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Designing the First Rosarium in Serbia to Fulfill Environmental, Societal, and Economical Purposes

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Abstract: Specialized botanical gardens such as a rose garden, or rosarium, play a significant role due to their multifunctional nature surpassing simple gene bank assembly. Thus, this study conducted a detailed analysis of a rose garden through field and desk research, SWOT analysis, and ecosystem services assessment, aiming to determine the major strengths and opportunities, as well as weaknesses and threats that can promote or constrain the establishment of the first national rosarium in Serbia. After the analysis, the need for complete green area reconstruction arose to achieve both attractiveness and usefulness. Featuring old varieties, wild species, and companies' own specific rose collections, the proposed garden has the potential to contribute major ecosystem services reflected in environmental, societal, and economic purposes. Owing to the uniqueness of the breeding program and collections created in the past decade, specific thematic parts—open field or greenhouse classroom, 'roses under the glass bell', abundant river flow, pollinators' shelter, taste garden, and scent garden—are envisaged in the future exemplary rosarium that would not be only a classroom but a showroom for interested nurseries, small-scale functional food producers, flower shops, or amateur gardeners that would become aware of new cultivars and expand their marketing and utilization.

Keywords: biodiversity; gene bank; *Rosa* × *hybrida*; sustainable development goals

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1. Introduction

The wealth of a country is not solely measured by its gross domestic product, total exports, or reserves of money and gold. The true wealth of a nation, region, or area lies in its land, water, air, and genetic resources of plants, animals, fungi, and microorganisms. Broadly speaking, plant genetic resources are natural assets crucial for human and animal nutrition or as raw materials for various industries. Genetic diversity encompasses the total number and variety of genes, or genetic information, contained within all individual species of plants, animals, fungi, and microorganisms on Earth. Germplasm represents a set of genotypes that can be collected, conserved, and utilized, while genetic resources are described as the plant genetic material that determines their characteristics and ability to adapt and survive [1]. Due to their adaptability to unpredictable environmental changes, biodiversity can also be defined as the response of living organisms to environmental variability over time [2]. On a global level, the importance of plant genetic resources is a constantly relevant topic [1]. One of the largest and most significant organizations addressing this issue is the Food and Agriculture Organization (FAO), an agency of the United Nations. Within this organization, the "FAO Global Plan of Action for Plant Genetic Resources" and the "International Treaty on Plant Genetic Resources for Food and Agriculture" are of particular importance. To fulfill its obligations to the FAO, Serbia has participated in numerous collaborative projects with European institutions and funds aiming to contribute to global efforts in preserving and utilizing plant genetic resources. However, these collaborative programs targeted edible and medicinal plants, while ornamentals were not coordinately preserved. While forest genetic resources, among which

species widely contribute to ornamentals and greenery, are recognized and preserved [3], annual and perennial flowering species are given less attention.

The significance and prevalence of horticultural production, along with the diversity of conditions under which ornamental species are cultivated, require a wide variety of cultivars and species with different characteristics [4]. As society evolves, new needs arise, sometimes in ways previously unconsidered. To meet these emerging demands, new varieties and cultivars with entirely different characteristics are being developed, requiring appropriate genetic material as a starting point for creating new genotypes. Considering global climate change, it is essential to develop such assortments that will maintain or improve production quality under novel conditions. On the other hand, there is a risk of losing the genetic resources necessary for developing new varieties. The reduction in genetic variability is a constant threat due to the development of global production systems, the modernization of agriculture, urbanization, and the neglect of natural populations, which represent an inexhaustible source of genetic diversity [5–8].

