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THE COMPLEX REMODELLING OF ACADEMIC BUILDINGS: THE CASE STUDY OF THE WATER CENTRE AT WARSAW UNIVERSITY OF LIFE SCIENCES (SGGW) CAMPUS

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ABSTRACT

This article examines the modernisation of higher education buildings. It includes a literature review of scientific works on the subject. The recently developed concept project for the modernisation of the Warsaw University of Life Sciences (SGGW) Water Centre building in Warsaw contained a wide range of works encompassing large-scale interventions involving remodelling, renovation, reconstruction and expansion of the existing building. The aim of the article is to examine the possibilities of adapting and optimising both the interior and exterior space through the use of contemporary, computer-aided design methods and incorporating sustainable development aspects. The research hypothesis is that a holistic approach to modernisation, integrating various industries and technologies, can significantly improve the functionality, energy efficiency, and accessibility of the building, and improve the development of the surrounding area. The research method adopted is a review of current literature on the topic and a case study of the Water Centre project on the SGGW campus in Warsaw. The results of the case study analysis indicate a number of problems related to the existing infrastructure and opportunities for improvement through the implementation of a design concept that takes into account the sustainable development goals (SDGs). The conclusions of the paper emphasise the need for interdisciplinary collaboration and a comprehensive approach that considers economic, social, and environmental aspects when modernising buildings with complex functions, which can contribute to improving the quality of space and meeting the needs of various user groups.

Keywords: campus modernisation, renovation, architecture, urban planning, BIM, sustainable development, SGGW

INTRODUCTION

Environmental problems caused by rapid urbanisation are causing countries to turn to sustainable development in the social and economic spheres. As carriers of educational and research activities, universities consume numerous resources and could shoulder more responsibility in ensuring sustainability. Many countries have developed and implemented sustainable policies for university campuses, which have increased diversity in campus

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construction. Universities, as major centres of education and research, consume large amounts of energy, water, and materials, and therefore bear a particular responsibility to lead by example in sustainability. In response, many countries have introduced dedicated sustainable-campus policies and initiatives, which have significantly increased the variety of approaches and designs in campus planning and construction (Chen, Cheng & Li, 2022).

The Warsaw University of Life Sciences (SGGW) plays a key role in promoting sustainable development in Poland. Implementing pro-environmental initiatives not only contributes to environmental protection and the rational use of its resources but also provides practical education for the academic community and society. The university belongs to numerous alliances and organisations bringing together universities.

The SGGW participates in international networks and alliances that directly address sustainable development, natural resource management, life sciences, and sustainable agriculture and forestry. In addition to the European universities alliance, UNI-GREEN focused on sustainable agriculture, green biotechnology, and environmental sciences, SGGW is a member of Euroleague for Life Sciences (ELLS), a network of leading European universities in the life sciences, focused on natural resource management, and agricultural, forestry, and environmental sciences. Its primary goals are education and research for the sustainable use of natural resources, bioeconomy, and solutions to climate change.

The SGGW is a member of the Association for European Life Science Universities (ICA), an association of over 50 European universities specialising in agriculture and life sciences. This organisation promotes education and research in the fields of life sciences, sustainable agriculture, food security, environmental protection, and bioeconomy. It organises numerous initiatives directly related to the UN sustainable development goals (SDGs), including the biodiversity challenge. The SGGW also actively participates in the CASEE Network – the regional arm of the ICA Board for Central and Eastern Europe, focused on the sustainable development of agriculture and natural sciences in Central and Eastern Europe.

Membership in the aforementioned organisations demonstrates the university's far-reaching ambitions in achieving sustainable development goals. According to the university's website, researchers from the SGGW's research institutes are engaged in projects that comprehensively contribute to the implementation of sustainable development principles across the entire campus and in the university's experimental facilities. One objective result of the SGGW's research in the area of sustainable development was its high ranking in the Impact Rankings, the only international ranking of universities based on the UN sustainable development goals (SDGs). The ranking aims to demonstrate the importance of higher education institutions in building a sustainable world and promote universities that work to address the greatest challenges of our time. The SGGW is gradually implementing systems that reduce energy consumption and utilise renewable energy sources. This began with the installation of energy-efficient lighting and photovoltaic panels and heat pumps. The first installations were completed in one of the student residences, in the sports facilities, and at the SGGW Forest Experimental Station in Rogów. In 2023, the photovoltaic panel system was expanded to a capacity of 650 kW on the university campus and 300 kW in the university experimental facilities. Electric vehicle charging points were also installed on the campus. Temperature monitoring and regulation systems linked to the control of heating substations, as well as ventilation and air conditioning monitoring systems, are used in the SGGW buildings. Thermal modernisation of the buildings is ongoing, and systems enabling significant automation of the operation of teaching and administrative facilities are being installed. Activities are also underway to optimise the use of cleaning products and paper for hygiene purposes (Biuro prasowe SGGW, 2025).

MATERIAL AND METHODS

The aim of this article is to analyse a case study of the modernisation of the building in question, taking into account original research methods and modern technologies. Conducting such studies and research can contribute to deepening specialised and detailed knowledge in the field of architecture and urban planning and improving the solutions used in buildings with this and similar functions. The results indicate a number of problems related to the existing infrastructure and the considered design options. The aim is to analyse the case study, and the manuscript fills a research gap related to the lack of research on this aspect. This lack of research is related to the rarity and low number of similar projects and the limited scope of activities undertaken. Furthermore, a discussion is sought to be developed based on the issues presented in this work. This article fills the research gap related to the lack of detailed studies related to the comprehensive modernisation of facilities serving as higher education facilities that are parts of building complexes with a similar function located in an area with a specialised function, where various groups of users appear (the campus).

The concept project of modernisation of the Water Centre and its surroundings at the SGGW in Warsaw is a part of an internal competition (Golański et al., 2024). This project was created through the cooperation of a team of employees and doctoral students from the Department of Architecture in the Institute of Civil Engineering at the SGGW. The competition focused on developing design solutions for the modernisation of a building that is over a decade old and requires general renovation and changes due to various construction, functional, and spatial problems (Instytut Inżynierii Lądowej SGGW, 2025). This study was conducted based on detailed solutions from the project. It gathered considerations, original reflections, as well as comparisons of several variants of the completed project. These variants differed in the level of complexity, advancement of technical solutions, and complexity of the functional program, as well as economic aspects (Stefańska et al., 2023; Stefańska et al., 2025). The closing ceremony of the post-competition exhibition, held at the SGGW Library in November 2025, provided an opportunity for the project teams to meet and discuss the project with the university authorities at the Rector and Dean levels. Students from the ‘Archi-Eco-Lab’ Scientific Club involved in the project activities presented the project and related workshop activities at the XXIV International Scientific Conference – Defining the Architectural Space – Architecture and History in November 2025 (Juchimiuk, Golański, Donderewicz, Fabisiak & Sobczyński, 2025).

