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# Indeterminacy as a Framework for Sustainable Architecture: Lessons from Spens, a Socialist Megastructure

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**Abstract**

In the second half of the twentieth century, the concept of indeterminacy in architecture emerged to address the realities of chance and change, with the megastructure representing a critical point of this ambition. As the aims of indeterminate architectural approaches align with current sustainable development goals, this study hypothesises this design concept as the basis for the sustainability of structures built within its framework. Through a case study of Spens, a socialist megastructure in Novi Sad, Serbia, the paper explores the potentials of megastructures in relation to requirements for more sustainable cities. Firstly, it evaluates Spens' current social sustainability through focus group discussions analysing sense of community, place, and wellbeing. Findings demonstrate a clear recognition of Spens' spatial qualities among users. Secondly, the paper examines the future environmental sustainability of Spens, focusing on strategies that enhance user wellbeing and urban life as a point of overlap between social and environmental sustainability, using the Green Space Factor (GSF) and Urban Greening Factor (UFG). Results reveal the significant yet underutilised potential for greening. The paper highlights the long-term societal value of such structures and strategies for leveraging their concepts for their sustainable adaptation rather than replacement amid ongoing retrofit or replacement debates.

**Keywords:** indeterminacy; megastructure; urban resilience; sustainable architecture; architectural concept; Spens; Novi Sad

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## 1. Introduction

The second half of the twentieth century saw changing views of and within the modern movement, headed by a faction of CIAM that became known as Team 10 around the time of the 9th CIAM meeting in 1953 [1]. This and following meetings until the formal dissolution of CIAM in 1959 laid the foundation for subsequent discourse on the future of urbanism through a reformulation of the dominant functionalist narrative to include urban topics of (re)surfacing importance—history and context, decentralisation, the human scale, phenomenology, community, growth, flexibility, and mobility, among others [2–6]. In the following decades, the previously unidirectional trajectory of modern architecture fragmented with diverse responses to critiques of city planning principles outlined in the Athens Charter of 1933 and realised through urban plans across Europe [7,8]. However, the lack of consensus among the developing directions—the contextual approach of critical regionalism, for example, had little in common with the radical restructuring of cities presented by megastructuralists [9]—places the commonality of the spatial production of the time only against the fixity and order of CIAM urbanism. And against this drive for order stand ambiguity, uncertainty, and indeterminacy [10] (p. 7), concepts that gained theoretical grounding with seminal works in various fields in the second half of the twentieth century, including philosophy [11–14], art [15–17], and music [18,19].

In architecture, these considerations were indicative of a broader cultural shift towards postmodernism as well as new directions for modernism, wherein architects began incorporating various forms and degrees of indeterminacy into design, addressing both the realities of chance (unanticipated use) and change (obsolescence). Rouillard categorises these diverse investigations of the future of modern architecture into three successive periods from 1950 to 1980 united by a common characteristic—"the immanence of the real in utopia" [20]. Within the first current of thought, concepts like the 'open form' of Oskar Hansen [21] and Aldo Van Eyck's idea of the space 'in-between' [22] first presented at the 1959 CIAM meeting in Otterlo, Yona Friedman's vision of a 'mobile architecture' [2], John Habraken's principles of 'open building' [23], the 'aesthetics of change' proposed by Alison and Peter Smithson and embodied by New Brutalism [24], John Weeks' 'indeterminate architecture' [25], the idea of 'non-plan' launched in New Society magazine [26], and Shadrach Woods' 'stem' and 'web' concepts [27,28] all sought to address the problems of determinism with varying strategies and on different levels of design.

These ideas, headed by members of Team 10 and their associates, led directly to the development of megastructural theories with the aim of "inventing systems that anticipated and represented its very transformation" [20]. Various 'mega' concepts were posited as positive design tools, e.g., 'megastructure' [29,30], 'mat-building' [31], and 'megaform' [32]. As these theoretical proposals found their implementation in megastructures worldwide, certain technological and economic challenges and limitations were revealed, contributing to their reframing from viable design solutions for a changing society to instruments of social commentary in projects such as No-Stop City by Archizoom Associati [33], Superstudio's Continuous Monument [34] or Koolhaas' Exodus, or the Voluntary Prisoners of Architecture [35].

From the initial sociological functionalism of Team 10 reflected in the adaptation of architectural forms to a changing society, which was surpassed by systems of (re)invention as embodied by megastructures, to their derealisation as instruments of counter-utopian commentary, these strategies chronicle the rise, culmination, and collapse of post-CIAM optimism [20]. This classification positions megastructures at a critical point in the history of this new chapter of modern architecture, as both its peak and unravelling. The megastructure provided perhaps the most fertile ground for the total application of indeterminacy as a strategy of resilience in the face of uncertainty, as demonstrated by the numerous works built under this concept in the wake of the modern paradigm crisis. However, it also carries with it the label of a failed promise due to the shift in its instrumentalisation from design strategy to critique [36] (p. 504) and remains largely overlooked as a feasible response to today's urban issues, among which the imperative of sustainability has become the dominant concern.

However, while the promise of the megastructure as a totalising urban model was never realised, its value today is certainly recognised on an architectural scale. Van Rooyen constitutes the contemporary concepts of 'open structure' and 'megaform' as the legacy of the megastructural discourse of the twentieth century [37]—the former infrastructural in character, enabling growth and transformation, as represented in the architecture of contemporary practices like Lacaton & Vassal, Elemental, and OpenBuilding.co, while the latter, combining architectural specificity with programmatic indeterminacy, can be recognised in the works of OMA, Bernard Tschumi, SANAA, and MVRDV, for example. Furthermore, Ashby highlights the indebtedness of contemporary theories like landscape urbanism and landform building to the megastructure movement of the previous century [38].

This continued consideration of megastructural and subsequent related concepts in both contemporary theory and practice long after their purported death by Reyner Banham in 1973 indicates their topicality as a productive design strategy [39–41]. A resurgence of interest in the broad concept of indeterminacy as a valuable strategy for urban sustainability and resilience in the 21st century [42–44] provides a solid basis for the closer examination of the narrower field of megastructural thought to this end. Moreover, the past decade has seen the 40th and 50th anniversaries of a number of built works belonging to the megastructural and associated movements, with some, like the Pompidou Centre, Free University Berlin, Barbican Centre, and the Brunswick Centre, under heritage protection, having undergone or currently undergoing renovations, while others, like the Nakagin Capsule Tower and Robin Hood Gardens, have been demolished under controversial circumstances. With the fate of numerous contemporaneous realisations still undecided, a re-evaluation of the contributions and future potentials of the megastructure in relation to today's imperative for sustainability is essential at this critical time in the lifespans of these buildings.

Considering the aims of indeterminate architectural approaches towards more adaptable, participatory spatial structures as a means of resilience closely align with current outlined sustainable development goals for cities [45], this study hypothesises this design concept as the basis for the sustainability of urban structures built within its framework. The megastructure is identified as the critical point of indeterminate ambition and, as a recurring topic of architectural discourse, with a great number of built examples from the previous century at the centre of the ongoing retrofit or replace debate, this paper explores the potentials of the megastructure in relation to the pressing requirements for more sustainable cities. Through a case study of the Sports and Business Centre "Vojvodina" (colloquially known as Spens), a megastructure of Socialist Yugoslavia located in Novi Sad, this paper examines the indeterminate 'hypothesis' of the second half of the twentieth century, postulating Spens' megastructural spatial concept as the basis of its sustainability today.

The significance of this paper is reflected in its contribution to underscoring indeterminacy as a valuable design strategy for sustainable cities—a topic that remains in the background of the sustainability discourse, which tends to prioritise energy-efficient technologies and materials to this end. The following sections of the introduction outline the theoretical foundations of the megastructure, examining how various theorists have framed the megastructure as a response to the realities of chance and change, before exploring the specific developmental context and spatial qualities of Spens that contribute to its resilience and positioning the authors' stance within the broader discourse on sustainability in architecture.

### *1.1. Theoretical Foundations of Megastructure*

The first formal definition of megastructure was provided by Fumihiko Maki in 1964, in which he outlines two inherent characteristics: its large static frame as a "man-made feature of the landscape" and its capacity to concentrate diverse functions in one place [29] (p. 8), favouring 'open-ended' structures—those composed of independent systems that can expand and contract without disrupting the others. This led to his theorisation of group form as a facet of the Metabolist movement based on a philosophy of change [46].

Four years later, Ralph Wilcoxon's 4-point definition further outlines the megastructure as a structure frequently composed of modular units, capable of great extension, a framework into which smaller, prefabricated units can be built, with a significantly longer lifespan than the smaller units it supports [30]. While Maki highlights the urban scale of the megastructure and its potential to house a multiplicity of functions within a single structure, Wilcoxen focuses more on its organisational principles and the relationship between the permanent frame and transient units.