Botanical gardens serve as gene banks where a wide range of specific plant species, crucial for horticulture and landscape architecture, are preserved [9]. Gene banks include parks, greenhouses, nurseries, laboratories, herbariums [10], and arboretums [11], where plant material is studied and conserved, enriching the genetic resources of horticultural plants in a given country. Among the world's most renowned botanical gardens is the Chicago Botanic Garden, featuring four natural habitats and 27 distinct gardens, including bonsai, children's, bulb, circular, water, sensory gardens, as well as rosarium. Of particular scientific and professional importance is the Plant Conservation Science Center, where gardens have been developed with breeding programs to address contemporary challenges such as rain gardens and rooftop gardens. Similarly, the Royal Botanic Gardens, Kew in London, serves as a unique research station, preserving not only plant genetic resources but also aligning with global SDGs 'and dedicating efforts to conserving fungal genetic resources, which are crucial for the future of life on Earth [12], maximizing the impact on science, education, conservation policy, and management. In addition, the Royal Botanic Garden Edinburgh (RBGE) has made the climate emergency and biodiversity crisis central to its organizational strategy. The institution is implementing changes to lessen the environmental impact of its operations and to adapt to the challenges posed by climate change [13]. Back in 2004, Phibbs et al. [14] noted little collaboration between 4-H groups and arboretums and botanical gardens; however, nowadays there are some gardens implementing the youth program [15]. Other significant botanical gardens, which act as repositories for rare and other ornamental species, include Jardim Botânico (Rio de Janeiro, Brazil), Brooklyn Botanic Garden (New York, NY, USA), Singapore Botanic Gardens, Royal Botanic Garden (Sydney, Australia), Denver Botanic Gardens (Denver, Colorado, USA), and Nong Nooch Tropical Botanical Garden in Thailand [16–18]. A lesser-known but highly important garden is the Balkan Botanic Garden of Kroussia in Greece, an ex situ botanical garden where a collection of about 2500 specimens, including around 50 native species and subspecies, is preserved for studying their potential in ornamental and utilitarian horticulture [19]. Serbia's most renowned botanical garden, which houses the genetic resources of leading European coniferous, deciduous, and herbaceous plants as well as succulents, is the "Jevremovac" Botanical Garden and Institute of Botany in Belgrade, founded in 1892. This botanical garden preserves relict species like Pančić spruce (*Picea omorica* (Pančić) Purk.), Bosnian pine (*Pinus heldreichii* H.Christ), and *Ramonda nathaliae* (Pančić & Petrović) ex situ [11], while they naturally grow in the Serbian national parks in situ.

Specialized gene banks are rosariums, or rose gardens, where roses are mainly preserved outside their natural environment (ex situ). One of the most renowned rosariums is the David Austin Garden, established in 1940 as a hobby project. It quickly developed into a successful breeding program, producing over 200 new cultivars. This rosarium features several themed gardens, such as the Victorian, Renaissance, terrace, patio, and long gardens, preserving a wide range of genetic diversity. The world's largest living rosarium is located in Sangerhausen, Germany, famously known as the "City of Roses". Spanning 13 hectares, this vast collection includes over 8600 different rose varieties and

species, represented by approximately 80,000 rose bushes. It is not only the largest but also one of the most valuable rose collections globally [20]. While rosariums are often seen as the primary way to display ornamental roses, they are also integrated into larger botanical gardens as thematic compositions [21]. An example of this is the International Rose Test Garden in Washington Park, Portland. Initially established during World War I as a preservation and testing ground for roses from around the world, it now serves as both a breeding site and a germplasm collection. The garden currently showcases 610 different rose varieties, with over 10,000 individual rose bushes [22].

In addition to living rosariums, the Rose Society's 'Heritage Rose Foundation' [23] supports the historic roses' preservation by providing a database of gardens worldwide. This database lists the main public rosariums in North America (23), followed by Europe (9), Oceania (5), and only one in Asia. Despite their distribution, each collection safeguards a substantial amount of rose germplasm, serving as a crucial backup or core collection that provides a valuable gene source and research insights [24]. Another specific digital collection, 'The Rosarium Project', gathers rose descriptions in books, pamphlets, catalogs, and articles from popular magazines, scholarly journals, and newspapers published before 1923 [25].

In addition to public gardens, private rosariums play a significant role in preserving historical and contemporary rose germplasm. In Italy, 'The Gianfranco And Carla Fineschi Rose Garden Botanical Association', commonly known as 'Roseto Fineschi', manages the rose garden organized into 21 sections encompassing species roses, ancient roses, and modern roses, while educational material regarding the historical accessions is also available [26,27]. A notable Serbian small-scale private rose gene bank is located in Pančevo, near Belgrade, founded by enthusiast Đura Kiš, who assembled a collection of over 1000 rose varieties driven by his love for roses. However, another significant rose collection is held by the private breeding company "Pheno Geno Roses" in Temerin, which boasts over 3000 varieties and newly created cultivars intended for various purposes, such as cut flowers, edible flowers, or fruits, and for greening both urban and rural, private and public green spaces.