The research area encompasses selected fields of architecture, construction, environmental engineering, landscape architecture, and social sciences. While land development in the context of modernising buildings with complex functions, such as the SGGW Water Centre, may seem interesting and niche, it encompasses a multi-threaded architectural and urban planning concept.

The research tools and methods adopted in the case study described in the article were multi-objective and are described as follows. The author’s scientific and professional archive served as a primary source of empirical data. A literature review and critical analysis were conducted, addressing the modernisation of public utility buildings with characteristics similar to those of the Water Centre, as well as the spatial development of university campuses. As part of the literature review in the area where the research was conducted, the ResearchGate, Web of Science, Google Scholar, Scopus, and *Acta Scientiarum Polonorum* database search engines were used as well as the Knowledge Base of the SGGW.

A case study was employed, focusing on the design concept for the modernisation of the SGGW Campus. The observational method was applied to conduct a visual assessment of the building and its surrounding area, as well as a technical evaluation of the existing condition prior to the development of the concept. The analytical method involved examining documentation, regulations, and input data, which facilitated formulating conclusions. Finally, a qualitative assessment was performed based on criteria identified through the literature review. The competition project for the modernisation of the SGGW Campus was selected as a case study example. The conclusions and discussion were supplemented with a literature review concerning research on similar implementations and projects with a comparable level of complexity.

RESULTS AND DISCUSSION

Renovation encompasses the comprehensive transformation of a property's function, layout, and appearance, frequently entailing significant structural modifications to adapt to evolving spatial demands. In contrast, refurbishment prioritises superficial enhancements, such as repairs and aesthetic refinements, to boost the usability and visual appeal while preserving the underlying structural integrity. Retrofitting, however, targets the incorporation of innovative technologies or features into extant structures to elevate energy performance, comply with contemporary regulations, or mitigate environmental impacts. Recent European research underscores the urgency of these distinctions in advancing sustainability, particularly in Central and Eastern Europe, where comprehensive retrofitting has demonstrated potential energy savings. These high-impact findings, with the former garnering citations for its policy implications amid EU decarbonisation efforts, emphasise how targeted retrofitting – beyond mere refurbishment – can align building upgrades with the European Green Deal's Renovation Wave, fostering economic viability and climate resilience in urban renewal projects (Fetting, 2020; Pacheco-Torgal, Granqvist, Vanoli, Bianco & Kurnitski, 2025).

Literature sources outline strategies for addressing the challenges in refurbishing buildings to achieve net-zero energy standards (Brophy & Lewis, 2012). A recurring emphasis is placed on adopting a multi--disciplinary approach that spans various fields, while ensuring consultants, contractors, and facilities managers align on a shared perspective. Energy considerations encompass diverse aspects across project phases, including design, management, and operation. The selection of materials and systems plays a key role in shaping the building's energy profile, encompassing both embodied and operational energy. Nevertheless, a low-carbon building must also meet human requirements; otherwise, the invested resources are rendered ineffective. Sustainability initiatives seek to enhance quality of life, particularly in terms of health and well--being, while minimising resource use.

The reviewed literature encompass resources that introduce an innovative method for renovating structures, merging elements from diverse expert fields, and incorporating principles of environmentally friendly architecture, architectural integrity, and optimal energy use (Leskovar & Premrov, 2019). This method highlights a number of frequently neglected attributes of structures that should be fully woven into the framework of renovation projects. These resources offer a summary of the primary strategies for renovation, categorised by their extent, depth, and key focuses. Moreover, they illustrate the ways in which particular advancements, such as expansions utilising modules made from wood, can support firms in the construction sector while strategising and advancing their upcoming manufacturing processes (Golański, 2016; Golański & Januszkiewicz, 2017; Golański, 2022). Multiple methodologies are employed when updating pre-existing edifices, and there exists a compelling requirement to merge the application of holistic and cross-disciplinary methods with current investigations, in addition to promoting education and increasing consciousness regarding their significance.

Summarising the literature research, it can be clearly concluded that the literature has shifted from purely technology-driven retrofits to socio-technical processes where technical excellence, rigorous management, digital integration, and genuine occupant partnership are equally important. Campuses that treat modernisation as an ongoing, participatory, data-informed process – rather than a checklist of green features – achieve the deepest and most durable sustainability gains.

Circular economies – the drive to minimise waste and maximise the use of resources, which has a positive impact on sustainable development – are gaining popularity.

In the coming years, further development and implementation of innovative solutions are expected, such as the widespread use of renewable energy to reduce greenhouse gas emissions and the pursuit of carbon neutrality in cities (Juchimiuk, 2015; Østergaard, Duic, Noorollahi, Mikulcic & Kalogirou, 2020).

From the reviewed literature, sustainable modernisation of university campuses consistently revolves around integration, user involvement, and long-term performance rather than isolated technical upgrades. The most critical recurring aspects can be grouped as follows:

– holistic and phased frameworks,
– active user and stakeholder engagement,
– closing the performance gap through monitoring and feedback loops,
– digital tools and information management,
– certification systems as project-management and communication tools,
– sustainability: energy- and material-efficient, circular economy,
– context-specific typological responses,
– balancing top-down standards with bottom-up demands.

Successful retrofits treat buildings as complex systems. The strongest frameworks (Ahmed, Mateo-Garcia, Arewa & Caratella, 2021; Ahmed, Dewidar, El-Hakeem & Guirguis, 2025) move systematically from diagnosis and benchmarking through technical intervention to monitoring and feedback. This phased approach prevents the common energy-performance gap (where predicted savings are not achieved in reality) and ensures that envelope upgrades, heating, ventilation and air conditioning (HVAC) renewal, lighting, and renewables are prioritised according to actual campus needs and payback periods.

Almost every paper emphasises that occupants (students, faculty, staff) must be involved early and continuously. Pre- and post-occupancy surveys plus participatory workshops dramatically increase acceptance of measures (e.g., new temperature set-points) and sustain energy savings (Ahmed et al., 2021). The Chinese context reveals that comfort and functionality often outweigh pure environmental criteria in users' minds; ignoring this leads to resistance or misuse of green features (Chen et al., 2022).

