity associated with the river, and, at the same time,

increasing the self-purification potential of the water [9]. Moreover, the modern understanding of these activities is inherently related to the restoration of natural hydromorphological features, as only such waters are thought to fulfill ecological functions [10]. In the literature from the UK and the USA, the term “restoration” or “ecological restoration” is more popular, but it can be concluded that the term renaturalisation is more precise because, as argued by Wohl, Lane, and Wilcox, not every river renaturalisation or rehabilitation (partial restoration) is a restoration of the original state. Moreover, the concept and underlying environmental techniques have shifted from reinstating stable ecological states towards supporting and reinitiating ecological, geo- and hydromorphological self-remediating processes [10].

The European Environmental Agency recognizes the negative impact of physical modifications of anthropomorphic

* Corresponding author.

rivers not only on their ecological functions but also on social functions (Lack of accessibility of rivers and streams, Lack of attractive open spaces next to water, Inadequate perception of rivers by the public) and spatial (Separation of urban spaces and rivers owing to technical infrastructure, Neglected areas along rivers, Blurring of the natural boundaries of urban landscapes – monotonous landscapes) [11]. The data collected in the EU LIFE + RESTORE cross-border program confirms the wide extent of undertaken river restoration: the RiverWiki online database, resulting from the EU-funded partnership, contains descriptions of over a thousand projects implemented within the EU [12]. Moreover, the River Restoration Center (RRC) in Great Britain recognizes over 5,000 completed and planned projects, of which over 3,000 are described in large detail in the RRC's online database [13].

A desk review conducted for this study included Scopus, ResearchGate, Google Scholar online research catalogues. Keywords “renaturalisation”, “ecological restoration”, “river”, “urban”, “design”, “blue infrastructure” were used for searches in multiple configurations. A single comprehensive study of the urban design strategies for successful urban river renaturalisation have been identified. Jamali and Mosler [15] in their comparative study of small rivers of London propose a set of design strategies aimed at improving the quality of urban river landscape and the flow of cultural ecosystem services accompanying the renaturalisation of rivers in cities: (a) Improving accessibility to the riverfront by increasing available routes to access the river; (b) Opening up sequential views to the riverfront; (c) Enhancing the foot/cycle paths along the river; (d) Providing footbridges across the river; (e) Improving legibility of the riverscape by enhancing signs and links; (f) Improving the physical accessibility to water by widening the river channel; (g) Designing a meandering and sinuous river channel; (h) Improving riparian vegetation; (i) Using natural materials for river banks and river bed; (j) Creating ponds and backwaters with native wetland and aquatic plants. The list, in its simple, easy-to-use form, can be easily transformed to design guidelines, project checklists, etc., but it needs more cross-examination against various local conditions.

The EU Biodiversity Strategy (European Commission, 2020) aims to (inter alia) “restore the free flow” of at least 25,000 km of rivers by 2030 [15]. The strategy calls for increasing the role of biodiversity in decision-making in both public and business matters. For this purpose, the strategy aims for the development of criteria and standards describing the features of biodiversity, its functions, values and sustainable use, already in 2021. In order to achieve that, means for measurement are to be devised for evaluating the environmental footprint of products and organizations, including life cycle and natural capital accounting, also in the international scope [15].

The concept of ecosystem services allows to include aspects of the use of natural capital in economic accounts for rational decision making of social importance and to estimate the mutual benefits of maintaining ecosystems. In this interdisciplinary approach, today we commonly distinguish supporting services (indirect, ensuring conditions for the provision of other direct services (benefits), which are: provisioning services – raw materials, fresh air; regulating services

– climate, water conditions, purification water, and cultural services [16]).

The knowledge about urban ecosystems, in which human activity permeates with deeper life-support processes, is growing extensively [17–22]. The ecosystem services approach allows for this knowledge to be applied in the practice of urban and regional development. Usually, the discipline of planning and design process is organized hierarchically, covering the scales of supra-regional (national, cross-border), regional (e.g., regional development plans and strategies) and urban (e.g., city strategic plans) planning. However, even at the local level, such as the urban design considered in this case, this process is usually delimited by sectoral issues (environmental protection principles, for example, environmental decisions, transport strategies, and finally the protection of cultural heritage) and horizontal strategies (as in the case of investments planned for financing from the European Structural Funds, such as the project in question, and urban sectoral policies). Regardless of this, however, design is inherently associated with the search for synergistic solutions and the avoidance of trade-offs, which is made possible when the designers have knowledge about the interrelation of various issues, needs, requirements [23]. It is particularly important in the face of the growing possibilities of river restoration in cities, as the growing body of documented projects exemplifies.

The level of urban planning of individual public spaces is especially suitable for the consideration of benefits related to cultural ecosystem services [24,25]. Meanwhile, there is only a very general consensus about the extent of cultural ecosystem services. Thus, recreational, aesthetic, educational, intellectual and spiritual services (or benefits) are recognized in this matter [15]. An analysis of the difficulties with the resolution of these abstract values is presented by Fish et al. [26] indicating, inter alia, the escape into the fluid category of “intangibles” (which is a key element of the definition from the Millennium Ecosystem Assessment [27]) or problems with defining the mechanisms of knowledge production, when cultural practices that are based on nature, exceed it, both geographically and semantically [28,29]. At a more practical level, the main methodologies for assessing ecosystem services, such as TEEB, CICES, and Millennium Assessment, take into account the highly local specificity of the issue through the use of participatory determination of key benefits. Detailed participatory approaches vary, depending on the degree of formalization of the issue and the approach of those who shape the process – public decision-makers and contractors themselves. Usually, however, the participatory approach fosters to some extent the political transparency of the process of shaping the space, potentially creating the possibility of formulating postulates, negotiating rights and meeting the needs in the common space in question. Therefore, it gives the right place to determine the above-mentioned values in a non-economic way and taking into account intangible assets. It is worth noting, however, that the quality of space/landscape associated with small rivers in cities may have supra-local economic, aesthetic, natural, etc. significance, which falls out of the scope of local planning (e.g., tourist-oriented development, which is directed towards stakeholders outside of the local community involved in the local level of planning)

[30,31]. This gap may be supplemented by economic analysis (e.g., focused on various types of services, for example, tourism), and maybe the subject of the profit and loss account in the local economy [32], or may be a part of a larger tool of evaluating the validity of an urban project, for example, in form of cost-benefit analysis [33].

A conceptual framework valuable both for researchers and design professionals tackling the issues of cultural ecosystem services and cultural values of space was proposed by Fish et al. [26]. The researchers distinguish three categories of benefits (well-being dimensions related to spaces and practices that are components of the system of cultural ecosystem services). These are identities, experiences, and capabilities – including physical and intellectual. It is notable that especially the first two of these categories, in their spatial aspect, are traditionally the subject of urban studies and in terms of creative shaping of reality – urban design. The relations of the last value – competencies – are defined by the authors broadly (includes knowledge, physical and intellectual fitness, health, etc.). Its relations to space have only recently been the subject of wider scientific interest in the empirical aspect (e.g., environmental psychology, spatial welfare studies) and slowly penetrating into the practice of evidence-based design [34,35].

The aim of the study is to present: (i) the conditions, methods and effects of urban design for the renaturalisation of the Sokołówka River in Łódź, (ii) a strategy for the continuation of previous Sokołówka Valley restoration processes river, and (iii) identify the common points of value recognized in urban planning with an interdisciplinary approach to ecosystem services in the field of cultural services, in regard to urban river renaturalisation processes.