While size is inherent to the megastructure, it is not its sole defining characteristic, as evidenced by the above definitions. Banham therefore summarises the aim of the megastructure as the proposal of giant frameworks created by professional architects to which modern society could add, subtract, and reconstruct in their own high-tech rendition of a spontaneous urbanism—"vast, it offered architects the chance to create super-monuments on a scale matching the modern city; adaptable, it offered the citizenry the possibility of creating their own small-scale environments within the enormous frame" [47] (p. 9).

While Maki uses the terms "megastructure" and "megaform" interchangeably, Frampton later differentiates between these concepts, distinguishing the former by its focus on programmatic indeterminacy and the latter by its "form-giving potential of certain kinds of horizontal urban fabric capable of effecting some kind of topographic transformation in the megalopolitan landscape" [32].

Another 'mega' concept was that of mat-building, a term coined by Alison Smithson in 1974 to encompass buildings that "epitomise the anonymous collective, where the functions come to enrich the fabric, and the individual gains new freedoms of action through a new and shuffled order, based on interconnection, close-knit patterns of association, and possibilities for growth, diminution, and change" [31]. Stemming from the relational thinking of Team X and most clearly realised in the design for the Free University Berlin by Candilis-Josic-Woods, the particularity of mat-building lies in "a shallow but dense section, activated by ramps and double-height voids; the unifying capacity of the large open roof; a site strategy that lets the city flow through the project; a delicate interplay of repetition and variation" [48]. This places an emphasis on the continuous process of spatial production, governed by the complex and varying relations of the city.

All of the above strategies, while various in their theoretical roots, formal articulation, and relation to urban context, embrace the inevitable influences of chance and change on architecture, mainly through:

- The volumetric indeterminacy of the whole (allowing for growth or contraction of the proposed formal model)
- The concentration of a multiplicity of functions within a (usually) horizontal structure (confluence of programmes prompting exchange)
- The programmatic and/or aesthetic indeterminacy of its parts (conceptualising segments of the whole as transient—anticipating changes in programme or unexpected uses of space over time)

It is no coincidence that these ambitions found their joint expression in the megastructure and not another built form. While a megastructure is much more than its prefix suggests, unavoidably, its size is the foundation upon which these freedoms lie, as Koolhaas' theory of 'Bigness' proposes: "Only Bigness can sustain a promiscuous proliferation of events in a single container . . . Through contamination rather than purity and quantity rather than quality, only Bigness can support genuinely new relationships between functional entities that expand rather than limit their identities" [36] (p. 511). This consideration of architecture as a singular, cohesive object, composed of autonomous yet interrelated segments, reflects an urbanistic strategy contained within a building, made possible only by its large scale.

Bigness also finds the architectural project split in two: as a result of increasing distance between core and envelope, the façade of the building can no longer reveal its interior complexity; thus, "interior and exterior architectures become separate projects, one dealing with the instability of programmatic and iconographic needs, the other—agent of disinformation—offering the city the apparent stability of an object" [36] (p. 501). It is this articulation of the object and its methods of metamorphosis that remain within the domain of professional disciplines—whose interdependence lies in the ambition of the megastructure's realisation—while the dynamics of its use and interior transformation remain in the realm of society, turning architecture decidedly into a project of collective responsibility and authorship. It is primarily in this openness to change, requiring the continuous participation of its users and stakeholders, that the resilience of megastructures is reflected, as will be demonstrated in this paper through the case of the Sports and Business Centre "Vojvodina"—Spens—in Novi Sad.

### *1.2. Spens: Megastructure of Socialist Yugoslavia*

The architectural scene of late 1970s socialist Yugoslavia reflected the developments in the European and global architectural landscape traced at the beginning of this paper. Architects, whether through their own practice or by following architectural journals, closely tracked the evolution of architectural discourse, and the architectural milieu distinctly mirrored the pluralism of trends evident internationally. The departure from "stereometric" internationalism arose from a critical reassessment of both modernist principles and the architects' own professional experience, allowing for more personal contributions and creative expression.

This shift was facilitated by the broader socio-economic context of the country, with the "buoyant" 1970s foreshadowing the economic peak of the following decade. Marked by social welfare, the 1970s brought about a more liberal approach to architectural values and the opportunity to explore the modalities of late modernism, driven by a pressing need to reconsider architecture within the local context [49]. Two intensive decades of post-war reconstruction in the country provided substantial experience in the architectural field, in both practical and theoretical terms. Thus, the architecture of that period expressed a more inclusive and open architectural language, often with a regional character; it became more tectonic, experimental, and representative, yet still socially grounded, with set goals of a self-managed socialist society—welfare and strong public interest.

Architectural commissions equally reflected the dynamism of the times—large and representative economic centres, university complexes, department stores, and sports centres. The programmes and their demands indicated society's readiness to continue developing through architecture that encouraged growth both programmatically and visually [50]. Such projects also showed that the housing crisis had been managed, opening space for an architecture of social standards. The architectural community eagerly embraced these new challenges as opportunities to express fresh perspectives and ideas. Increasingly complex social demands, along with the need to establish meaningful international connections and project the state's image globally, prompted the planning of spaces for major events. Through these projects, Živorad Janković established himself as an architect adept at addressing the challenges of large sports centres with a strong social role. His team realised centres across the country, demonstrating diverse approaches, contextual adaptation, and architectural relevance—key qualities leading to his commission for the City Sports Centre

"Vojvodina" in Novi Sad, later named the Sports and Business Centre "Vojvodina", and better known as Spens.

By the late 1970s, Novi Sad's economic growth—as the administrative centre of a wealthy autonomous province—created favourable conditions for the realisation of a major sports centre, building on concepts explored through architectural competitions in the 1960s [51]. The city's nomination to host the World Table Tennis Championship, moved from 1983 to 1981 after China's withdrawal, accelerated the project. The shortened deadline, combined with a strong ambition to distinguish the host city with the creation of a complex, state-of-the-art centre that far exceeded the event's requirements, led to the commissioning of an experienced Sarajevo-based team, led by Prof. Janković and Prof. Branko Bulić.

The spatial concept of the Centre was largely derived from the specific urban location—an area where the old urban matrix intersects with the new modernist one. This influenced a number of conceptual decisions, leading to the design of an urban-architectural megastructure that follows established pedestrian flows and serves as their superstructure, offering a series of its own urban 'amenities'—sheltered public spaces to complement existing ones (Figure 1). The original layout reveals the project's exceptional spatial logic:


**Figure 1.** Digital orthophoto showing Spens in the wider urban matrix—central zone of Novi Sad, Serbia. Source: GeoSrbija, Republic Geodetic Authority of Serbia (https://a3.geosrbija.rs/ accessed on 25 March 2025); annotation by authors.

> "a nearly utopian vision of a vast, free circulation space that envelops the arenas and halls, allowing visitors to freely choose which event to visit or to merely peek into the sports hall and experience the atmosphere of the event underway. This idealised world of a prosperous society with the highest standards of community life realised through a diversity of sports, culture, or entertainment is the result of the ambitions of this same community to represent itself through such a programme" [52] (p. 166).

Although the building was initiated by a sporting event, from which it also received its colloquial name, Spens, the fact that the architects referred to the project as a 'centre' reflects the ambition to create a social hub that combines a range of public-interest programmes with the expansive interior streets and halls serving as public spaces. Even its commercial function—numerous retail and hospitality facilities—indicates the intention to position the building as a new urban centre.

The realisation of the Centre and its continued vitality—even through the country's challenging transitional period, which saw many similar facilities decline—attest to the sound and sustainable foundations of the building itself. Spens' spatial concept, its programmatic diversity, and the fact that it lies along the daily routes of the city's residents have ensured its longevity, despite its current poor technical and technological condition. Its future, therefore, rests on the strengths of its design as an urban megastructure, characterised by several highly significant qualities:

- Urban location: positioned in the central city zone, Spens is widely and easily accessible via all types of transport. Additionally, important pedestrian routes run through the Centre, generating high traffic flow within the building.
- High-density 'under one roof' concept: the dense organisation of elements contained under one roof and connected by interior streets (as opposed to a lower-density pavilion-type configuration) generates social benefits. The high flow of pedestrian traffic directed through its interior streets fosters social interaction and promotes the formation of communities within the space. The same spatial concept also offers significant environmental benefits: a substantial roof area suitable for green roofs and/or harnessing solar energy; energy and heat recycling, utilising residual heat from individual 'houses' for the transitional public spaces. The individual houses are diverse energy consumers, ranging from multi-sport halls to ice rinks to swimming pools, and their excess heat or cool energy can be exchanged and recuperated. Coupled with the use of typical and integrated structural and mechanical elements within one cohesive architectural object, this also implies certain economic benefits in terms of maintenance and replacement.
- Landmark quality: owing to the above qualities, alongside its monumental scale and formal articulation, Spens has a strong visual and symbolic presence in the urban fabric. The horizontal stepped form of the building, outlined by the exterior stairs and dominating roof, is a prominent feature of the cityscape (Figure 2), while its important public function makes it a daily destination for many citizens. The megastructure decidedly becomes a megaform, a landmark with "the capacity to inflect the surrounding landscape and give it a particular orientation and identity" [32]. In an increasingly universal context, identifiable places of civic importance carry significant social implications as reinforcers of citizens' self-identity and sense of belonging.
- Interior diversity comprising two aspects—programmatic and ambiental—is implemented in the Spens project:
    (a) Coupled with its high-density configuration, Spens' programmatic diversity, or mixed use, holds important social implications, namely through the potential of Bigness, as posited by Koolhaas [36], for the cross-contamination of programmes, leading to perpetual re-programming, which is crucial for architecture's long-term survival. This diversity also has environmental implications, as access to a variety of facilities in one place reduces the need for transport.
    (b) Ambiental diversity in this particular project is the result of a thoughtful concept that combines multiple interior 'houses' (Figure 3) and public voids within an enclosed structure. The qualities of daylight and greening were important to the architects, as environmental strategies with social implications were

reflected in the wellbeing of users, leading to the conception of numerous unique micro-ambiences enhanced by these qualities (Figure 4).