Low-energy renovation is not a one-time event. Continuous commissioning, real-time data dashboards, post-occupancy evaluation (Ahmed et al., 2021), and the digital platform (Carrasco-Beltrán et al., 2024) are essential to verify that modernised buildings actually perform as designed and to correct deviations quickly.

Modernisation projects generate enormous amounts of data, such as as-built drawings, energy models, maintenance logs, etc. (Zawada, Donderewicz, Gertner & Rybak-Niedziółka, 2024). Campus 2.0 demonstrates that a centralised BIM-based platform reduces errors, speeds up decision-making, and enables user-friendly interfaces (mobile apps, gamification) that further reinforce sustainable behaviour (Carrasco-Beltrán et al., 2024).

Piętocha (2024) positions BREEAM, LEED, and DGNB not merely as labels but as structured methodologies that force campuses to address the energy, materials, water, health, and management categories systematically (Piętocha, 2024). Achieving a high rating provides visible proof of commitment and often unlocks funding or regulatory advantages (Donderewicz & Zawada, 2024). Early integration of renewable energy sources (RES) technologies with an architectural envelope may benefit the effective energy efficiency of the buildings and areas (Juchimiuk, 2022a; Juchimiuk, 2022b).

Architectural and engineering solutions such as climate-friendly building technologies produced from renewable materials like engineered wood (CLT, LVL, glulam, KVH) contribute strongly to the overall environmental performance of the building in terms of embodied and operational energy (Berge, 2009; Maier, 2021; Stefańska, Cygan, Batte & Pietrzak, 2021; Dukarska & Mirski, 2023; Starzyk, Cortiços, Duarte & Łacek, 2025), life cycle assessment, and circular economy (deconstruction, re-use), addressing sustainable development and its goals (Golański & Januszkiewicz, 2017; Starzyk et al., 2025). Early integration of renewable energy systems into the building envelope is vital in developing innovative engineering solutions for energy-efficient architecture (Juchimiuk, 2022a).

While horizontal sprawl is common for traditional campuses. Some researchers argue that vertical or high--density development (especially in land-scarce megacities) can drastically cut per-capita energy and land use by shortening transport distances, enabling district energy systems, and integrating greenery at multiple levels (Piętocha, Li & Koda, 2025). This paradigm is particularly relevant when campuses must expand their enrolment without acquiring more land.

Official green-campus indicators (common in China, Europe, and North America) and global certifications provide rigour, but Chen et al. (2022) warn that strict compliance alone can produce buildings that users dislike or circumvent. The most effective modernisations hybridise regulatory requirements with localised user priorities.

Case study

The design philosophy behind the renovation project of the Water Centre and its surroundings at the SGGW Campus in Warsaw envisions a substantial enlargement and addition of upper levels to the current structure, aimed at completing the edge of the SGGW Campus and establishing a fresh, prestigious area. A central feature involves transforming the nature of the main indoor space by incorporating multiple links to outdoor vistas and fostering interactions between the internal and external environments. These communication zones, laid out along defined axes, are intended to encourage visitors to discover the building and provide visual access to the broader campus grounds, thereby setting up optimal circumstances for showcasing gatherings and programs held at the SGGW Water Centre – especially those focused on advocating cutting-edge and eco-friendly approaches in building practices, architectural design, and landscaping.

The building has been in operation since 2010. The 1.5-hectare facility includes a water park with a model river and a research and teaching building (Fig. 1). The SGGW Water Centre is the largest research facility in Poland dedicated to water, housing 20 laboratories in various fields. Its original function as a highly specialised research and teaching facility, at that time not integrated with the SGGW Campus, had largely been exhausted, a fact clearly revealed in user group research and participatory workshops. Problems with functional inconsistencies were compounded by the deteriorating technical condition and the need to adapt the building's envelope to current thermal insulation requirements. The extensive renovation work, which included thermal modernisation, the repair and replacement of HVAC systems, the reconstruction of the internal envelope, introducing fundamental changes to the building's use, and the demolition work provided the opportunity for an optimised and highly efficient expansion of the building, making it both self-sufficient in terms of energy generation and integrated with the urban environment, bordering zones with different primary functions (the SGGW Campus and residential developments).

This project was created in cooperation with a team of staff and doctoral students from the Department of Architecture in the Institute of Civil Engineering at SGGW. The competition involved preparing and presenting design solutions for the modernisation of a building that is over a decade old and requires changes due to a series of construction, functional, and spatial problems. This study was carried out based on the detailed solutions of the project. It gathered considerations, original reflections, as well as comparisons of several variants of the completed project. These variants were distinguished by the level of complexity, advancement of technical solutions, complexity of the functional program, and economic issues. The conclusions and discussion were supplemented with a literature review concerning research on similar implementations and projects with a comparable level of complexity.

Social interaction constituted a significant contribution by providing ongoing review of the developing design concept and delivering direct review (feedback loop). User involvement in the building's design process was achieved through interviews and workshops organised by the lecturers, as well as external partners (Other Space Foundation and the Academy of Young Architects) involving high school youth, seniors, dog owners, SGGW students, academic and teaching staff, and local residents, as well as through direct engagement in the design process by assisting and creating original studies that humanise the space around the SGGW Water Centre, with these studies forming an integral part of the design concept (architecture students) (Vietrova, Vasyliev & Swacha, 2025). A fundamental component of the development was the design credo, which defined the pattern language concerning the spatial arrangement, cultural and social aspects, neurodiversity needs, and a broadly understood strategy for implementing blue-green systems. The multi-thematic project is undoubtedly characterised as the Green Flagship of the SGGW, encompassing aspects of biodiversity. Local identity (*genius loci*) is expressed through the presence of pavilion structures (follies) and a footbridge with clearly articulated spatial features (Fig. 2). The building itself was conceived as a demonstrator object for pro-environmental architectural solutions, methods of shaping green buildings, and sustainable construction technologies.

Fig. 1. Existing SGGW Water Centre

Source: own work.