2. Materials and methods

2.1. Study site

The study site is located in Łódź (Fig. 1), a city with a population of approx. 690,000, originally developed

around the industry – mainly textiles, and recently rapidly developing in the post-industrial economy. External circumstances conducive to this new development include improved supra-regional and international transport accessibility (shortening the travel time by rail to nearby Warsaw, the intersection of new highways). Although the city is relatively densely populated (average population density 2,350 inh/km²), about half of the areas within its administrative boundaries are non-urbanized, comprising of wastelands, forests, waters, arable lands, and ecological lands [36]. This fact is turned into an economical advantage through the successful application for organizing Expo Horticultural Global Fair, originally planned for 2024, and during the pandemic postponed to 2029. The city committed itself to provide a large exhibition area adjacent to a newly developed central district with a large railway station (“the New City of Łódź”) [37].

One of the measures of the city’s inclusion in the global economic system are the prices of land, which in the vicinity of the newly developed Łódź Fabryczna station exceeded EUR 450/m², and in the studied area they amount to approx. EUR 100/m². The area of the study is located 2.5 km north of the border of the strict downtown mixed-use zone of the city urban centre.

2.2. Water system and topography

The site is located in the upper course of the Sokołówka River, one of many historically occurring rivers in Łódź, belonging to the category of small rivers (the river basin covers an area of approx. 19 km² in this case) – Fig. 3. The catchment area has been gradually urbanized for a long time. The analysis of data from 2009 [36] shows that forest and agricultural land cover approx. 1/3 of the catchment area. At the same time, the average flow of the river has decreased many times since the 1960s (to 0.18 m³/s in 2009–13) with a simultaneous increase in the coefficient of flow variation [35]. Flood safety, significant given this variability, was largely ensured by the successive

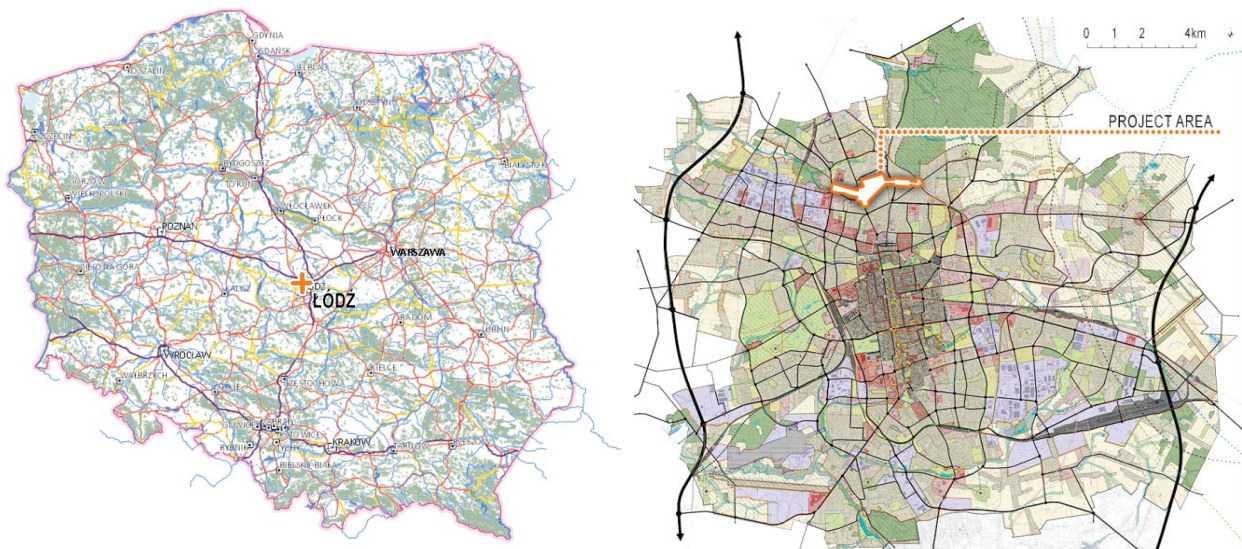


Fig. 1. Study site location (topographical map of Poland with forests in green), – urban context – Łódź masterplan.

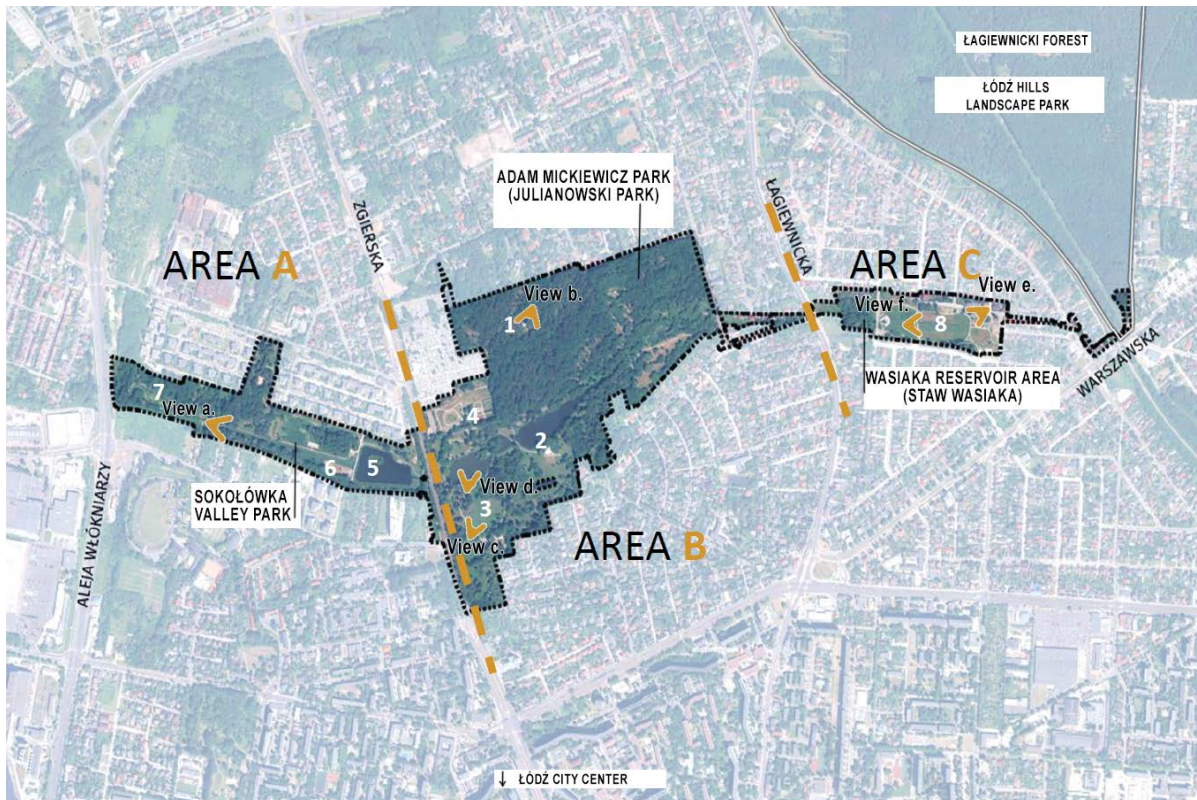
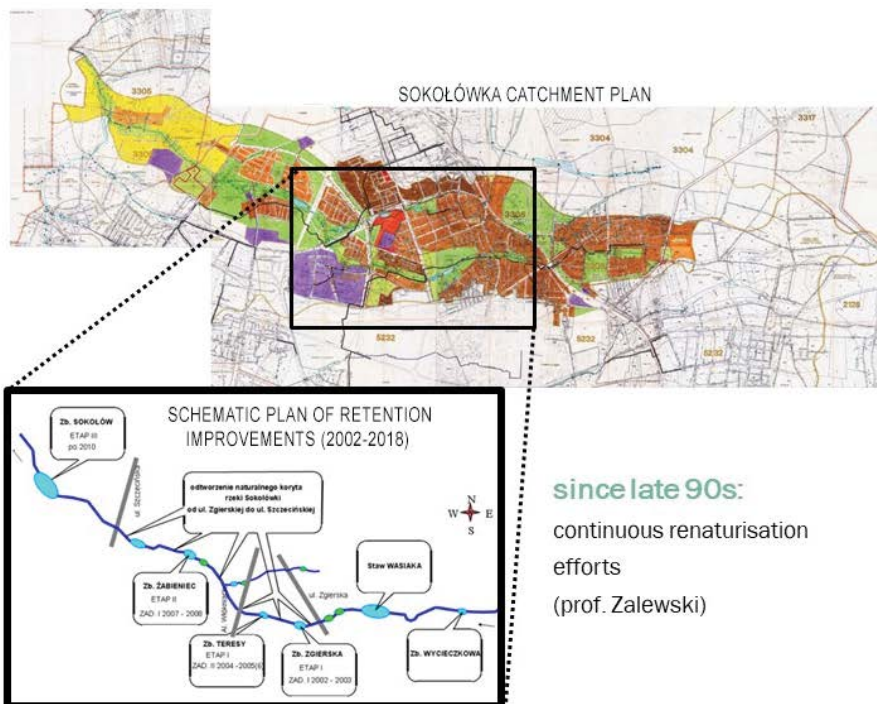