**Figure 2.** One of Spens' 6 major entrances characterised by large exterior stairs and distinctive polycarbonate and steel roof canopy. Author: Maja Momirov. Copyright 2021 Baza—Spatial Praxis Platform.

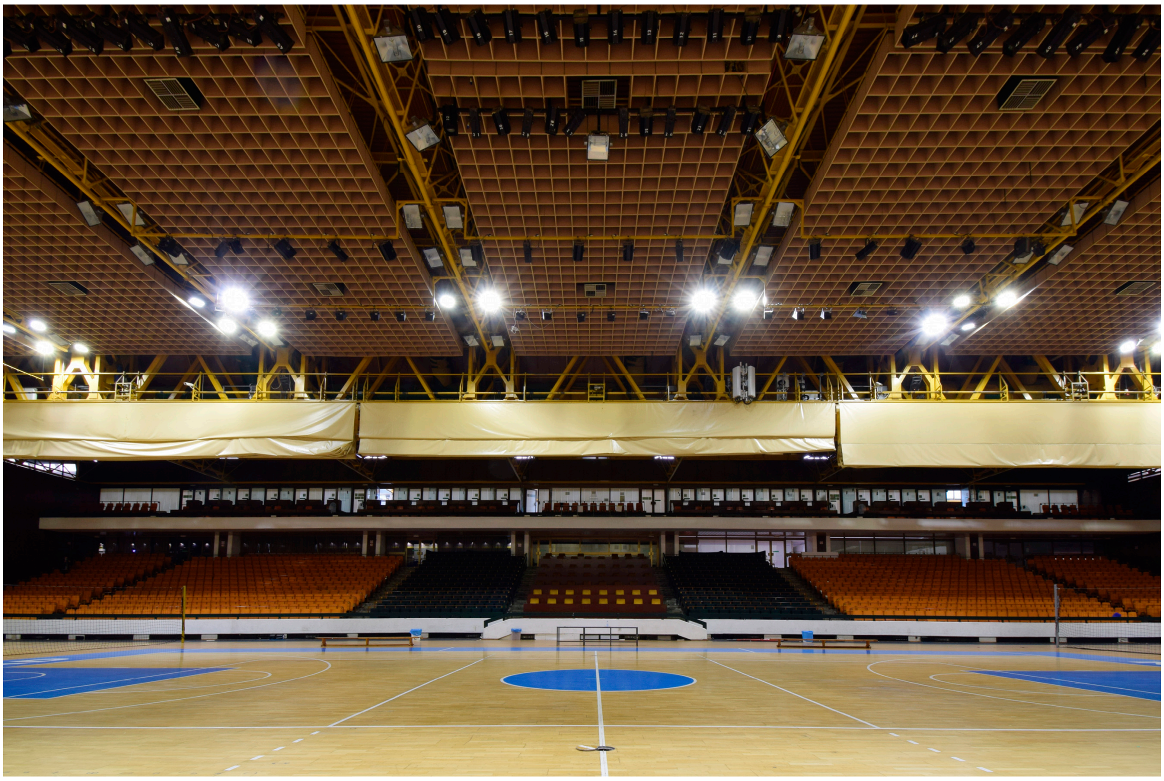


**Figure 3.** Spens' main multi-sport hall and event space, which, along with its ancillary functions, comprises the largest of the multiple 'houses' of this complex megastructure. Author: Maja Momirov. Copyright 2021 Baza—Spatial Praxis Platform.

**Figure 4.** Main indoor public space on the first floor between two houses, whose ambience is defined by rich indoor vegetation and daylight entering from skylights. Author: Bojan Stojković. Copyright 2021 Baza—Spatial Praxis Platform.

Of the guiding principles of 'mega' approaches outlined since the second half of the last century, Spens can be said to contain them all. Spens as Maki's open-ended structure housing diverse functions; Spens as Wilcoxon's permanent framework comprising transient units; Spens as a horizontal megaform, containing elements of the surrounding urban fabric and modifying it in turn; Spens as mat-building, a condenser of relational processes; Spens as Bigness, whose iconic envelope betrays no sign of decades of internal programmatic flux. Perhaps it is this careful amalgamation of socially responsible approaches—resulting in a unique example of Yugoslav architecture and the sports typology in general—that provides the necessary conditions for its sustainability today. These identified spatial qualities of Spens, derived from its indeterminate megastructural concept, present the foundation for examining the building's resilience in the 21st century.

### *1.3. Rethinking Sustainability: A Return to the Architectural Concept*

Since the 1987 Brundtland Report positioned sustainable development as a global agenda, defining it as meeting "the needs of the present without compromising the ability of future generations to meet their own needs" [53], the need for sustainable cities has only gained in significance, prompting the development of comprehensive global plans of action in this direction [53]. In contemporary discourse, sustainable development has predominantly been framed through three 'pillars' of sustainability—economic, social, and environmental. However, closer inspection reveals the taxing relational complexity of this seemingly simple itemisation. Firstly, the existing literature compounds a variety of perspectives and predominantly focuses on each pillar in isolation, rather than exploring the relationships between them [54,55]. Secondly, the literature is conflicted as regards the treatment of the economic dimension, with large institutional actors placing emphasis on economic growth as the key to achieving social and environmental goals, while others position the economic pillar in service of social and environmental values [56]. Thirdly, the social dimension of sustainability remains the least examined of the three, despite its long-term significance to this agenda [55]. This imbalance is also evident in both mainstream architectural practice and architectural education, where sustainability is often equated with measurable environmental performance through the application of renewable energy sources, smart systems, and energy-efficient materials, etc., foregrounding technological solutions over socially responsive, spatially adaptable designs [57]. Understandably, since social impacts are harder to quantify, slower to emerge, and more uncertain in outcome, yet their neglect risks reducing architecture's role to one of technical optimisation. This paper argues that such an approach overlooks architecture's core responsibility: to provide spatial solutions that meaningfully and continuously engage with societal needs [58]. From this perspective, the social dimension must form the foundation of sustainable architectural practice, with environmental strategies serving as complementary project layers. While financial considerations remain an important aspect of any project, public developments should not be driven by cost alone but rather evaluated in terms of the long-term economic value generated through socially and environmentally responsive design—an approach this paper will further explore in the following sections.

## 2. Materials and Methods

As relayed in the previous section, this paper proposes a reframing of the idea of sustainability in architecture towards spatial concepts that are primarily socially sustainable and to which environmental practices can be superimposed, yielding economic benefits as a long-term outcome. In line with this aim, the introduction presented indeterminacy, here explored through the megastructural approach, as a valuable design strategy for achieving sustainability in the 21st century. An introduction to the Spens building in Novi Sad proposed the core aspects of the spatial concept that present the basis for its sustainability today. The remainder of the paper is organised into 2 sections, whose methodologies are outlined below.

### *2.1. Social Sustainability*

The first section evaluates the social sustainability of the building through focus group discussions by analysing three aspects of social sustainability—sense of community, sense of place, and sense of wellbeing. Considering the time elapsed since its construction, an evaluation of Spens' social sustainability from the perspective of its users can show how effectively the building has supported community engagement, adapted to changing social needs, and contributed to the urban fabric, providing important insights into the long-term viability of megastructural design strategies in fostering enduring social value.

The focus group discussion was conducted at Spens on 16–17 February 2025. The sample comprised 28 participants, with a balanced distribution in terms of gender and age—specifically, 12 women and 16 men, ranging from 18 to 70 years of age (Table 1). Participants were eligible for inclusion if they were within this age range and had prior experience with Spens.