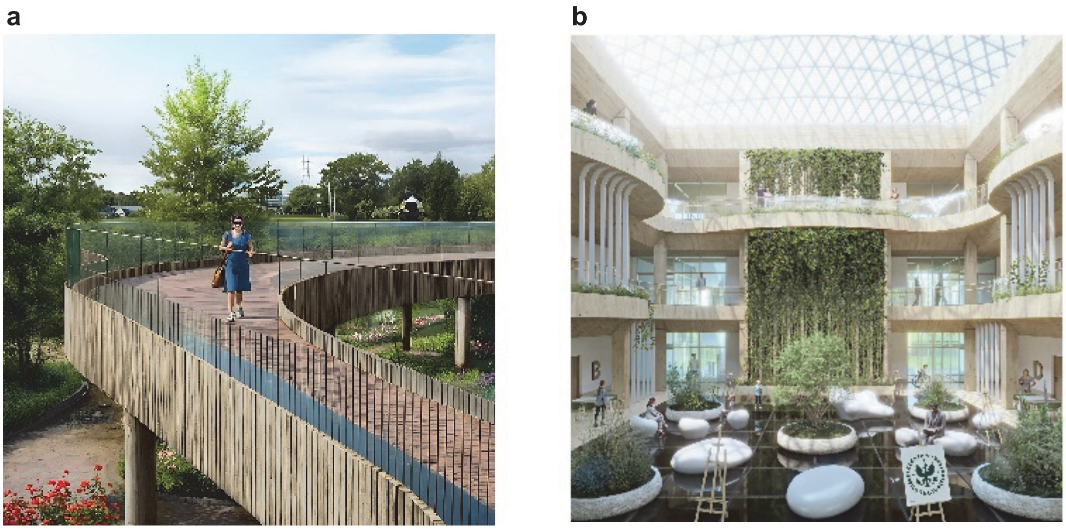

Fig. 2. Concept project of SGGW Water Centre with neighbouring area: a – external elevated pathway, b – atrium with greenwall and gridshell skydome

Source: own work.

The team's work resulted in a fully fledged concept for the modernisation of the building and its surroundings. The solutions consisted in the implementation of pro-environmental measures that would fit into the prevailing trends and practices from international implementations. The guiding idea was to create a consolidated open space tailored to the needs of various user groups, ranging from students, lecturers and administrative staff, to the local community and guests from abroad. The proposal integrated, to the greatest extent possible, the 17 SDGs, which, together with the 169 associated tasks, form the global Agenda 2030. These encompass three dimensions of sustainable development: economic, social, and environmental. All three fundamental aspects of sustainable development (social, environmental and economic) were taken into account and expressed in the concept (Fig. 3).

a b

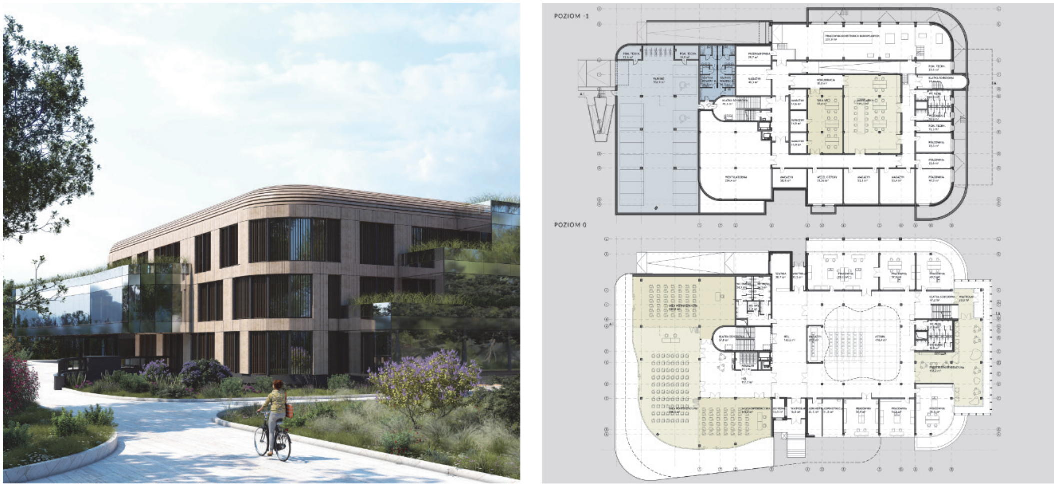

Fig. 3. Concept project of SGGW Water Centre with neighbouring area. Environmental aspects addressed in the concept project: a – view along Ciszewskiego street, b – Plans of levels –1 and 0

Source: own work.

Sustainable design solutions

The reconstruction of the SGGW Water Centre aims to transform the facility and its immediate surroundings and to give it a new identity as a 'green' showcase for the SGGW that promotes directions related to renewable energy sources and materialises the SGGW's pro-ecological ambitions. The concept assumes the expansion of the building in a way that emphasises its function as a corner closure of the SGGW Campus, a change in the character of the building's central interior, and the introduction of a series of external visual connections and interior-exterior linkages. It is essential to create central representative spaces with an axial character through the implementation of a communication system that provokes exploration, visually opens up the SGGW Campus area, and enables broad promotion of events and activities carried out in the New Centre for Innovation.

The main idea of the modernisation is based on creating high-quality spaces with respect for nature. The solutions introduce green elements into the interiors, building façades, and roof surfaces and implement diverse forms of green space development – from arranged greenery to areas of spontaneous vegetation aimed at realising the idea of biodiversity. Ecological, spatial, and social aspects play a significant role. They constitute an exposition of processes and technologies related to blue-green infrastructure.

The design inspiration is derived from traditional Chinese gardens. They represent a combination of nature, philosophy, and art, reflecting a harmony between humans and nature. Characteristic elements of such gardens form a kind of landscapes containing ponds and streams (symbolising the sky), stones (representing mountains and earth), pavilions and gazebos (places for rest and contemplation), bridges (symbolising the transition between different states of being), and vegetation (carefully selected to bloom in different seasons, providing a changing, beautiful landscape).

The renovation initiative for the SGGW Water Centre aims to improve the structure's overall utility by introducing extra areas dedicated to learning, research endeavours, meetings, displays, and various gatherings, all while aligning with objectives for sustainable progress (Fig. 2).

Significant alterations to the functionality encompass:

– Converting spaces in the basement (Level −1) into areas for instructional purposes, including a virtual reality laboratory.
– Adjusting the layout on the main floor (Level 0) to incorporate a retractable, temporary seating arrangement capable of holding 100 individuals.