Fig. 2. Study site. 1 – Forest restaurant and surrounding semi-natural forest, 2 – historic ponds (Stawy Julianowski), 3 – location of the historic palace (non-existent) and park, 4 – sports zone, 5 – recently built retention reservoir (Zbiornik Zgierska), 6 – recreation zone (grill sheds, youth zone) – built recently with a participatory civic budget, 7 – semi-natural pond (Stawy Teresy), 8 – recently built dry reservoir (Stawy Wasiaka). The study site was divided into areas A, B, and C for practical reasons. The demarcation lines go along the main roads dissecting the green areas along the river. Views (a)–(f) shown in the Figs. 7 and 9–13.



2010-2011

SWITCH project (Sustainable Water Management Improves Tomorrow's Cities' Health Water:

- Retention potential enlarged
- Quality of water improved Sedimentation-Filtering system (ERCE PAN)
- limited recreation and landscaping programme due to restricted funds

since late 90s:

continuous renaturalisation efforts (prof. Zalewski)

Fig. 3. Sokołowska River catchment and retention improvements. Source: Municipality of Łódź.

construction of retention facilities in the course above the study area and in it (overflow reservoirs, dry reservoir). These construction works included various elements of renaturalisation preceding the subject project. The water system in the study area includes four ponds, three of which are flow-through and one of the lateral (with a natural overflow enabling periodic water exchange with the river during the stretching), and a dry reservoir (“Stawy Wasiaka” – vide Fig. 2 – element no. 8, Fig. 3). Two elements are especially notable: restoring the semi-natural state of Teresy Pond (western part of the study site. vide Fig. 2 – element no. 7) and introduction of Sequential Biofiltration System of Sokołówka – SSBS [38–41]. Together with other semi-natural solutions employed (local planting of aquatic vegetation for phytoremediation), these features improve water quality [40,41]. Nevertheless, most of the river in the study site is, however, in a state-qualifying it for the “heavily modified water bodies” category.

2.3. Immediate urban and planning context

The project’s surroundings are mainly single-family housing areas, with some recent additions of multi-family housing (Fig. 2). On the west side, the area is adjacent to a large logistics and industrial area. In this part, there is also a narrow strip of biologically active land along the river, supplemented with single-family housing, creating the little potential for ecological continuity, with large green areas extending further west along the Sokołówka River valley. On the eastern side, the area of the study covers a section of the channelized underground river. The channel crosses the embankment of the railway line and reaches a patch of the urban forest in the eastern border of the study site and upwards of the river current. This forest is part of the protected area of the Łódź Heights Landscape Park. The ecological connection here is very limited, if existing at all, due to the extensively urbanized area, almost 400 m wide, dividing natural and semi-natural areas. There is more urbanized land and retention facilities upstream. It is worth noting, however, that in the study site traces of the activity of beavers were observed by the research team, a species protected in Poland since 1921 [42], and since 2001 – partial protection, and population rapidly growing.

As for urban planning and heritage conditions, the study site is mostly covered by local plans of a conservative nature (for most built-up areas), including developing the ecological and landscape potential of the river valley. In addition, the central part of the study area (Mickiewicz Park) is subject to strict heritage protection, due to the historical location of an important palace (now non-existent) together with the park, as well as functional continuity with the former Julianów farm, transformed into a public park at the beginning of XXth century [43].

The study site stretches over public green areas, separated by two major roads (ul. Zgierska and Al. Włókniarzy), as well as a number of local streets. The three parks with smaller linking public green areas are arranged along the Sokołówka River (from the west: Park Nad Sokołówką, Mickiewicz Park, the area of the Wasiaka Pond Local Recreation Center), and two undeveloped green areas between the last two.

The area is diversified in terms of the landscape transformation – the locally preserved natural alder forests typical of the river valleys of this region are intertwined with planted forest and arranged greenery (the central-southern part – Mickiewicz Park, which in part is a remnant of the 19th-century palace park, transformed into the 20th century). Locally, dispersed recreational facilities are located (four medium-sized playgrounds, numerous smaller playgrounds, and sports facilities, including many randomly located as a result of investments from the civic budget). A few buildings are also located in the area, directly connected with the green areas: an amphitheater building, a derelict historic park restaurant, numerous gazebos).

The above-mentioned elements of the landscape physical structure constitute the basis for the existing strong identity of the area, substantially overlapping with the project boundaries. Historical aspects, including architectural relics (the building of a forest restaurant, adapted for this function during World War II, and earlier probably – part of the farm that existed earlier here), is also important for this identity, especially for the central, largest green area (Park Mickiewicza). Other elements adding to this identity are local monuments, anthropogenically shaped landscape features (old tree alleys signifying the XIXth century axis composition of the palace park), iconography (photos, palace postcards, decorative entrance gates to the park, flower beds, ponds, terraces and stairs, etc.). The palace layout, together with the adjacent farm, were so important points of reference that the entire neighborhood of the Julian family took the administrative name, and the central park itself is commonly called Julianowski Park to this day [43].

The goals of the interdisciplinary restoration project were outlined by the municipality in the contract for designers:

- creation of a “green” tourist trail along the Sokołówka River, which will connect the green areas located in the river valley, that is, Sokołówka Valley Park, Mickiewicz Park and Wasiaka Pond. The trail will be extended westwards to Al. Włókniarzy and to the east to the Łagiewniki Forest, thus creating a green corridor in this part of the city;
- revalorization of the Sokołówka Valley Park by renaturalisation of the river bed, creation of flower meadows and retrofitting of the existing infrastructure for recreation;
- restoring the splendour of the Mickiewicz Park at the turn of the 19th and 20th centuries, recreating the old infrastructure, urban furniture, alleys, plantings, restoring the historical appearance and functions of this public space, with particular emphasis on recreating the former outline of the Heinzel Palace (using greenery and other innovative solutions) dedicated to arranged green areas, for example, water jets, foggers, light installations, etc.), as well as the creation of a marina for boats on the ponds and the revalorization of a wooden farm building intended for gastronomic functions.
- development of the method/form/type of connection of the areas existing in the river valley green, resulting in the form of a tourist path;
- creating tourist infrastructure, including information/educational tourist paths;

- taking into account the special role of the Sokolówka Valley Park, Mickiewicz Park, and Wasiaka Ponds in activities related to the organization of EXPO Horticultural 2024.