**Table 1.** Participant demographic characteristics (N = 28).

| Characteristic | N | % |
|---|---|---|
| **Age (years)** | | |
| 18–30 | 9 | 32.1 |
| 31–40 | 5 | 17.9 |
| 41–50 | 7 | 25.0 |
| 51–60 | 3 | 10.7 |
| 61–70 | 4 | 14.3 |
| **Gender** | | |
| Male | 16 | 57.1 |
| Female | 12 | 42.9 |
| **Education** | | |
| Secondary education | 9 | 32.1 |
| Bachelor's degree | 12 | 42.9 |
| Master's degree | 7 | 25.0 |

Note: Percentages are calculated based on total sample size (N = 28). Categories are mutually exclusive.

Based on an analysis of distinct user groups within Spens, it was determined that the sample should be organised into four focus groups according to their modes of engagement with the facility. The following user categories were identified: (1) Employees of the Sports and Business Centre "Vojvodina" (Spens) (7 participants); (2) Employees operating within leased premises and clubs at Spens (8 participants); (3) Users of the sports facilities at Spens (6 participants); (4) Users of non-sport-related facilities (7 participants). Exclusion criteria comprised individuals younger than 18 years and those without any prior experience with Spens.

The initial phase of recruitment employed a convenience sampling method, drawing participants who were either professionally or personally known to members of the research team and who conformed to the predefined user groups. In the second phase, participants recruited during the initial phase were asked to recommend additional individuals who met the research criteria. This approach corresponded to the snowball sampling technique, with particular attention paid to maintaining a balanced number of participants across all four focus groups.

To gather data on the social sustainability of Spens, a qualitative research approach was adopted, utilising the focus group methodology supported by a semi-structured interview guide. The guide was previously pilot tested to ensure clarity and comprehensiveness. During the interviews, 20 open-ended questions were used to explore themes related to identification with and perception of Spens, user experience, and the building's role in promoting social sustainability (File S1).

To supplement and cross-validate the data collected through the focus groups, a survey-based approach was also employed. The questionnaire was designed to build upon the issues addressed in the focus group discussions and included a combination of open- and closed-ended questions given to participants of the focus groups at the end of the session. It comprised a total of 27 questions, of which 12 were closed-ended and 15 open-ended (File S2). The questions addressed the demographic characteristics of participants, frequency of visiting, levels of satisfaction with the building's offerings, and perceptions of Spens as an element of urban identity, with the aim of providing a clearer understanding of its social sustainability.

The questions were developed based on a review of existing literature on focus group methodologies [59,60], prior research experience with Spens [61,62] and the reception of Yugoslav architectural heritage [63], as well as the established research hypotheses and objectives. Interviews were conducted until data saturation was achieved, defined as the point at which no new concepts emerged during three consecutive interviews. Saturation was reached after approximately 15 interviews. All interviews were audio-recorded, professionally transcribed, and accompanied by field notes taken during the sessions. Manual coding was employed to analyse the qualitative data collected through focus group interviews. This process involved a systematic, interpretive approach aimed at identifying key themes and patterns relevant to the research objectives. After transcription, the data were reviewed line by line to ensure familiarity with the content and to capture context-specific meanings. To protect privacy, every participant was given a letter/number code.

Initial codes were developed inductively, grounded in the data. These codes were assigned to relevant segments of text, including statements, phrases, or exchanges between participants, that reflected recurring ideas or concepts related to three aspects of social sustainability of the building (File S3). A secondary cycle of coding involved grouping similar codes into broader categories or themes, allowing for the emergence of higher-level analytical constructs. The manual coding process was guided by principles of qualitative content analysis and was conducted in multiple rounds to ensure consistency and validity.

To enhance reliability, coding decisions were discussed among the research team, and any discrepancies were resolved through consensus. This method allowed for the exploration of subjective meanings, shared understandings, and divergent views within the group, which are essential for interpreting social dimensions of sustainability in architectural and urban contexts. The questionnaire data were analysed using IBM SPSS v29, primarily to generate basic descriptive statistics and provide contextual background for the qualitative findings (File S4). Due to the small sample size, quantitative results were not treated as statistically significant but served as a supplementary reference for interpreting themes from the focus group discussion. Responses to open-ended questions were analysed manually through inductive coding. Answers were grouped thematically, and recurring patterns were identified using descriptive interpretation. This process allowed for a more nuanced understanding of participant perspectives.

### *2.2. Environmental Potential*

The second section explores the potential future environmental sustainability of Spens in the 21st century, building on its marked social role explored in the previous section. In line with this, the paper focuses on environmental strategies that enhance user wellbeing and urban life, as a recognised point of overlap between social and environmental sustainability. Environmental sustainability is therefore examined through the inherent potential of megastructures, with a focus on the spatial framework and the integrated vegetation to this aim. A dual analysis of Spens' environmental contribution was conducted: in its current footprint, with the current situation of green areas, and in its possible future with the scenario of its reconstruction in a sustainable direction. The analyses were conducted using two tools for evaluating specific design solutions in order to determine the extent to which they contribute to the quality of urban life: the Green Space Factor (GSF) [64,65] and the Urban Greening Factor (UFG) established by the Mayor of London [66]. Together, these tools provide complementary metrics for evaluating green infrastructure. As they originate from different planning frameworks and geographical contexts, the use of both may improve the validity of findings by cross-verifying results.

Through the GSF, ecological principles are integrated into urban development to improve the quality of living conditions in the city. Green elements such as vegetation, green roofs, green walls, and biodiversity of species are assigned weighting factors based on their projected impact. From a list of 35 elements and practices—so-called "green points" that enhance the ecological value of space—at least ten should be present in each green area. In terms of design standards, every site must meet a minimum target GSF, which should also be applied in reconstruction projects. The UFG is a planning tool used to develop and improve green infrastructure. It is also based on weighting factors and target values calculated accordingly. The target factor and the distribution of surface cover types, combined with their assigned ecological impact weights, are the main components for calculating this factor.

These factors establish the relationships between different parts of the space (such as vegetated areas, covered surfaces, roofs, and exterior walls) that have a positive effect on ecosystem functioning in relation to the total area being analysed. Different types of spaces carry different ecological significance and are therefore assigned different weighting factors. These weighting factors are defined, among other things, based on their positive effects on the ecosystem—such as evapotranspiration efficiency, dust filtration and capture, rainwater infiltration and storage, soil protection from harmful substances, and the availability of space for plants and animals. These factors represent quantitative requirements and do not address the qualitative aspects of spatial planning.

In calculating both factors, the existing situation was documented based on available project documentation, visual analysis from the site and photographic documentation. For the future analysis, the conceptual design for the reconstruction, extension, and construction of the Sports and Business Centre “Vojvodina” (Spens) by Konstantinović et al. [67] was used as the basis. The forecasted situation of Spens, based on the abovementioned reconstruction proposal, proposed an increase in the area of groundcover and tree planting of the surrounding free space, along with the application of a green wall on the facade of the parking garage in line with current architectural trends for this typology. The integration of an extensive green roof was planned on part of the total roof area, reserving the rest for the application of solar panels for generating energy. This increase in green infrastructure, especially through the activation of the roof plane, is expected to compensate for the environmental impact of the expansion of the building’s footprint by one additional sports hall in the proposed conceptual solution and further enhance the ambiental qualities of the original concept.

The conclusions reflect on the contribution of indeterminate megastructural concepts to long-term social and associated environmental sustainability goals, while also reflecting on economic value as the synergistic effect of social and environmental strategies.

## 3. Results and Discussion

### *3.1. Spens as Social Infrastructure: Community, Place, and Wellbeing in the Urban Present*

Eizenberg and Jabareen define social sustainability as the sum of four interrelated concepts—equity, safety, urban forms and eco-prosumption—underscoring the important role of the city and its forms, which, according to the authors, should foster community cohesion, place attachment, safety and healthy communities while also addressing climate change and uncertainty [68]. This perspective, therefore, also underscores the interrelatedness of social and environmental concerns in urban contexts.

Spens serves as a vital case study exemplifying principles of social sustainability in built environments. Utilising qualitative data from user testimonials, this chapter investigates three primary dimensions of social sustainability as experienced in Spens: sense of community, sense of place, and sense of wellbeing. Personal narratives reveal Spens’ function as a vibrant social space and significant landmark in the city.

This research explores dimensions like collective belonging, emotional attachment, user interactions, participation, accessibility, etc. Such attributes cultivate diverse and inclusive communities, reinforce emotional ties to places, and underscore their cultural and historical significance as well as material and symbolic values [69,70]. Moreover, it is crucial to acknowledge the physical and psychological comfort that urban spaces must provide. Well-organised environments not only positively impact health and safety but also facilitate fulfilling experiences by ensuring access to essential amenities, high-quality materials, and adequate green spaces [71]. This holistic view of social sustainability combines environmental aspects, community dynamics, and individual wellbeing, illustrating that successful urban spaces must consider the multifaceted needs of their users [72,73].