The extension to the facility entails (Table 1):

– Expanding the available floor space by substituting the current surface-level parking lot with a subterranean parking facility.
– Extending the footprint on the ground level (Level 0) and the upper level (Level +1) in proximity to the entrance of the SGGW Campus.
– Constructing additional sections on Levels 0, +1, and +2 to accommodate classrooms for education and observation decks offering sightlines across the SGGW Water Park.

Table 1. Area schedule

Area	Gross floor area (GFA)
Existing	4,768 m²
New area	3,862 m²
Total area after renovation	8,630 m²

Source: own work.

Furthermore, the architectural plan incorporates plant life within the internal spaces, exterior walls and rooftop areas, and fosters ecological diversity by combining formally designed green zones with regions of naturally occurring flora (Fig. 4).

The core concept behind the design is to establish a superior environment that honours the natural world and serves as a demonstration of sustainable biophilic principles in building design (Table 2). This goal is realised through the inclusion of verdant features inside the building, along its outer surfaces, and across the roof expanses, thereby reinforcing a commitment to visual appeal that blends seamlessly with the environment. The landscaping surrounding the SGGW Water Centre features both meticulously planned plantings and zones of unmanaged growth, intended to enhance biological variety. The initiative places strong emphasis on environmental, layout-related, and community-oriented elements, which are intended to showcase various mechanisms and innovations associated with blue-green systems. As a result, visitors can directly witness the operations of systems like water reclamation or plant care protocols, thereby amplifying the site's role in education.

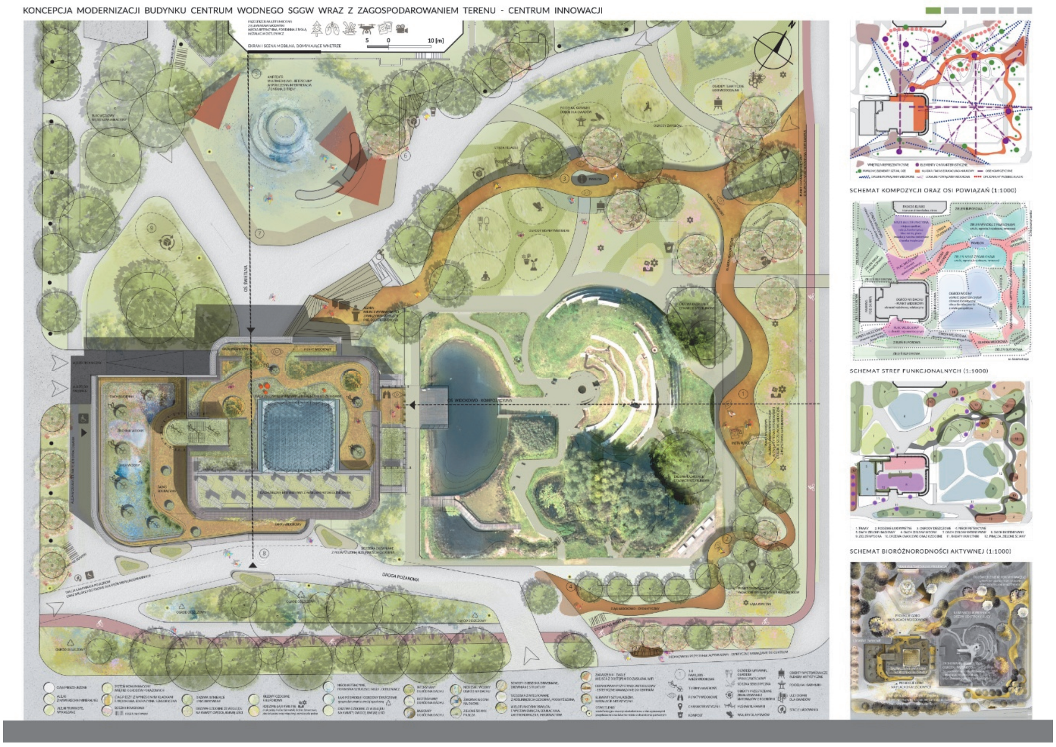

Fig. 4. Concept project of SGGW Water Centre with neighbouring area. Site plan

Source: own work.

Table 2. Stages of remodelling process of SGGW Water Centre and campus surroundings in Warsaw

Sustainable building solutions	Design and engineering field
Prefabricated structure made of glued- and cross-laminated timber	Building materials Construction technologies Structural design
Photovoltaic panels: photovoltaic (PV)/building integrated photovoltaics (BIPVT)/ /organic photovoltaic (OPV)/perovskites – tracking systems, agrivoltaics	Architectural design Building envelope Renewable energy sources (RES) design Landscape design
Green wall	Interior design Landscape design
Artificial mist fountain	Interior design Heating, ventilation and air conditioning (HVAC)

Source: own work.

The language of patterns (credo) contained in the concept of land development is an emanation of process-oriented thinking, rather than the localisation of individual functions. Its foundation was a multi-layered and multi-faceted field interview. This made it possible to identify visual features and hidden characteristics of the subject area and to discover values strongly associated with the terrain as a place, the definition of this place, and its redefinition anew. As we know, 'place' in urbanism does not exist without people. This is precisely what distinguishes a place from a 'non-place'. To build a 'place' with its unique *genius loci*, it is essential to combine tradition, culture, form, and an appropriate quality of life. In the subject project, tradition is expressed through myths, culture through the heritage of academic life, form through art, and quality of life is created by pro-ecological solutions (land art and reuse) (Borkowski & Winiarska, 2025). Culture as the heritage of academic life is expressed via the Axis of New Horizons – metaphorically and literally intersecting the volumetric object of the Water Centre – this is a compositional axis connecting points that are the horizon lighthouse, the light lighthouse, and the perspective lighthouse. In turn, form is expressed through art. It accompanies the mythological, meandering form of the Path of Knowledge and Innovation. There, in the form of 'milestones', a platform of 'wandering artifacts' will be launched, illustrating the fragility of human fates and similarly the fragility of the life of works of art, sometimes extracted from the oblivion of history, but just as often falling into forgetfulness. The awareness of the accompanying overall new quality of life is demonstrated through the location around the Water Park of a group of pavilions erected on reuse principles. These are the Circular Towers Pavilions, the Sustainable Development Pavilion, the Event – Organic Pavilion, and the Resilience Tower. This location constitutes an allegorical dimension of humanity's struggles to save the Globe and its natural environment (here – towers, historically, as a defensive form).