Additionally, the planned project had to meet the criteria of financing from the European Structural Funds for the development of tourism (indicators: length of created tourist routes; a number of reconstructed tourist infrastructure buildings).

2.4. Social participation

The design process included social participation based on the importance of “local social value” in the contemporary shaping of space in the spirit of Eco and Smart City [44]. The participation was planned as a two-stage consultation of the concept design: two preliminary variants and one final design. Submissions of new proposals (activities, amenities, etc.) were taken into consideration. Two complementary forms of participation were envisaged: participation in two public meetings and submitting comments in writing. Due to the SARS-Covid-19 pandemic starting in the country, the meetings were held in the form of videoconferences. The first meeting included: presentation of initial concepts (including spatial analyzes and proposals for functional solutions – development plan on a scale of 1: 2000 with photographic references (examples), a session of questions and answers. After the meeting, residents and social organizations submitted applications with proposals by e-mail. The project team, in consultation with the project managing municipal department, replied in writing to all comments submitted, regardless of whether or not the proposed solutions were introduced to the project.

The issues raised in consultations by the participants include:

- willingness to ruthlessly protect trees;
- water quality improvement, as well as rising the ecological potential of the water system;
- protection and development of the ecological potential of the naturalistic part of Mickiewicz Park – resignation from initially proposed interferences such as hardening the alleys, lighting (perceived as harming the ecosystem);
- opposition to the proposed symbolic elements recreating the landscape and architectural composition related to the Heinzel Palace, obscured during the 20th-century restoration;
- opposition to the separation of a bicycle route in the part of the existing alley with shared bicycle and pedestrian traffic.

Not all comments were taken into account, which resulted in social resistance, which was expressed in an article on the first page of the local newspaper (the local leader defends the park against “concreting”), a letter to the mayor of the city, signed by several local organizations and scientists from a dozen related and unrelated fields with the subject of land development and behind-the-scenes negotiations with politicians.

2.5. Design process

The project consisted of a concept design with a set of urban analyses, feasibility study, a set of procedural, material, functional specifications for design-and-build tender (“functional-utility programme”), and a detailed assessment of construction costs for budgeting. The process included gaining approval of main infrastructural requirements (connection to existing roads, media), heritage protection settlement, and environmental impact screening, but not assessment, which is intended for the next phase. This is recognized as an investment pre-planning phase, as opposite to project documentation (permit and construction documentation). The concept design was developed in the form of CAD drawings with the accuracy corresponding to the drawings on a scale of 1: 2000-1: 250 (terrain) and urban and architectural details (development of the building on the site) – in scales 1: 250-1:1, in 2D (sections, views), and 3D (axonometries, perspective sketches, visualizations).

Research on the city landscape is based, inter alia, on a multi-component analysis of specific areas and their surroundings, which allows for a detailed understanding of the urban structure. It contains elements concerning both inventory and interpretation issues in the field of environmental, compositional, functional, and infrastructural issues [45–48]. In the introductory part, the analysis concerns the recognition of the most important elements of space, such as the functions of areas and buildings, transport system, technical infrastructure, and the species system occurring in the studied area [45,49]. As part of the recognition of the functions of areas and buildings, the division into elements related to residential, service and commercial, industrial, and public buildings (including the division into buildings with sacred functions, performing various administrative functions serving the society, etc.) is used [45,50,51]. The recognition of functions of the areas includes the distinction between green areas, distinguishing their individual types (the division includes separate identification of forests, urban parks, squares, urban agriculture areas, etc.), and the division into areas modified by human intervention and natural areas [52]. The recognition of environmental qualities at this phase of the development was limited to a general inventory of plants with an assessment of their condition, supplementary to a previously prepared detailed inventory of the most robust area of the historical park (Mickiewicza Park in Zone B). The resulting project was divided into two parts: one limited to minor interventions into the environment, and the other – subject to environmental screening and assessment (most interventions in the watercourse). A transport analysis is carried out separately, which includes the identification of the typology of roads divided into main roads, where there are motorways, national and provincial roads, access roads for district and housing estates and local roads with woonerfs, or connections of very local importance [47,48,53].

In addition, the system of parking spaces, public transport stops, and junction points related to the functioning of roads, the public transport system, and pedestrian communication are recognized. This group of analyses also recognizes elements of technical infrastructure related to urban network systems. The results of the conducted

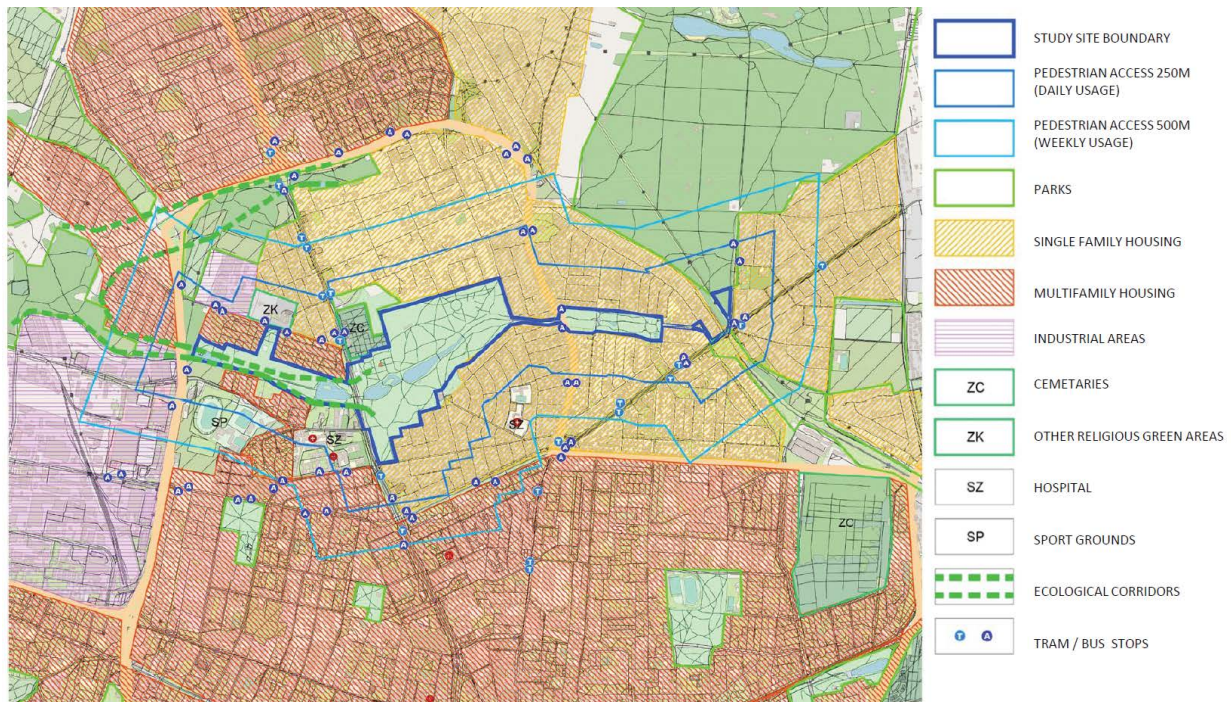


Fig. 4. Urban context and accessibility analysis of the study site.

analyses make it possible to check the obtained data in terms of historical and legislative terms, and then in terms of the composition and colour layout of the studied area. Another examined category is compositional elements, which include the assessment of the proportions and height of buildings. A component of this analysis is the separation of urban and landscape interiors in the urban structure together with wide and fissured openings. Moreover, it includes the recognition and systematization of the arrangement of dominants, characteristic points, and compositional axes. Parallel to the compositional analysis, colour analysis of the space is performed, taking into account environmental and urban elements [48].