#### 3.1.1. Sense of Community

When it comes to the sense of community, focus group discussions about Spens revealed a rich constellation of meanings anchored in inclusivity, social mixing, polyvalence, emotional labour, and public value. Spens is portrayed by respondents not just as a facility but as a vibrant urban institution, a ‘melting pot’ that accommodates diverse actors—top athletes, sport enthusiasts, children, café-goers, homeless individuals, and spectators—under one roof. Spens is, no matter how problematic its current management and governance, “a space for all” and a key place for social interactions in the city. Participants consistently emphasised the social permeability and openness of the space. One respondent captures this ethos to the point: “100,000 square meters under one roof, where at the same time it is possible to have top athletes, politicians, drug addicts, homeless people, dogs, and pigeons, all of them there. . . You can do that when you have public space, and that’s very nice” (Employee at Spens, P29M).

This openness cultivates informal cultural practices and spontaneous gatherings, which were repeatedly described in places like the ‘kadica’ and the exterior stairs—improvised venues for performances, protests, or socialising. “The ‘kadica’ that’s downstairs when you go down the stairs, I remember some kids having performances there, some dances for parents, so it obviously has a purpose. On the plateau, I know there are flower fairs and also some tournaments or something like that, so it has its role” (User of non-sports-related facilities, P11F).

Spaces like Spens allow for ‘use beyond use’. Intergenerational continuity also strengthens this communal fabric. Respondents spoke of introducing their children to the same spaces they once trained in, emphasising Spens’ role as a site of public heritage: “To pass it down from generation to generation” (User of sports facilities, P4M).

Moreover, the non-profit nature of sports emerged as a key axis in participants’ understanding of community value. One responder commented:

> “This facility is very socially beneficial (. . .) state, city, and so on, bodies should recognise that and see that if we want to engage in sports, which is not a profitable activity, we must have a facility that can enable citizens to engage in sports, and that facility is not self-sustaining” (Employee at Spens, P24M).

Several emphasised that sports—and Spens by extension—should prioritise public good over commercial viability. This is especially salient in comments opposing privatisation, such as “I would never mention privatisation. . . that means the loss of Spens” (User of non-sports-related facilities, P7M) or “Spens never promised material gain from the beginning, no matter what condition it was in” (Employee at Spens, P23F).

The role of Spens as a city hotspot was also consistently articulated, with participants invoking metaphors like “a city within a city”, reinforcing its centrality in the civic imaginary of Novi Sad. Its multifunctionality (concerts, flea markets, sports, protests) enhances its value as a shared space where social boundaries blur. Finally, functional polyvalence and usage saturation were described both as strengths and stress points. While users appreciated how “every cubic meter is used,” many also pointed to overcrowding and strained infrastructure:

> “I do not know if the organisation is problematic, but how it goes at a higher level, how many sport clubs get to train at Spens from the city authorities. The hall is divided into six parts—two small basketball, two small volleyball and two large—volleyball and basketball. I do not know how it goes at a higher level, but I think that overcapacity regarding the sports part is a big problem” (User of sports facilities at Spens, P3F).
>
> “We need another Spens” (User of sports facilities at Spens, P5F).

Even though Spens fails to maintain competitiveness with nearby shopping centres when it comes to hospitality and retail services, in terms of sports and recreation, it offers an unparalleled range that no other facility in Novi Sad or even Vojvodina can match. Spens, as such, embodies the relational, affective, and symbolic dimensions of community, making it more than a building—it is a civic infrastructure for collective memory and shared urban experience. Moreover, Spens’ multifunctional role contributes to its inclusivity. Described as a ‘melting pot’, the facility brings together diverse demographics—young athletes, elderly patrons, children, and business professionals—creating everyday opportunities for intergroup interaction. This inclusiveness reinforces social cohesion and supports the notion of Spens as a socially sustainable space.

3.1.2. Sense of Place

The theme of place is articulated through various forms, both positive and negative, of emotional and social connection to Spens. This indicates a deep personal and emotional investment, particularly for those who have spent a significant portion of their lives there. Several respondents described Spens as a "second home", a sentiment that underscores a deep sense of belonging and familiarity. One long-time user remarked, "The pool has been my home for as long as I can remember. It's the first thing that comes to mind and my favourite place in the city" (User of sports facilities at Spens, P2F).

Many associated Spens with positive emotional states, joy, and satisfaction. A user of the sports facilities enthusiastically stated:

> "Happiness. Definitely happiness! When I go to the pool, I'm happy; when I come here for training, I'm happy; when my little sisters have a jazz competition here and I watch them, I'm happy. And also, when we go to a concert. . . so more or less, that's what it reminds me of" (User of the sports facilities at Spens, P1M).

Another user simply described it as, "Sports. Happiness and all the best things" (User of the sports facilities at Spens, P3F).

Narratives of nostalgia further strengthen the sense of place. Spens was frequently described through memories of childhood, early friendships, and family rituals with statements like, "I'm sentimentally attached to Spens. Even now, as they say, if I had a pebble in my shoe for 20 years, I'd still miss it" (Employee operating within leased premises and clubs at SPENS, P14M).

Even the respondents that only visit Spens occasionally have strong emotional attachments to the space, rooted in childhood experiences they had at Spens, "It ties me to my childhood. I lived nearby and went to private English lessons, to training, and to buy bread. So, in childhood, it was the centre of my life activities" (User of sports facilities at Spens, P6M).

Users also noted the building's historical role in hosting political, cultural, and sports events, which contribute to its strong position in the urban and emotional landscape. Its description as a "city within a city" or "urban hotspot under one roof" reinforces its polyvalent identity. This strong identification with the space supports the argument that Spens facilitates the cultivation of tight-knit relationships over time, often blurring the line between personal and communal space. "I have a strange sense of belonging. And when someone from outside says something, I feel like they're touching something that's mine" (Employee operating within leased premises and clubs at Spens, P17M).

Workplace narratives echo this communal ethos. Employees frequently referred to their colleagues as part of the "Spens family", emphasising affective bonds, shared sacrifices, and collective pride. As one participant observed, "There was so much excitement, so many friendships, so much unity in which we carried everything together, and the line between whether we were colleagues or something more blurred. Of course, all of that had its charm, that atmosphere that made us one big family" (Employee at Spens, P23F).

Spens holds a powerful symbolic presence in the collective imagination of Novi Sad's residents. Many testimonies framed Spens as an icon, a landmark inseparable from the city's identity. Phrases like the "DNA of Novi Sad", "Icon of Novi Sad", and "Temple of sport" exemplify its cultural embeddedness, reinforced by its location, architectural distinctiveness, and multi-generational relevance. Its unique design is repeatedly identified as a key source of its cultural and symbolic value in statements like, "Architecture is something that is universal for this building, and that is what should remain, I think, authentic as it is, and yet gain some more contemporary purposefulness in relation to society today and the needs of the people who are there" (User of non-sports facilities, P10M).

Spens also functions as a physical centre of Novi Sad, situated at a critical urban crossroads that links multiple parts of the city, making it an important point of passage, "An unavoidable part due to its location and very important for the development of younger generations. Due to its long existence, everyone has heard of and used Spens's services and space in some way" (data from questionnaire).

The interweaving of personal memory and urban identity exemplifies what Gieryn describes as the social construction of place [74]: Spens becomes more than a building; it is a repository of memory and meaning. During interviews, it was noted that most respondents felt simultaneously proud of what Spens once represented and deeply disappointed in its current condition and management.

#### 3.1.3. Sense of Wellbeing

Wellbeing here is not merely conceptualised as individual health or comfort but as a holistic state emerging from the integration of physical infrastructure, symbolic attachment, and social atmosphere. Participants regularly referenced both the uplifting and frustrating aspects of the space, revealing a layered affective relationship.

Positive references include Spens as a site of joy, comfort, relaxation, and satisfaction. Activities such as sports, watching children perform, or simply spending time in the complex were identified as sources of positive emotional response to space. These are also tied to sensory stimuli such as natural light, greenery, and spaciousness. The presence of greenery was repeatedly noted as an essential component, "Greenery is also a dominant element for me. I mean, no other building has so many plants indoors" (User of sports facilities at Spens, P2F). Even when minimal, these natural elements were described as refreshing, calming, and necessary: "I think that the very form of the building is okay, and I think that these plants are very valuable; they are something that perhaps gives life to that space" (User of non-sports facilities, P10M).

However, the overall sense of wellbeing is ambivalent—deeply felt but frequently undermined by material degradation. Issues such as poor hygiene, leaking roofs, lack of heating and non-functioning ventilation systems were widespread concerns. Yet, these complaints often coexist with expressions of affection and commitment: "There are a thousand things that annoy us, but good feelings come first" (User of sports facilities at Spens, P3F). Another participant remarked, "Somehow I'm torn—super happy, but on the other hand, so angry I do not even know what to say" (Employee, P19M).