The design concept of the New Innovation Centre intentionally references the 'Water' past as well as the green, innovative future. The concept respects the needs of the academic community and the university's conference ambitions. It assumes the use of elements from the former fountain in the building and structural roof elements as decor, building material for small architecture, pavilion construction, or viewing bridges. These elements aim to visually connect with the previous form and function of the SGGW Water Centre. Such actions give the place a unique identity and emphasise the role of a sustainable approach to modernisation investments and the promotion of circular construction. Elevated green flower beds and solid benches with versatile orientation create transparent recreational interiors, while simultaneously contributing to the unsealing and greening of the surroundings of the New Innovation Centre. The use of solid, durable materials such as steel, natural stone and glued-laminated timber ensures a sustainable and resilient structure.

The structure of the newly designed part of the building consists of columns, beams, and cross-braces made of glued-laminated timber, as well as floors executed in CLT technology. CLT floors combine the properties of natural wood with prefabrication technology, allowing for large spans of structural elements and quick assembly on the construction site. Connections between wooden elements are made using wooden joint systems and steel connectors.

The applied tracking photovoltaic panel systems contribute to reducing electricity consumption and lowering the costs associated with maintaining the facility. They also serve as an element of the educational path designed on the roof. It is accessible to users and visitors of the facility. The photovoltaic system is hidden behind the attic.

In the atrium, a green wall is proposed, which will serve as the main decorative element of the interior and provide a backdrop for presentations – thus, this solution will be promoted in the media. The green wall should be located in a room with a stable temperature ranging from 18°C to 21°C.

Inspired by Chinese gardens, an artificial mist fountain is proposed. It is generated from normal water by forcing it through aerosol nozzles under high pressure. It can increase air humidity, lower the temperature, and create a mystical aura. The use of the 'fountain' as a carrier for projections – holograms – is planned. This solution represents a reference and continuation of the object's previous function in water research.

Building information modelling (BIM) plays a pivotal role in architectural design by enabling precise simulations of energy performance and resource utilisation, allowing designers to minimise environmental impacts such as carbon emissions and waste generation from the outset. It supports the integration of sustainable features like green roofs, solar panels, and efficient water systems, ensuring that buildings align with certifications such as LEED or BREEAM to achieve long-term ecological benefits (Piętocha, 2024). BIM also facilitates collaborative lifecycle assessments among stakeholders, optimising material choices and operational efficiencies to promote biodiversity, reduce urban heat islands, and enhance overall resilience to climate change (Juchimiuk & Golański, 2025). An example of this application is the BIM model used for the concept design of the SGGW Water Centre building in Warsaw, as referenced on Figure 5.

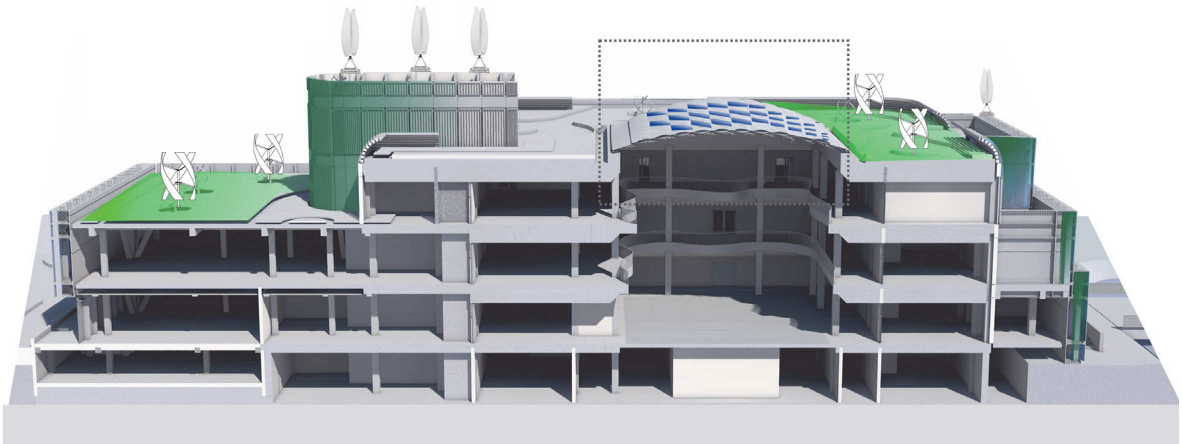

Fig. 5. BIM model of water centre used in concept design process for project of environmental aspects addressed in concept project of SGGW Water Centre

Source: own work.

Project phases

The modernisation project for the SGGW Water Centre in Warsaw was strategically developed in phased variants to allow for efficient resource allocation, reduced operational disruptions, and progressive integration of sustainable features (Table 3). In Stage I, the focus is on constructing an underground parking hall and expanding Level 0, which lays the foundational infrastructure for improved accessibility and functionality. This initial phase ensures that core structural enhancements are completed before advancing to the upper levels, minimising the risks associated with simultaneous large-scale works. Stage II involves the expansion of Level +1, building on the groundwork to incorporate additional spaces for academic and innovative activities while maintaining the site's historical water-themed elements. By sequencing the project this way, the design team can address immediate needs like parking without compromising the overall vision of a green, innovative centre. Stage III encompasses the expansion of Level +2, along with the installation of a new skylight and green roofs, which enhance the natural lighting, energy efficiency, and environmental integration. These elements promote sustainability by incorporating photovoltaic systems and green walls, aligning with circular economy principles (Fig. 6). Finally, Stage IV, which is completely independent, handles the land development, providing flexible timing to optimise the landscaping, recreational areas, and external connections. This phased approach not only respects budget constraints and timelines but also enables ongoing monitoring and adjustments based on feedback from stakeholders. Overall, the variant-based development underscores a holistic strategy that balances innovation, heritage preservation, and ecological responsibility for the New Innovation Centre.

Table 3. Stages of remodelling process of Water Centre and surroundings at SGGW Campus in Warsaw

Stage	Description
I	Construction of the underground parking hall and expansion of Level 0
II	Expansion of Level +1
III	Expansion of Level +2, including a new skylight and green roofs
IV	(Completely independent) Realisation of land development

Source: own work.