Consequently, in the design process: (i) the potential for the development of the areas was analysed through comparison to similar recent realisations published in landscape design literature (Divisare, Landezine), visual reference analysis based on keywords (Pinterest, Google). The collected images were used for internal communication within the team, the concretization of the vision, and – after selection – effective communication with the ordering party and consulted residents; (ii) the principle of hierarchy of needs in the public space was adopted, aimed at increasing its use (safety, modulating thermal comfort – shading, opportunities for social contacts). In addition, during the works, in late spring, despite the onset of the pandemic, it was possible to observe more important places of existing social activity during on-site inspections and inventories.

The conceptual design work itself, along with public consultations, was divided into two iterative stages: introductory and detailed. In the first stage, two variant preliminary concepts were developed, in which: the most important spatial problems were identified and the initial directions of revalorization divided into zones were determined, and two draft

variants of solutions were determined, which were publicly consulted. The variants differ in: sports functions of various types, the degree of interference in the landscape (e.g., the type and amount of paving in the renaturalised zones).

In the second stage, a detailed final concept was developed. Final solutions were selected from the variants. Detailed solutions were defined and conceptually outlined, subject to agreements with the departments dealing with individual branches (transport, monument protection, architecture, greenery). The proposals for improvement of the proposed solutions resulting from public consultations were taken into account. As a consequence, interventions in the renaturalised zones were reduced to a minimum (e.g., abandoning the paving of many paths).

3. Results

3.1. Spatial problems

During the design work, the following spatial problems were identified: (i) low comfort – portable toilets, no access to current water, mobile gastronomy in random locations; (ii) comfort and image – the standard and technical condition of many recreational amenities, park furniture and other small architectural objects – below the modern expectations of Łódź and the country; (iii) limited accessibility – no night lighting, low permeability of the surroundings – a small number of pedestrian connections with the city, fragmentation of recreational areas through main roads lacking pedestrian crossings; lack of continuity bicycle routes; (iv) low aesthetic and ecological value of parts of the water system (western part, partially eastern); (v) low intensity of development of the surroundings (wastelands) – potential

for enlarging the park, but also the lack of readability of the space; (vi) inconsistent development – recreational facilities, surfaces, located in a chaotic manner and aesthetically incompatible with the surroundings; (vii) lack of appropriate links between zones for different social groups (unused sociability potential of the place); (viii) unused potential for creating the identity of a place on the basis of its historical intangible assets – related to the demolished Heinzel Palace, Julianów farm, historical events; (ix) lack of legibility of space, no spatial information system.

3.2. Directions of revalorization proposed in the project

For the entire area, that is, the water system and the surrounding areas, zones of diversified revalorization goals were delineated. The revalorisation goals ranged aimed at improving accessibility, safety, comfort, usability (supporting sports, recreational, cultural, educational activities), identity (historical, landscape values), biodiversity, and ecological potential to varying degrees (Fig. 5). The spectrum of these solutions is presented in more detail below, using the example of a naturalistic zone, a historic landscape park, and a local recreational junction created around a dry reservoir.

In the naturalization zone, landscape architecture and urban design interventions are planned to be minimal, giving field for the ongoing restoration of the riparian ecosystem. In terms of the landscape composition, the existing interiors and viewing openings were preserved, and only small point plantings of tall and low vegetation (species characteristic of the riparian zone) were introduced.

In terms of urban design, efforts were made to improve the accessibility of attractive landscape elements, including the waterbed itself (reducing the slope). These were however subordinated to the water system renaturalisation (semi-natural meandering of the riverbed with a diversification of the cross-section and slope, introduction of mineral and wood debris, increasing the self-cleaning potential by introducing water vegetation, achieving a connection between the bed and the ground – elimination of seals and heavy fortifications in favour of fascine), as in Figs. 6 and 7. The boundary condition for shaping the water system was to sustain or enlarge the retention potential.

In terms of the aesthetics of the urban detail, low-processed materials (wood, mineral surfaces) of natural origin and patinated (weathered) highly processed materials (rusty steel) were used to correspond with the semi-natural surroundings (Fig. 8). As regards the ecological restoration of the area, flower meadows based on the succession of local species (without additional seeding) have been planned in this zone. The measures to improve accessibility include the creation of pedestrian and bicycle paths with an even surface, gently overcoming the height of the slopes (slope max. 5%), lighting the area, locating benches with armrests (for elderly people with mobility limitations), location of a public toilet, creation of missing pedestrian connections and cycling with neighbouring areas (increasing pedestrian permeability).

In the area of the historical landscape park, the planned revalorisation goals include: (i) strengthening the strolling and cultural function, (ii) enhancing the readability of the 19th-century composition, (iii) improving the infrastructure

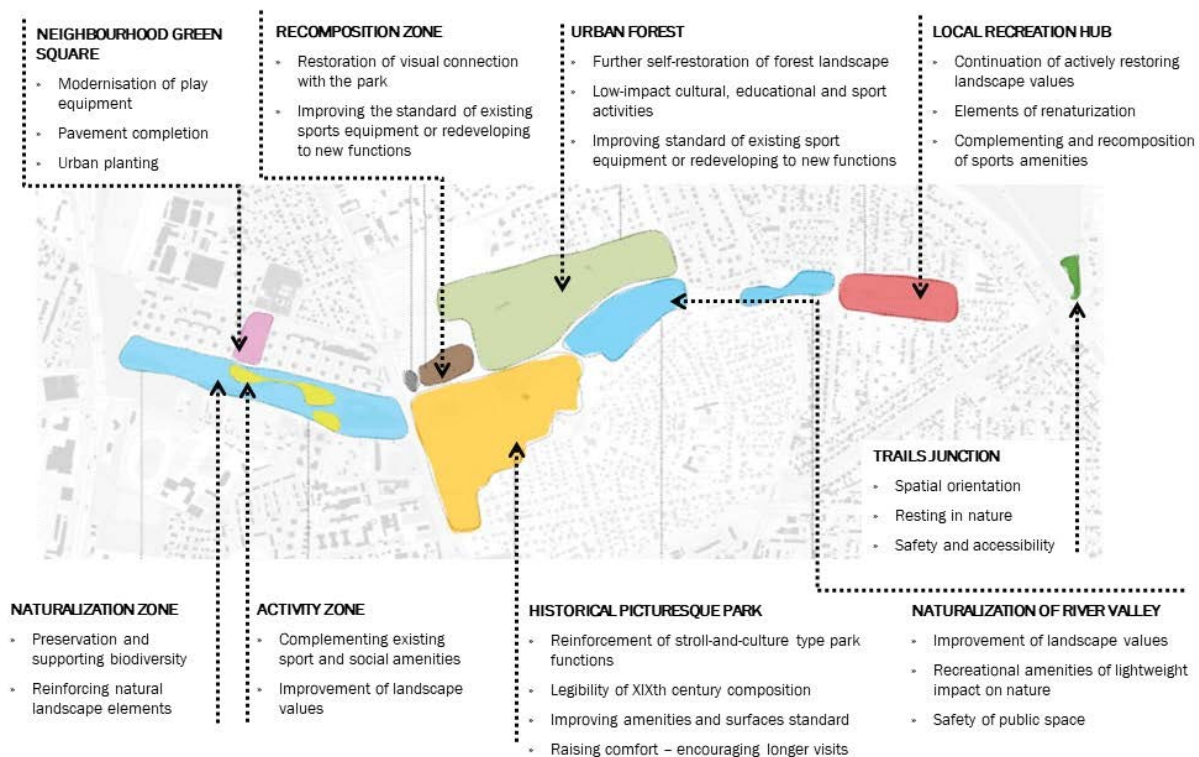


Fig. 5. Proposed directions of revalorisation of space.