Such cognitive dissonance underscores a critical sociological insight: wellbeing in urban public spaces is relational—not derived solely from physical conditions, but also from symbolic meaning, collective memory, and emotional labour.

> "If I were to look at the physical condition and all that, I would describe it as a building that needs a lot of investment to regain its former brilliant splendour. Not just investment, I do not just mean finances, but I also mean effort, and the effort of manpower, the effort of everyone, to raise awareness of the need for such a building" (Employee at Spens, P24M).

Respondents called for expanded programming to enhance wellbeing, including children's theatres, cultural workshops, and recreational activities that would reinforce Spens as a site for generative encounters. This reflects a desire for active wellbeing—one produced through interaction, creativity, and civic participation. "That recreational part is certainly also the health of the population. Most children here train in something, even if they do not become professional athletes, but they spend part of their lives in some activity that affects everyone psycho-physically" (User of sports facilities at Spens, P2F). Importantly, participants also linked wellbeing to a sense of justice and equity. The belief that Spens should remain publicly accessible and non-privatised was tied to emotional wellbeing—articulated through a moral imperative to preserve inclusive, non-commercial urban space.

Wellbeing at Spens is a dialectical phenomenon: participants report profound satisfaction coexisting with deep frustrations. Yet, across the data, the emotional resilience of users and their aspirations for improvement point toward Spens' capacity to support long-term, socially sustainable wellbeing and health. This paradox—emotional richness amid physical decline—reveals the deep psychological and social investments users have made in Spens. It indicates that wellbeing is not solely a function of material conditions but also of symbolic and relational dimensions. These dimensions constitute a form of embedded social capital that would take decades to cultivate in new constructions, highlighting the fundamental advantage of existing civic structures like Spens and reinforcing the idea of reconstruction over replacement as the more socially sustainable path. Addressing infrastructural concerns, while reinforcing the strong symbolic and communal values tied to the space, is crucial for its sustainable future.

### *3.2. Perspectives for Environmental Sustainability*

The second section examines Spens' future environmental sustainability in the 21st century, building on its established social role. It focuses on strategies that enhance user wellbeing and urban life as a recognised point of overlap between social and environmental factors vital to urban sustainability. The aspects of the spatial concept with the highest environmental relevance are identified before a parallel analysis of Spens' environmental contribution in both its current situation and forecasted state after reconstruction in a sustainable direction. While Spens' capacity to support contemporary technological systems that would enhance its environmental performance lies beyond the scope of this research, which focuses on environmental aspects that are directly related to its socially driven megastructural concept, the contingency of its spatial structure provides strong grounds for the assumption that it would successfully accommodate technological innovation.

#### 3.2.1. Spens' Spatial Concept as Basis for Sustainable Transformation

From the outset, the development of indeterminacy has been underpinned by the idea that architecture should accommodate change without compromising the clarity of the architectural object [29,32,36], the image of which is strongly linked to aspects of social sustainability, as demonstrated in the previous section. A concept originally developed as a means of dealing with the reality of obsolescence within a rapidly changing social context, today it gains further significance with the current reconstruct or replace dilemma faced by existing building stock from this era, including Spens. In addition to the clear social value of already established urban places outlined in the previous section, research shows reconstruction is typically also the more sustainable option from an environmental perspective, mainly due to lower investments in materials, energy and transport [75–77].

While almost any building can be reused or retrofitted to a certain degree of success, indeterminate structures aim to facilitate these processes, providing easier transitions in programme through modular structures with shorter lifespans than the main structural framework, the integration of unprogrammed spaces or providing a matrix for future extension, consequently incurring fewer costs and guiding future interventions. Thus, the volumetric and programmatic indeterminacy of Spens serves to facilitate changes in its form, capacity and use in line with the changing needs of the society that gathers within, while maintaining its intended architectural expression. By extending the lifespan of buildings, the environmental impact of more frequent cycles of demolition and new construction is avoided. This is particularly important for typologies with shorter useful lifespans due to technological changes or those situated in rapidly changing urban contexts. Between the 1981 census (the same year Spens was built) and the 2022 census, the population of Novi Sad's urban area increased by nearly 100,000 inhabitants, or almost 60% [78]. Such growth necessitates the expansion of urban infrastructure, including Spens as the main sports and event centre and an important public space of the city. The foresight of the original design to accommodate future changes through a systems approach in the organisation of space—with a carefully planned overarching structural and mechanical system and interconnected communication routes uniting the independent 'houses' comprising the sports halls and their ancillary programmes—provides a solid basis for expanding the building's sports and commercial functions, leaning on the existing infrastructure, which should be more sustainable than new construction.

Most megastructures are distinguished by their pronounced horizontality, giving rise to a 'fifth façade'—an expansive roof surface. The 'under one roof' concept of Spens, in contrast to the often-found dispersed pavilion-type configuration for sport complexes, provides a vast continuous roof area that forms the basis for the integration of energy-efficient technologies like solar panels, green roofs or stormwater management that contributes to the performance and quality of urban space. Ecological functions lost through processes of urbanisation can be partially restored through the implementation of green roofs [79]. Buildings like Spens with a large roof surface have the potential to recover a portion of the lost green space as part of the natural environment with vegetated roof surfaces, and, by lowering roof surface temperatures and the temperature of the surrounding air, they contribute positively to mitigating urban heat islands. Furthermore, through rainwater absorption, they reduce runoff and the burden on sanitary and drainage systems [80,81] and energy consumption [82] and improve sound absorption, all of which contribute to a general sense of wellbeing. The enclosure of multiple sport hall typologies under one roof holds further environmental implications for the interior—through the formation of sheltered public spaces (interior streets). Specific ambiental qualities are created by temperature regulation through passive heat exchange, whereby heat from the sports halls is transferred to the adjacent interior communication routes and public spaces, improving thermal comfort without additional energy input.

The original spatial concept of Spens integrating both green zones inside the building and out through surrounding landscaping can be considered somewhat ahead of its time, given that the megastructural focus of the last century was more on adaptable systems and programmatic combination. However, the application of this strategy is more than likely linked to a key megastructural theme—urban design ambition, or the creation of "a version of the city in microcosm" [38]—which has been underscored by the architects of Spens as the main driver of the spatial concept [83]. This aspect of the spatial concept is recognised as a key strategy for furthering the environmental potential of Spens into the 21st century.

The benefits of this strategy are several. Planting greenery in the open areas surrounding the building (in the exterior) forms part of and complements the green infrastructure within the broader urban and suburban landscape [84]. Plants also help mediate the contrast between artificial building materials and the natural environment, reducing negative environmental impacts. In this context, greenery monitors micro-ecological conditions, its condition most clearly reflected in the vitality of vegetation located in close proximity to, or in direct contact with, built structures. The 'natural' effect fostered by living plant material gives adjacent built structures the role of a 'host substrate', creating the need for construction materials to be adapted accordingly. The positive influence of greenery also shifts perspectives on the use of 'toxic' or undesirable materials and finishes, encouraging the development and use of new materials that are more aligned with nature.

The use of plants in interior spaces helps large, enclosed areas feel more natural and cohesive, softening the sense of artificiality, enclosure, or confinement [85]. Plants improve microclimatic conditions, contributing to a healthier indoor environment, and enhance user experience through their aesthetic qualities. This, in turn, positively affects both physical and mental health. In work environments, plants have been shown to support cognitive performance and productivity among employees [86]. They also help users feel better overall [87,88], encouraging more frequent use of such spaces and a desire to return to them. Research has shown that plant material has specific effects on physical wellbeing by improving temperature regulation, humidity, and air purification [89,90], especially in air-conditioned spaces [91], while also supporting mental health through aesthetic impact, noise reduction [92], and fostering a sense of connection to the natural environment [93].

Considering the widespread research on the positive physical and psychological effects of greenery both inside and surrounding built structures, they could be considered a large contributing factor to the positive perception of Spens by its users, linking environmental and social benefits. Although originally only a complementary addition to the primary concept, the integrated greenery within and surrounding Spens has grown to become a primary association with the building and one of its greatest qualities and potentials for its sustainable future.

#### 3.2.2. Evaluation of Green Infrastructure Potential

Leveraging the existing spatial qualities—the extendibility of the spatial framework and the environmental potential of the roof and green zones—was a primary aim for the sustainable reconstruction of Spens, laid out by the development strategy [62] and subsequent concept design proposal of its authors. The analysis of the results obtained from both the GSF and UFG models, which use different weighting values, shows that the final factor value increases significantly with the proposed conceptual design compared to the existing condition of the complex.