Given the abundance of underutilized and underexplored rose varieties, belonging to different Rosa species, inter- and intraspecific hybrids, and the lack of organized rose conservation sites, this study aimed to (i) assess the main rosary environmental, educational, and sociological aspects; (ii) assess the ecosystem services provided by the rose gene bank; (iii) propose a design of the rosary to fulfill those aspects; and (iv) promote the establishment of living labs or living catalogs.

2. Materials and Methods

2.1. Locality Description

The experimental research site is the Pheno Geno Roses complex in Temerin, the town adjusted to Novi Sad, the second largest city in Serbia. Completely fenced, the given area accounts for 9433.7 m^2 and has a single entrance from the street. The area has three greenhouses for rose hybridization and seedling cultivation.

Hot summers and cold winters typical for this area characterize it as continental with semi-arid elements, while the soil is classified as high-quality chernozem. Annual precipitation reaches 540–820 mm, but the patterns are not favorable due to the long drought episodes followed by heavy rainfall with monthly precipitation occurring in only a few days [28,29].

2.2. Rose Collections and Accessions

Rose collections bred by the Pheno Geno Roses breeding company currently occupy 1312 m^2 out of the total green area (9433.7 m^2), comprising 14%. In addition to more than 200 standard, long-appreciated cultivars, parentage plant material in the form of commercial older world-famous varieties ('William Shakespeare', 'Papa Meilland', 'Soeur Emanuel', 'Chandos Beauty', 'Gloria Dei', 'Grande Amour', 'Charles de Gaulle', 'Grand Prix', 'Cleopatra', 'Don Juan', 'Williame Shakespeare', 'Graham Thomas', 'Othello' and many more), fragrant species *Rosa damascene* accessions, and wild roses like *Rosa rugosa*,

the area represents a unique gene bank featuring some novel rose collections. Eleven unique collections in detail described by Ljubojević et al. [30] include compact landscape roses—Abundant Reka® (comprising 7 cultivars), flower arrangement cut roses—Art Vaza® (10 cultivars), unique Striped Fresca® collection (6 cultivars), patio roses from the Pixie® collection (10 cultivars), a collection of winter hardy roses—Winterjewel® (6 cultivars), feminine Fragrant Frayla® collection (9 cultivars), Mella®—collection of pollinators attracting roses (7 cultivars), cheerful Fashion® collection (7 cultivars), oil abundant Sense of Love® collection (7 cultivars), and Edible rose collections—Taste of Love® (9 cultivars) and Aurora (5 cultivars). Figure 1 shows the current representation of each of the collections in the company's garden. It can be seen that the Taste of Love collection occupies the largest area of 610 m^2, while the Fashion collection provides the smallest percentage of only 1%.