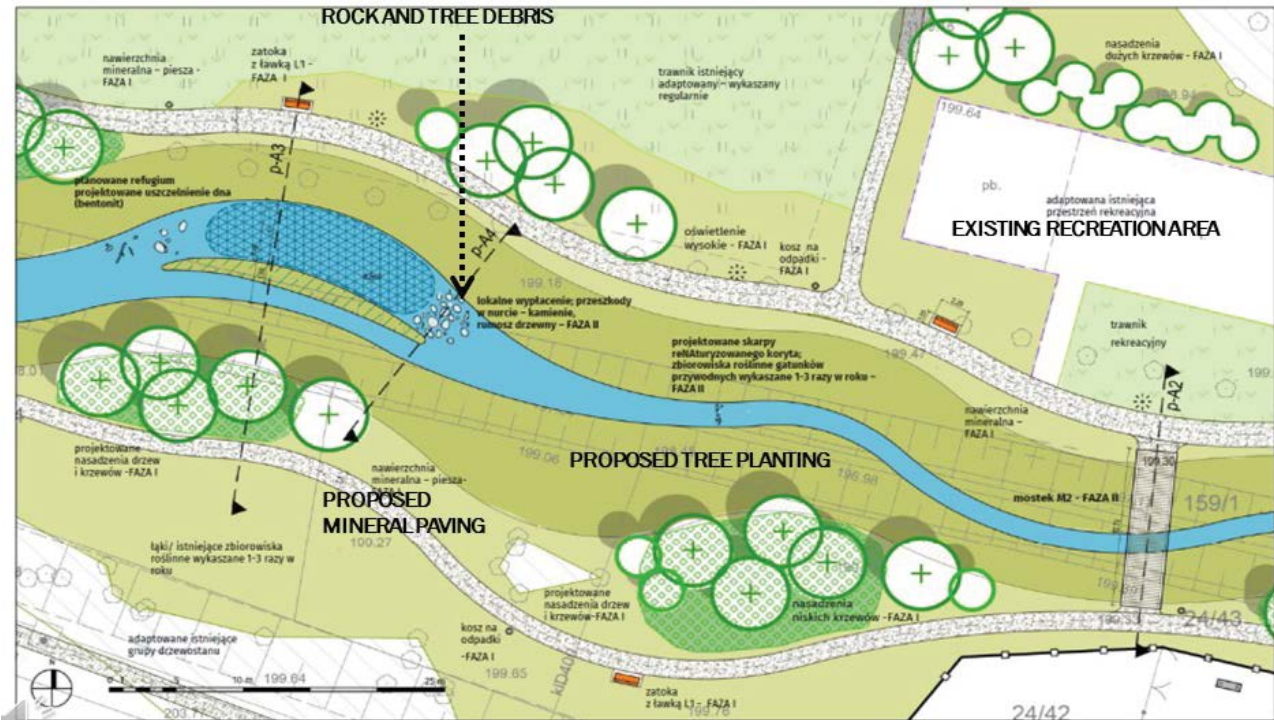


Fig. 6. Renaturalisation elements, integrated with surrounding park functions – Zone A. Source: Excerpt from final concept design, Studium – Workshop of Architecture.



BEFORE



AFTER

Fig. 7. View (a) BEFORE: Sokółówka River in the existing state, Zone A (2020, photo), AFTER: renaturalisation elements, integrated with surrounding park functions (artists impression, excerpt from final concept design, Studium – Workshop of Architecture). Proposed hydromorphological changes: semi-natural meandrization (engineered stabilized embankments), restoring waterbed roughness (gravel, stone, and wood rubble), restoring waterbed and banks water permeability, the introduction of native hydrophyte plants (supporting biodiversity, improving water quality through phytoremediation). Source: Excerpt from final concept design, Studium – Workshop of Architecture.

and standard, improving the comfort – encouraging longer visits. In terms of composition, it was proposed to recreate fragments of the blurred composition of the palace park, of which there are now two alleys on the compositional axes intersecting in the location of the palace. For this purpose, it is proposed to create an urban design feature marking the location of the palace itself (recreating the outline in the existing grass surface, small elevations of the level) and the

western gate (symbolic gate inspired by the original form of the entrance gateway). In terms of transport links, it is planned to connect the green areas separated by a collective street with an overpass and a bicycle crossing through the thoroughfare street. The existing layout of paths formed in the 20th century was basically left unchanged, while it is intended to introduce the mineral surfaces more consistent than the existing asphalt and paved surfaces and to improve



"Rocking boar" toy



"Rocking sheep" toy



Fig. 8. Play equipment for the renaturalisation and local recreation hub zones. Animal representations help children develop positive emotional responses to domesticated and wild animals.



BEFORE



AFTER

Fig. 9. View (b) urban forest BEFORE: existing derelict building of historical value in Zone B, (photo, 2020), AFTER: building restoration with adjacent forest garden – semi-natural intergeneration hub (performance space, outdoor dining, adventure playground, mini-farm with goats and guinea hen – a reference to historical Radogoszcz folwark, which gave name to the whole neighbourhood. *Source:* Excerpt from final concept design, Studium – Workshop of Architecture.



Fig. 10. Views (c and d) AFTER: (artist's impressions of project results). Zone B – historical park connected with landscaped ponds on Sokołówka River. Examples of preserving and enhancing a historical identity of recreational areas (left – outline of historical palace recreated in form of stepped platforms, right – fountain marking the historical compositional axis, providing oxygen to the water).

the continuity of bicycle connections. Shaping greenery is subordinated to the principle of increasing decorativeness while developing the conditions for the development of biodiversity (low greenery diversification: introduction of flower meadows with honey-yielding plants, planting of ground-level cover plants – native species, and locally – in a demarcated historic park area – ornamental species with high values that require special care, for example, rhododendrons). A high percentage of unpaved areas and the existing bird sanctuary in a separate part of the island on a pond have been preserved. It is planned to unify and improve the standard of park furniture (comfortable benches with armrests, other types of seats), conserve the existing sculptures, and replace some playground equipment. Park furniture was planned to improve the comfort of use and accessibility for all user groups: a drinking fountain near the playground, installation of public toilets, the introduction of lighting on the most important pedestrian

routes. In terms of the water system, it is planned to replace heavy embankments with natural ones (fascine), improve water accessibility – create coastal terraces in place of steep slopes, a gazebo, local planting of aquatic plants (improvement of the self-purification potential of water, enhancing habitat conditions).

In the local recreation hub zone, it was decided to soften the existing, somewhat raw, technical spatial composition of the dry retention reservoir built a few years ago. This is to be achieved by introducing a diversity of the topography (mounds, depressions in previously flat reservoir bed – Figs. 11–13). The shape of the landscape interiors was also corrected by groups and rows of greenery, limiting the views of unattractive building fragments. The aim was to create a landscape that is more esthetically pleasing, taking advantage of the phenomenon of biophilia [53]. In terms of accessibility, the urban permeability was improved by creating a pedestrian and bicycle paths along the river, a



BEFORE



AFTER

Fig. 11. View (e) local recreation hub, Wasiaka Dry Reservoir area. BEFORE: existing dry retention reservoir – Zone C; AFTER: planned extension of an existing playground (water features), tree planting – partial shading of play areas for thermal comfort, water-course meandrization (semi-natural, engineered reinforcement of banks), introducing more variety to previously constructed dry reservoir bed (occasional floodplain) – mounds, hollows, restoring waterbed and water permeability, extending native hydrophytic planting). Artist's impression, courtesy of Studium – Workshop of Architecture. *Source:* Excerpt from final concept design, Studium – Workshop of Architecture.