Regarding Spens' GSF, a comparison of results between Spens' existing situation (GSF 0.45—slightly under the target level of 0.50) and its potential future (GSF 0.99) demonstrates a significant improvement in the green infrastructure of the complex according to indicators calculated using this method (Figure 5a–c). Of the 35 listed elements and practices, Spens' forecasted state includes 15 green points, which is above the minimum of 10. The value attained through the strategies outlined in the concept design proposal would meet the targets set for new developments [94], even despite the expanded footprint of the building in this scenario, which encroaches on an existing green zone. Given the constraints typically associated with reconstructing existing structures, this result is particularly notable, as the typical minimum target factor for reconstruction projects is 0.30 [95].

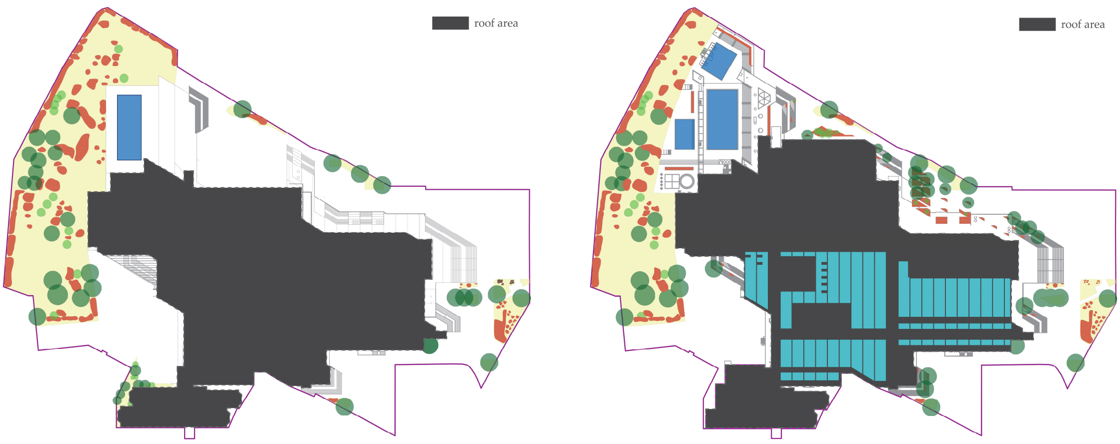
An analysis of the results of the UGF model (Figure 6a–c) also shows an improvement in green infrastructure in the proposed solution (UGF 0.30) compared to the existing situation (UGF 0.25). The current UGF value of 0.25 places it at the lower end of the target range for buildings with predominantly commercial use. Given the overall level of green infrastructure development in the region, the increase to 0.30 represents a notable improvement—positioned at the upper limit of the target range for Washington, D.C., for example, and at the lower limit for European cities with developed green infrastructure. This result is considered successful, especially since it concerns the reconstruction of an existing building, where, as mentioned previously, numerous constraints are often present. For newly designed buildings, the target is generally a minimum UGF of 0.30 or higher [96].


(**a**) (**b**)

| Element group | Element description | Key | Unit | Area or quantity - Existing Situation | Area or quantity - Proposed Conceptual Solution | Weighting | Weighted area, m² - Existing Situation | Weighted area, m² - Proposed Conceptual Solution | Runoff coefficient C |
|---|---|---|---|---|---|---|---|---|---|
| Preserved vegetation and soil | Preserved large (fully grown > 10 m) tree in good condition, at least 3 m (25 m² each) | | pcs | 35 | 28 | 3.5 | 3033.9 | 2427.2 | 0.1 |
| | Preserved small (fully grown ≤ 10 m) tree in good condition, at least 3 m (15 m² each) | | pcs | 17 | 11 | 3.0 | 773.2 | 500.3 | 0.1 |
| | Preserved tree in good condition (1.5–3 m) or a large shrub (3 m² each) | | pcs | 91 | 75 | 2.4 | 643.8 | 530.6 | 0.2 |
| | Preserved natural meadow or natural ground vegetation | | m² | 16,823.35 | 12,683.9 | 2.2 | 37,128.2 | 27,992.7 | 0.1 |
| | Preserved natural bare rock area (at least partially bare rock surface, not many trees) | | m² | 0 | 0.0 | 1.9 | 0.0 | 0.0 | 0.7 |
| Planted/new vegetation | Large tree species, fully grown > 10 m (25 m² each) | | pcs | 0 | 26 | 2.8 | 0.0 | 1827.0 | 0.1 |
| | Small tree species, fully grown ≤ 10 m (15 m² each) | | pcs | 0 | 98 | 2.3 | 0.0 | 3368.2 | 0.1 |
| | Large shrubs (3 m² each) | | pcs | 0 | 3054 | 1.7 | 0.0 | 15,591.3 | 0.1 |
| | Other shrubs | | m² | 0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.2 |
| | Perennials | | m² | 0 | 97.3 | 1.6 | 0.0 | 158.8 | 0.2 |
| | Meadow or dry meadow | | m² | 0 | 0.0 | 1.8 | 0.0 | 0.0 | 0.2 |
| | Cultivation plots | | m² | 0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.3 |
| | Lawn | | m² | 0 | 0.0 | 1.1 | 0.0 | 0.0 | 0.3 |
| | Perennial vines (2 m² each) | | pcs | 0 | 2844 | 1.3 | 0.0 | 7354.9 | 0.2 |
| | Green wall, vertical area | | m² | 0 | 2204.9 | 0.9 | 0.0 | 2054.0 | - |
| Pavements | Semipermeable pavements (e.g. grass stones, stone ash) | | m² | 0 | 0.0 | 1.0 | 0.0 | 0.0 | 0.6 |
| | Permeable pavements (e.g. gravel and sand surfaces) | | m² | 0 | 0.0 | 1.4 | 0.0 | 0.0 | 0.4 |
| | Impermeable surface (calculated automatically) | | m² | 77,743.7 | 71,395.1 | - | - | - | 1.0 |
| Stormwater management solutions | Rain garden (biofiltration area) with a broad range of layered vegetation | | m² | 0 | 0.0 | 2.8 | 0.0 | 0.0 | 0.2 |
| | Intensive green roof / roof garden, depth of substrate 20 – 100 cm | | m² | 0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.1 |
| | Semi-intensive green roof, depth of substrate 15 – 30 cm | | m² | 0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.4 |
| | Extensive green roof, depth of substrate 6-8 cm | | m² | 0 | 10,389.7 | 1.4 | 0.0 | 14,426.5 | 0.6 |
| | Infiltration basin or swale covered with vegetation or aggregates (no permanent pool of water, permeable soil) | | m² | 0 | 0.0 | 2.3 | 0.0 | 0.0 | 0.1 |
| | Infiltration pit (underground) | | m² | 0 | 0.0 | 1.5 | 0.0 | 0.0 | 0.1 |
| | Pond, wetland or water meadow with natural vegetation (permanent water surface at least part of the year; at other times the ground remains moist) | | m² | 0 | 0.0 | 2.8 | 0.0 | 0.0 | 0.1 |
| | Retention or detention1) basin or swale covered with vegetation or aggregates (permeable soil) | | m² | 0 | 0.0 | 2.0 | 0.0 | 0.0 | 0.2 |
| | Retention or detention1) pit, tank or cistern (underground, notice units: volume!) | | m³ | 0 | 0.0 | 1.4 | - | - | - |
| | Biofiltration basin or swale | | m² | 0 | 0.0 | 2.7 | 0.0 | 0.0 | 0.2 |
| Bonus elements, max score 1 per category | Capturing stormwater from impermeable surfaces for use in irrigation or directing it in a controlled manner to permeable vegetated areas | | m² | 0 | 0.0 | 0.7 | 0.0 | 0.0 | |
| | Directing stormwater from impermeable surfaces to constructed water features, such as ponds and streams, with flowing water | | m² | 0 | 0.0 | 0.8 | 0.0 | 0.0 | |
| | Shading large tree (25 m² each) on the south or southwest side of the building (especially deciduous trees) | | pcs | 27 | 31 | 0.9 | 604.5 | 694.0 | |
| | Shading small tree (15 m² each) on the south or southwest side of the building (especially deciduous trees) | | pcs | 17 | 21 | 0.9 | 228.3 | 282.1 | |
| | Fruit trees or berry bushes suitable for cultivation (10 m² each) | | pcs | 0 | 1069 | 1.0 | 0.0 | 15,778.9 | |
| | A selection of native species – at least 5 species/100 m² | | m² | 0 | 0.0 | 0.9 | 0.0 | 0.0 | |
| | Tree species native to Helsinki and flowering trees and shrubs – at least 3 species/100 m² | | m² | 0 | 0.0 | 0.9 | 0.0 | 0.0 | |
| | Butterfly meadows or plants with pleasant scent or impressive blooming | | m² | 0 | 266.7 | 0.8 | 0.0 | 218.8 | |
| | Boxes for urban farming/cultivation | | m² | 0 | 0.0 | 0.6 | 0.0 | 0.0 | |
| | Permeable surface designated for play or sports (e.g. sand- or gravel-covered playgrounds, sports turf) | | m² | 0 | 0.0 | 0.7 | 0.0 | 0.0 | |
| | Communal rooftop gardens or balconies with at least 10% of the total area covered by vegetation | | m² | 0 | 0.0 | 0.6 | 0.0 | 0.0 | |
| | Structures supporting natural and/or animal living conditions such as preserved dead wood/stumps or birdboxes (5 m² each) | | pcs | 0 | 0.0 | 1.2 | 0.0 | 0.0 | |
| | **GREEN FACTOR** | | | **0.45** | **0.99** | | | | |
| | **TARGET LEVEL** | | | 0.50 | | | | | |
| | **Site area, m²** | | | 94,566 | | | | | |
| | **Total weighted area, m²** | | | **42,419** | **93,191** | | | | |

(**c**)

**Figure 5.** (**a**) Graphical representation of green space factor elements included in the existing situation; (**b**) Green space factor elements included in the proposed conceptual solution for Spens; (**c**) Green Space Factor analysis comparing the contributions of various elements in the existing situation and proposed conceptual solution for Spens.