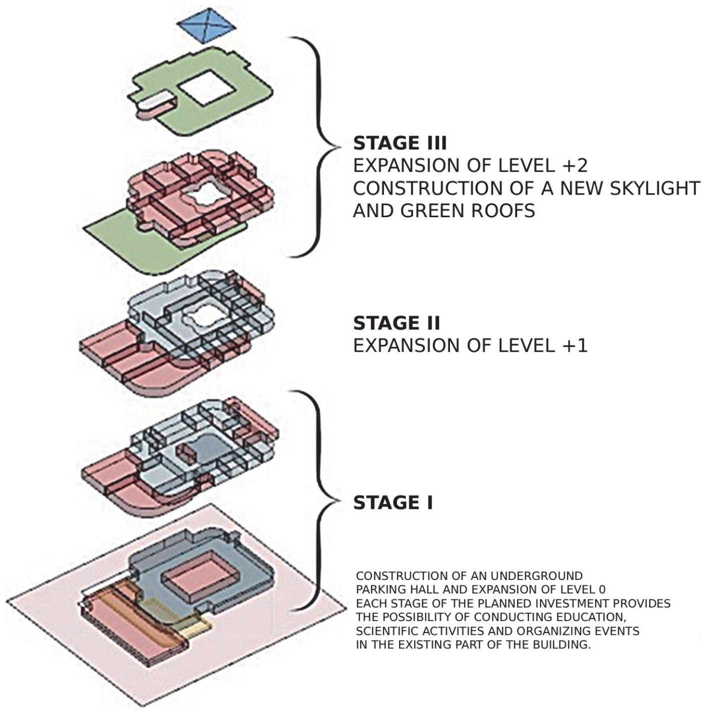

Fig. 6. Concept project of SGGW Water Centre with neighbouring area. Site plan

Source: own work.

CASE-STUDY RESULTS

The research findings identified sustainable design aspects related to the modernisation of the subject building. Criteria and keywords were adopted that correspond to architectural and urban issues in relation to the modernisation, including the general renovation and retrofitting of buildings with complex functions, similar to the subject building of the SGGW Water Centre.

The table lists eight key criteria from theoretical research on sustainable renovation, assessed for the SGGW Water Centre project in Warsaw, with '+' indicating fulfilment in areas such as holistic frameworks, user engagement, digital tools, sustainability (energy/material efficiency and circular economy), context-specific responses, and balancing standards with demands, while '–' marks shortcomings in performance monitoring/feedback and certification systems (Table 4).

Table 4. Architectural and engineering design solutions

Recurring aspects in sustainable renovation	Criteria met in project
Holistic and phased frameworks	+
Active user and stakeholder engagement	+
Closing the performance gap through monitoring and feedback loops	–
Digital tools and information management	+
Certification systems as project-management and communication tools	–
Sustainability: energy- and material-efficient, circular economy	+
Context-specific typological responses	+
Balancing top-down standards with bottom-up demands	+

Source: own work.

The project's holistic and phased frameworks effectively integrate remodelling, renovation, reconstruction, and expansion, aligning with theoretical models for comprehensive sustainable upgrades in higher education buildings. Active user and stakeholder engagement is demonstrated through designs that cater to academic needs and conference goals, promoting inclusive participation as advocated in research. However, the lack of closing the performance gap via monitoring and feedback loops overlooks a critical theoretical aspect for ensuring ongoing efficiency and adaptability. Utilisation of digital tools and information management, such as CLT prefabrication and photovoltaic systems, supports streamlined processes and innovation, meeting scholarly recommendations for tech-driven renovations (Fig. 7). The absence of certification systems as project-management and communication tools misses an opportunity to leverage standards for validation and outreach, contrary to the theoretical emphasis. The strong focus on sustainability through energy and material efficiency, including circular economy practices like material reuse, embodies core research principles for eco-friendly modernisation. Context-specific typological responses are achieved by tying the design to the site's water heritage and green future, creating a tailored approach as suggested in the literature. Balancing top-down standards with bottom-up demands is evident in features like green spaces and durable materials that address both regulations and user preferences.

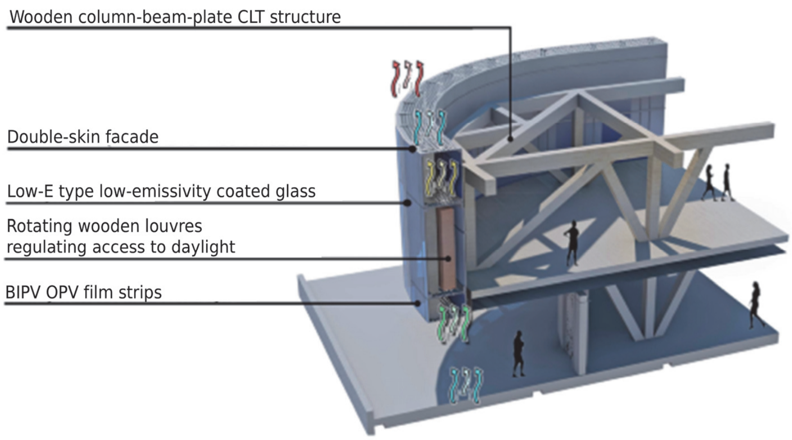

Fig. 7. Integration of building-integrated organic photovoltaic (BIPV) double-skin façade featuring organic photovoltaic coating (OP) with engineered wood structure

Source: own work.

Overall, the project's alignment with six out of eight criteria highlights its potential as a model for sustainable academic building transformations. Incorporating monitoring mechanisms and certifications in future phases could address the gaps, enhancing the alignment with full theoretical frameworks for long-term impact.

The modernisation effort for the SGGW Water Centre exemplifies a thorough application of sustainable development principles, encompassing not only construction and material choices but also operational frameworks (Table 5).

Table 5. Architectural and engineering design solutions

Sustainability aspect	Architectural and engineering design solutions
Social	Use of social participation tools
	Humanisation of the SGGW Campus space by creating quiet zones for neurodiverse individuals and areas with a distinct local identity (*genius loci*)
	Improvement of the city's aesthetics, organisation of SGGW Campus space
	Creation of a landmark for the SGGW Campus – a flagship building with a clearly pro-ecological character that strengthens the image of SGGW as a green higher education institution
	Demonstration of pro-environmental construction technologies
Environmental	Use of ecological materials
	Thermal modernisation
	Use of renewable energy sources and their integration with the building's external partitions
	Re-use strategy
	Design for deconstruction
	Biodiversity
	Greening
Economic	Dematerialisation
	Circular economy
	Energy efficiency
	Design for manufacturing and assembly (DfMA)
	Improvement of building's technical condition
	Maintenance costs reduction
	Increasing the surface area of buildings, return on investment

Source: own work.