Fig. 12. Local recreation hub, Wasiaka Dry Reservoir area – Zone C. BEFORE: existing dry retention reservoir (occasional floodplain) and, Sokółówka River – heavily modified water body; AFTER – watercourse meandrization, dry reservoir bed diversified with mounds and depressions, hydrophyte planting, wooden deck – recreational and educational path. Source: Excerpt from final concept design, Studium – Workshop of Architecture.

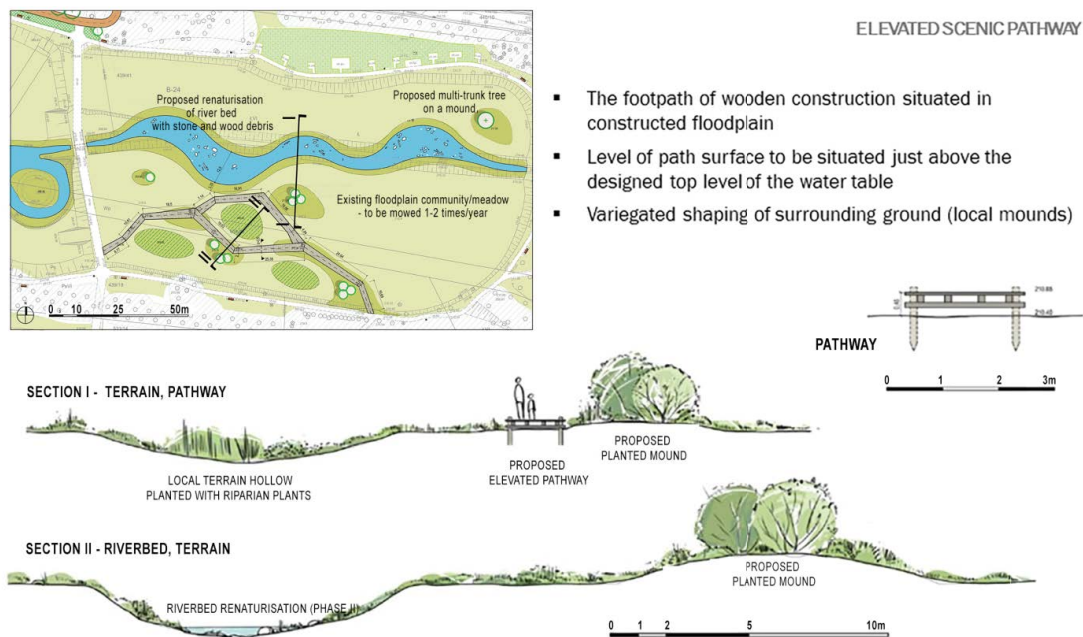


Fig. 13. Local recreation hub (Stawy Wasiaka) – renaturation elements integrated with surrounding city landscape. Source: Excerpt from final concept design, Studium – Workshop of Architecture. Design: l.arch. M. Kolendowicz.

continuous link to adjacent green zones. The increase in both the recreational functionality and comfort and social character of places (sociability) is planned. This is to be achieved by creating an additional playground module – dedicated to water and sand games, arranging places to sit on the lawn next to it (seats-boulders), and enriching the greenery providing a sense of situational safety (limiting too much visual exposure), and limiting temperature fluctuations (including, in particular, local shading in summer).

The planned urban spatial interventions in the landscape discussed above will enable the provision of cultural services

of ecosystem services in terms proposed by Fish et al. [26], that is, experiences, identities, and competencies.

Firstly, designing the city landscape will ensure the boundary conditions for the implementation and maximization of activities inherent in the semi-natural landscape values of the river valley. These conditions are the qualities of public space recognized in urban imperplanning: accessibility, legibility, and finally the attractiveness of walking – walkability. Accessibility, in a wide sense of this term, is improved firstly by the presented design by affording additional entrances to the area, where there were urban blocks

impermeable for pedestrians (increasing urban structure permeability). Secondly, it is improved by enhancing the perceived space – raising safety (through proposed lighting, monitoring of crucial areas), and comfort (thermal comfort, for example, providing partial shade to the playground in Zone C, physiological comfort – access to water and toilets). Thirdly, several qualities directly linked to walkability are improved. These are: widening the crucial pathways, providing smooth and visually appealing surfaces (fine mineral compacted mixture, stone, etc.), separation from bicycle traffic, increasing interest by providing visual variety in terrain (mounds, hollows, river meanders – Zones A, C, additional trees, shrubs, etc.), enhancing legibility (provision of spatial information system) [55]. It is assumed here, that such interventions will result in both increased attendance to the study site, and a greater range of activities. These activities in turn are part of new experiences enabled by the design (e.g., afternoon by the river, bike trip, birthday picnic, science lesson, concert, and so on).

Second, the design will contribute to the emergence and dissemination of identities associated with the new shape of river and surrounding recreational areas. In the case of the discussed examples, the generators of these identities are elements of the city's image from the point of view of urban planning. Most notably, the meandering river is an edge with a special shape, unique in the urban context, and trees introduced along the river as part of restoration works strengthen this edge. This particular character makes the area highly imageable [45], and thus – contributing to forming identities significantly.

Thirdly, in terms of competencies provided by the developed ecosystem, there are a few that were explicitly designed for and possible to specify as direct results of design decisions. One competence most explicitly intended in the design is knowledge about ecosystems gained through the proposed educational path connecting all the parks. Also, the mere increased presence of users and the explicitly designed possibility (affordance) of observation of changing water levels can build knowledge about the relationships and values of naturally or semi-naturally shaped water relations in the city (rainwater management). Another inscribed into design competence is a dexterity resulting from play – both from use of artificial play equipment and the landscape features, for example, “walking on water” (on rubble, etc.), climbing trees, and similar activities possible in semi-natural, varied surroundings of restored rivers and river valleys. It is notable, that the existing space is prohibiting most such activities – by physical amenities, park regulations, or both. Summary of the above discussed resulting space qualities, activities, and experiences is provided in Table 1.

4. Recommendations

Design strategies to improve the quality of urban river landscape and optimize cultural ecosystem services generation accompanying urban river restoration:

- Improving the physical accessibility of the river by increasing the number of pedestrian connections with the city,
- Recreating and improving the quality of walking and cycling paths along rivers,
- Improving the readability of the landscape by providing spatial information,
- Improving physical accessibility to the water table by widening the riverbed, flattening the banks, building terraces, amphitheater stairs, platforms, etc.,
- Treating the elements recreating the hydromorphological features of the natural water flow as highly attractive and engaging landscape elements (bends, meanders, depth variation – plows, rapids, natural bottom materials, debris, etc.),
- Introducing calm flow zones, flow-through reservoirs, artificial wetlands – planted with aquatic vegetation – as an element that visually enriches the landscape, increasing its attractiveness through the development of biodiversity and water purification,
- Recreating the vegetation of the river zone (trees, shrubs, perennials) as an element that is visually attractive and potentially – increasing thermal comfort – shading,
- Creating recreational zones in areas by the river to maximize outdoor activities with a view or surrounded by water (recreational lawns, picnic areas, playgrounds, areas for outdoor amateur sports, temporary and mobile gastronomy) and in buildings (gastronomy, libraries, small trade, etc.),
- increasing the potential for the development of competencies – knowledge about ecosystems, for example, educational paths.