(**a**) (**b**)

| Key | Surface cover type | Factor | Area - existing situation (m²) | Contribution | Area - proposed conceptual solution (m²) | Contribution |
|---|---|---|---|---|---|---|
| | Semi-natural vegetation (e.g. trees, woodland, species-rich grassland) maintained or established on site. | 1 | 16,706.57 | 16,706.57 | 12,559.62 | 12,559.62 |
| | Wetland or open water (semi-natural; not chlorinated) maintained or established on site. | 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Intensive green roof or vegetation over structure. Substrate minimum settled depth of 150mm. | 0.8 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Standard trees planted in connected tree pits with a minimum soil volume equivalent to at least two thirds of the projected canopy area of the mature tree. | 0.8 | 5179.83 | 4143.86 | 6709.58 | 5367.66 |
| | Extensive green roof with substrate of minimum settled depth of 80mm (or 60mm beneath vegetation blanket) – meets the requirements of GRO Code 2014. | 0.7 | 0.00 | 0.00 | 10,389.69 | 7272.78 |
| | Flower-rich perennial planting. | 0.7 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Rain gardens and other vegetated sustainable drainage elements. | 0.7 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Hedges (line of mature shrubs one or two shrubs wide). | 0.6 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Standard trees planted in pits with soil volumes less than two thirds of the projected canopy area of the mature tree. | 0.6 | 638.61 | 383.17 | 668.01 | 400.81 |
| | Green wall –modular system or climbers rooted in soil. | 0.6 | 0.00 | 0.00 | 352.92 | 211.75 |
| | Groundcover planting. | 0.5 | 3667.57 | 1833.79 | 3943.03 | 1971.52 |
| | Amenity grassland (species-poor, regularly mown lawn). | 0.4 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Extensive green roof of sedum mat or other lightweight systems that do not meet GRO Code 2014. | 0.3 | | 0.00 | 0.00 | 0.00 |
| | Water features (chlorinated) or unplanted detention basins. | 0.2 | 1054.97 | 210.99 | 2150.00 | 430.00 |
| | Permeable paving. | 0.1 | 0.00 | 0.00 | 0.00 | 0.00 |
| | Sealed surfaces (e.g. concrete, asphalt, waterproofing, stone). | 0 | 0.00 | 0.00 | 0.00 | 0.00 |
| | **TOTAL AREA (m²) (include all land within the purple line boundary)** | | 94,567.00 | | 94,567.00 | |
| **URBAN GREENING FACTOR** | | | | **0.25** | | **0.30** |

(**c**)

**Figure 6.** (**a**) Graphical representation of surface cover types included in the Urban Greening Factor analysis for the existing situation; (**b**) surface cover types included in the Urban Greening Factor analysis for the proposed conceptual solution for Spens; (**c**) Urban Greening Factor analysis comparing the contributions of various surface cover types in the existing situation and proposed conceptual solution for Spens.

The analysis of both models, despite their differing weighting systems, demonstrates a clear improvement in the overall factor values through the proposed solution compared to the current situation of the site. Thus, while Spens in its current state does not meet targets according to these models, it shows to be a fruitful spatial framework for achieving environmental sustainability in the case of a future reconstruction scenario.

## 4. Conclusions

The aim of this paper was to underscore the sustainable potential contained within the spatial concept of the megastructure, arguably the most comprehensive manifestation of the broader idea of indeterminacy in architecture as outlined in the introductory literature review tracing the concept's development. At a crucial point in the lifespans of megastructures and buildings from associated movements encompassed by the idea of indeterminacy, highlighting this concept as a means of urban resilience today contributes to their reconsideration as spatial structures with significant sustainable potential within ongoing retrofit or replacement debates.

Through a case study of the Spens building in Novi Sad, a socialist megastructure awaiting reconstruction, this paper sought to reframe sustainability in architecture towards a return to the fundamentals—sustainable spatial concepts. An evaluation of the social sustainability of Spens through focus group discussions analysing three aspects —sense of community, sense of place, and sense of wellbeing—demonstrated a clear recognition of the spatial qualities of the building by all categories of users, whose positive emotional attachment and related frustrations regarding its dilapidated state are shaped by the identified qualities of the original spatial concept. Key characteristics like Spens' multifunctionality and programmatic density, its role as an urban centre and architectural icon, generous sheltered public spaces and vibrant vegetation were all pointed out by users in a positive light. Predominant feelings of communal pride, joy and nostalgia associated with being in the space, but also frustration at its current condition, also indicate a strong attachment of users to both the physical structure and communities nurtured under its roof.

An analysis of the current and future environmental sustainability of Spens in relation to its socially driven concept, focusing on strategies that enhance user wellbeing and urban life, highlighted the environmental potential of the spatial framework and the integrated vegetation. The results obtained from the GSF and UFG model reveal the current underutilisation yet significant potential of greening strategies like green roofs, walls, and tree planting in achieving a greater environmental contribution and improving the quality of urban life, particularly as a means of offsetting the impact of building extensions as often necessary aspects of the adaptation and reconstruction of existing structures for contemporary needs.

Both analyses brought into direct relation the qualities of the original spatial concept and dimensions of both social and environmental sustainability, demonstrating Spens' current sustainability reflected in the social values identified in the focus group discussions and its future potential for greater environmental sustainability, which could be achieved by leveraging its spatial qualities. This approach positions economic sustainability as the outcome of carefully considered long-term strategies focused on achieving social and environmental aims. A feasibility study conducted for the purpose of assessing the viability of reconstructing Spens determined that, while financially unviable, the economic benefits of the reconstruction project—reflected in the long-term value to society gained through the mental and physical health benefits of sports activities for all ages, reduced $CO_2$ emissions with improved energy efficiency of the building, and the creation and protection of jobs—outweighed the costs with a positive B/C ratio of 1.71 [97].

This paper contributes to the literature on the under-represented social dimension of sustainability essential to architecture and highlights its interrelatedness with the environmental dimension through themes related to user wellbeing and the economic dimension through the inferred long-term value of social and environmental benefits. The research does, however, have certain limitations. Firstly, despite including several user categories, the non-random sampling method for the focus groups potentially limited the diversity of the collected viewpoints, while the relatively small sample size restricts the generalisability of the findings. Furthermore, the self-reported nature of the data may be subject to response bias, including tendencies towards social desirability and recall inaccuracies. Nevertheless, in assessing the social sustainability of Spens, this type of qualitative approach presents a valuable methodology for gaining rich insight into user experience. In relation to the examined environmental sustainability, the GSF and UGF offer useful frameworks for quantifying the ecological performance of urban design strategies. However, as preliminary planning tools evaluating a conceptual reconstruction proposal, these analyses do not reflect actual future implementation or its qualitative aspects, which were not possible to analyse at this time. Instead, this paper served to highlight the reconstruction potential of buildings of this type, whose spatial design can be considered inherently sustainable, within ongoing debates on this topic. It advocates for a more holistic approach to sustainable architecture, one that does not undermine the significance of technological and financial parameters but understands the social dimension as the basis of the architectural agenda, through which the remaining dimensions can be considered. These insights may inform future architectural practice and policy, especially in light of the precarious fate of many megastructures from the second half of the 20th century. They highlight the need to reassess the long-term societal value of such structures and to consider strategies for leveraging their concepts in the direction of their sustainable adaptation based on existing and recognised qualities rather than replacement.

**Supplementary Materials:** The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/su17198527/s1, File S1: Focus group questions; File S2: Questionnaire on the social sustainability of Spens; File S3: Codebook; File S4: SPSS tables.

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**Institutional Review Board Statement:** The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of the Faculty of Technical Sciences of the University of Novi Sad (No. 01-553/4) on 4 February 2025.

**Informed Consent Statement:** Informed consent was obtained from all subjects involved in the study.

**Data Availability Statement:** The original contributions presented in this study are included in the article/Supplementary Materials. Further inquiries can be directed to the corresponding author.

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