DISCUSSION

The SGGW Campus modernisation transcends a conventional retrofit by embedding Agenda 2030 into the physical, social, and economic fabric of this piece of academic infrastructure. Its triple-loop learning framework – technical innovation, participatory governance, and circular materiality – offers a scientifically robust, scalable archetype for sustainable urban regeneration and green construction transformation (Juchimiuk & Golański, 2025).

Renovating mixed-use, mid-sized public sector buildings provides an ideal platform to advance sustainability by incorporating energy-efficient systems that reduce operational expenses and mitigate environmental impacts. Passive solar strategies, including optimised window placements and external shading, effectively diminish the dependence on artificial climate control in these versatile environments. Pro-ecological engineering solutions, such as rainwater harvesting and greywater systems, enhance water efficiency and reflect the public sector's commitment to sustainable resource management. Selecting recycled materials like reclaimed wood and sustainable insulation minimises embodied carbon emissions while extending the building's service life (Golański, Juchimiuk, Kwiatkowski & Figat, 2025). Addressing neurodiversity in renovations involves integrating sensory-friendly elements, such as tuneable lighting, sound-absorbing materials, and dedicated calm spaces to accommodate users with conditions like autism or ADHD. Adaptive reuse preserves historical features while enhancing building envelopes to achieve nearly zero-energy performance. There is a pressing need for intensive actions to green the interiors of buildings in urban spaces, as this fosters biodiversity by introducing plant life that supports local ecosystems and improves air quality. Such greening initiatives also promote users' mental health by creating restorative environments that reduce stress and enhance well-being through biophilic connections to nature. Green roofs, vertical gardens, and indoor plant integrations not only bolster biodiversity but also contribute to thermal insulation and natural cooling in densely populated areas. Smart engineering with IoT sensors optimises energy use across mixed functions, ensuring seamless operation in retail, administrative, and communal areas. Social participation is encouraged via inclusive designs like accessible entrances, shared plazas, and stakeholder-involved planning to build community ownership. Modular approaches in renovations minimise waste and facilitate adaptable spaces for evolving needs without significant environmental harm. Life-cycle analyses guide decisions to harmonise ecological gains with economic sustainability in public projects. Neurodiversity-friendly features, including adaptable seating and intuitive signage, further ensure equitable access and comfort for all. Community engagement through workshops strengthens social ties, positioning the building as a vibrant civic centre. Integrating renewable energy sources, such as solar arrays and wind turbines, complements interior greening efforts by powering sustainable systems and reducing the reliance on fossil fuels. Finally, multi-sensory accessibility tools like tactile maps support neurodiverse individuals, while holistic greening strategies underscore the interplay between urban biodiversity, mental health benefits, and renewable energy adoption.

CONCLUSIONS

The modernisation of buildings with complex functions, such as the SGGW Water Centre, is complex and multifaceted. A holistic, multifaceted approach is necessary, integrating various disciplines and co-creating a project team divided by thematic areas (architecture, landscape design, structural design, construction technology, HVAC). The article examines the modernisation of higher education buildings, including research of scientific works on the subject. The recently developed concept project modernisation of the SGGW Water Centre building in Warsaw contained a wide range of large-scale interventions involving remodelling, renovation, reconstruction and expansion of the existing building. Modernising these types of buildings is important, brings benefits, increases the efficiency of existing buildings, and produces operational savings through energy efficiency. It results in the creation of better spaces that meet a range of regulations and the needs of various social groups, including those with disabilities. It also makes it possible to intensify and optimise the use of the functional spaces, creating more educational and conference rooms that meet applicable standards. This type of concept creates opportunities for implementing modern technology, including interactivity, VR, and AR technologies. Design variability is beneficial and justified for many reasons, allowing for personalised design solutions and more precise fulfilment of needs. However, it is important to be mindful of the drawbacks, obstacles, inhibiting factors, limitations, and challenges. In the future, the modernisation process can be improved by paying attention to aspects such as social participation, sustainable development, and technology integration. Within this topic, research directions related to analysing the impact of modernisation on the environment, user health and well-being, and economic efficiency can also be identified. The impact of modernisation on the image of SGGW and its relations with its surroundings is also a significant aspect. One of the requirements of the investor was to turn the SGGW Campus into a landmark; a showcase building with a clearly pro-ecological character that strengthens the image of SGGW as a green higher education institution.

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KOMPLEKSOWA MODERNIZACJA BUDYNKÓW AKADEMICKICH: STUDIUM PRZYPADKU CENTRUM WODNEGO NA KAMPUSIE SGGW W WARSZAWIE

STRESZCZENIE

W artykule omówiono przegląd literatury i analizę krytyczną w odniesieniu do modernizacji budynków użyteczności publicznej o cechach podobnych do Centrum Wodnego SGGW. Niedawno opracowany projekt koncepcyjny modernizacji budynku Centrum Aktywności Wodnej SGGW w Warszawie zawierał szeroki zakres prac, dużych interwencji obejmujących przebudowę, renowację, rekonstrukcję oraz rozbudowę istniejącego budynku. Celem artykułu jest zbadanie możliwości adaptacji i optymalizacji przestrzeni zarówno wewnętrznej, jak i zewnętrznej poprzez wykorzystanie współczesnych, komputerowo wspomaganych metod projektowych oraz uwzględnienie aspektów rozwoju zrównoważonego. Hipoteza badawcza zakłada, że podejście holistyczne do modernizacji, integrujące różne branże i technologie, może znacząco poprawić funkcjonalność, efektywność energetyczną oraz dostępność budynku, a także przyczynić się do rozwoju otoczenia. Metoda badawcza obejmuje przegląd aktualnej literatury związanej z tematem oraz studium przypadku projektu Centrum Wodnego na kampusie SGGW w Warszawie. Wyniki analizy studium przypadku wskazują na liczne problemy związane z istniejącą infrastrukturą i możliwości poprawy poprzez wdrożenie koncepcji projektowej uwzględniającej cele rozwoju zrównoważonego (SDGs). Wnioski podkreślają potrzebę współpracy interdyscyplinarnej i kompleksowego podejścia, które bierze pod uwagę aspekty ekonomiczne, społeczne i środowiskowe podczas modernizacji budynków o złożonych funkcjach, co może przyczynić się do poprawy jakości przestrzeni i zaspokojenia potrzeb różnych grup użytkowników.

Słowa kluczowe: modernizacja kampusu, renowacja, architektura, urbanistyka, BIM, rozwój zrównoważony, SGGW