5. Discussion

The examples presented below show similar but not identical solutions to those used in Łódź. The design of space, despite the similarities, is in each case slightly different due to several contexts – spatial, social, cultural, etc. The following realisations did not avoid mistakes that also occurred during the Sokołówka Trail Valley design, which was described earlier in this article. Renaturalisation and design in the spirit of Eco Smart City are carried out in various places. An interesting example of a similar solution on a slightly larger scale is the Berlin FlusBad by Realities: United Studio (1998/2011). This concept, based on the revitalization of the river to reclaim it for its users, was implemented taking into account the resilience and re-urbanization of the neighbouring areas. Moreover, it employs great respect for the natural ecological structure of the area. In 2017, this way of thinking meant that FlusBad was included in the list of top priorities in Berlin's development strategy [56–58]. FlusBad Berlin is a manifestation of grassroots urbanism – a long-term grassroots initiative of a local association. The conceptual project developed by Realities: United covers the development of the Spree Branch surrounding Museum Island – a cultural district in the already very vibrant center of the city.

A 1.5 km long section of this large river would be transformed into a sequence of a section of a natural water treatment plant preceding the river bed for bathing purposes. In the architectural and urban sense, the changes include the creation of a wetland in the current river bed, the creation of an embankment in the form of amphitheater steps,

Table 1
Impact of design features on cultural ecosystem services

Existing state	Proposed state	Result	Expected long-term effect
Recreation areas (parks) in Zones A, B, C are disconnected by thoroughfares and local streets of low walkability	Proposed pedestrian and cycle crossings, traffic calming physical features, enhancing on-street planting	New activities afforded: walking and cycling along the river	New experience: a trip along the river
No physical features informing about existing ecological qualities of the area	Proposed educational path	New activities afforded: learning about the local ecosystem on site	Improved knowledge about the local ecosystem New experience: individual or group stroll through the designed path
Scarce benches and sitting equipment – low sittability, moderately attractive views of water and ponds	Variable sitting opportunities – benches, single seats, tree trunks, the landscaped river meanders in view (Zone A, C)	More activities afforded: sitting with a highly pleasing view of a semi-natural riparian landscape	More people visiting the area New experience: observing intricate river landscape
Portable public toilets without running water available	Public toilets in Zones A, B, with running water, drinking and sanitary water fountain provided in Zone B near the playground and picnic area	Enhanced comfort for staying visitors	More visits to the area, longer stays, more demanding visitors catered for (parents with toddlers, seniors, etc.) New experiences: family events, etc.
Water inaccessible due to steep embankments of river and ponds	Access to water through mildly sloped embankments, and decks	New activities afforded: playing with water stream, observing	Positive feelings towards natural free-flowing water New experience: direct contact with the semi-natural river
Existing grill sheds taken over by antisocial groups (public space not working)	Municipal monitoring installed, public toilet and lighting installed in the vicinity, semi-natural river channel nearby	Enhanced perceived safety, esthetics, and usefulness of the sheds	New experience: Sheds will be used for actual grill parties by multiple social groups. New experiences: grill party by the river
Limited availability and comfort of eating (food trucks admitted in one location only)	Proposed restoration of the old restaurant in the forest (Zone B)	New activities afforded: dining out in semi-natural surroundings within a walking distance from home	More visits to the park New experience: Dining out in semi-natural surroundings in a walking distance from home
Existing playgrounds hardly related to nature	Proposed equipment – water features, animal toys (local species)	New activities afforded: playing with water and representations of real animals	New experience: engaging play with natural elements in a walking distance from home

providing for multiple informal activities. The large area of wetlands certainly has the potential to significantly increase biodiversity. Nevertheless, the problem of rapid surface runoff from the surrounding hardening and roofs has been solved only partially – dirty rainwater is to be drained through a collector located under the wetland to the other branch of the river.

A particularly important aspect of this project is the great innovation resulting from the lively culture of space, characteristic of Berlin. Both the restoration of the habitat and water purification turn out to be synergistic with the possibility of bathing in the surroundings of historic monumental buildings in Berlin, creating a unique experience [56–58].

Unfortunately, not all initiatives of this type succeed, as exemplified by the initially highly praised Eco Boulevard Project in Madrid, where the finally implemented scheme caused a lot of social resistance and another wave of gentrification in the re-urbanized district. Taking into account the unclear actions of local authorities and activists, some of the pro-ecological solutions planned in the project had to be abandoned, which failed the entire assumption. This is an example that shows that ecological solutions are often introduced “forcibly” without taking into account real social expectations [59,60].

An example of a renaturalised river not quite integrated with the surrounding urban fabric can be taken from the

Liesing River project (a case study in the Life Program database run by the European Commission) [61]. The Liesing is a small river located in the industrial and residential district of Vienna, on the southern edge of the city. Its 5-km section was completed in 2005 as part of the Life Project.

The urban context is a mixture of medium and low-density housing (low-rise multi-family housing, single-family housing), an industrial plant zone, a small cemetery, and agricultural land. The study site was covered by a water system with a small supply of green areas (20–60 m strip). Continuity of pedestrian and bicycle traffic was ensured along the river, across the four main roads crossing it. However, the landscape values of the river are only moderately utilized: several playgrounds, schools and a few restaurants attract users to the site.

The enterprise included the reconstruction of the water system, plantings, construction of a path along the river – including a supra-regional bicycle route, and a small park – a recreation area with places to sit, picnics, and a multi-functional lawn. Access to water has been slightly improved – a short section of the pedestrian bicycle path goes down to the level of the bed, which has been slightly widened and flattened.

In terms of the condition of the water system, the riverbed was originally highly modified (straight, steep slopes, sealed and hardened riverbed), the water quality was bad, the problem was also the rapidly changing flow resulting from direct connections to the rainwater drainage system, devoid of small retention elements. In terms of hydromorphology, the emphasis was placed on “loosening the flow” – widening the riverbed, flattening the banks, local, minimal engineering-strengthened meanders, that is, the predetermined execution of rapids, restoring the rough structure of the bottom, in total obtaining certain freedom of flow within the limited terrain possibilities (a strip about 20 m wide). The local wet meadows have also been preserved.

According to the authors of this paper, the visual landscape values connected to the Liesing River improved, but only to a moderate extent. It is more important however in the focus of this research, that the district is not functionally integrated with the river, despite its good accessibility (public transport along the river, numerous accesses to the river (high permeability). Architects and planners frequently in such situations use the term “an area (city) turned away from the river”.

6. Conclusions

A holistic, interdisciplinary urban planning strategy is beneficial for maximizing the transfer of cultural ecosystem services in the restoration of rivers in the city landscape.

The presented project can promote dynamic urban development by solving ecohydrological, compositional, functional, and technological problems in a fairly transparent manner, following the requirements of supporting the development of socio-ecological systems and the approach to ecosystem services, including in particular cultural ecosystem services.

Renaturalisation of rivers in an urban environment is incomplete without a careful design of the surrounding public spaces. The process of urban planning includes all

the factors of recognizing an urban landscape – accessibility, safety, sociability, identity, etc.

Future monitoring of the ecological and social performance of the Sokołówka Valley is important for understanding the compliance of design assumptions and records with reality and the profitability of the investment process. One of the expected social long-term effects of the restoration project is the emergence of new and intensified experiences, competencies and identities. More research is needed on the influence of the restored ecosystem on these, probably social sciences methodology should be employed to connect them to the very spatial components in question.

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