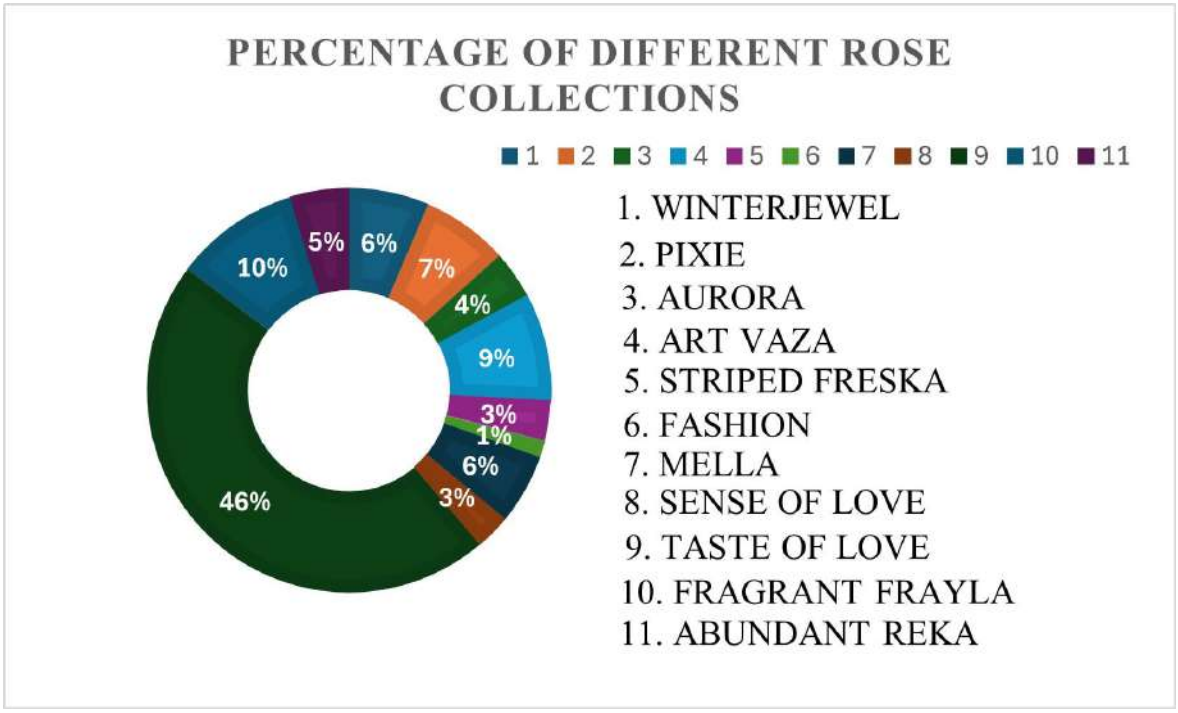

Figure 1. The current area percentages covered by each rose collection in the rose garden.

Characterization of varieties within the collections was performed on-site during two consecutive years (2023–2024) following the UPOV descriptor [31], surveyed in the available literature [30] and databases, and supplemented with the interviews with the employees and visitors.

2.3. SWOT Analysis—Current State and Future Possibilities

Synthesized SWOT results were used to determine the key drivers and hindrances to the most appropriate rosarium design proposal. This tool was previously explored by Qumsiyeh et al. [32] while exploring the role of botanical gardens in facing environmental challenges. The SWOT analysis included data obtained through field research and analysis, a literature survey, and employee interviews. The obtained data were further classified into internal and external factors for the SWOT matrix formation. The strengths and weaknesses represent positive and negative features of internal factors, i.e., benefits and disadvantages of investigated rose collections, space, and context. The positive and negative external factors were characterized as opportunities and threats, which indicate the main environmental, societal, and economic potentials.

During the creation of the future conceptual design, based on all previous factors, the sketch with the conceptual solution (2D representation of the current state) was transferred into AutoCAD 2022 software (Autodesk, San Rafael, CA, USA). A 2D representation of the new design was then transferred to Realtime Landscaping Architect 2020 (Idea Spectrum, Snoqualmie, WA, USA), producing a 3D visualization of the rose garden.

2.4. Ecosystem Services Matrix

Based on the previous research [33], as well as the Millennium Ecosystem Assessment [34], we assessed the possible ecosystem services (ESs) that the rose gene bank could provide. The possible ESs were divided into four standard categories: provisioning, regulating, cultural, and supporting, and subsequently matched with three major sustainability pillars—environmental, societal, and economic purposes.

3. Results

3.1. Rose Collections Created by the Pheno Geno Breeding Company

Breeding roses for the 21st century needs by Pheno Geno Roses Company thus far, but not finally, resulted in 11 unique collections. Summarized, those roses are created to tackle all senses while being sustainable and suitable for various purposes and landscapes. Eye-catching 'Fashion', 'Freska', 'Abundant Reka', and 'Art Vaza' collections feature ornamental genotypes that are vigorous, abundantly flowering, and moderately disease resistant. Fragrant 'The Sense of Love' and 'Frayla' collections are noted for their intense scents due to the high concentrations of volatile compounds. 'Taste of Love' and 'Aurora' that can be used as fruit species consumed fresh or processed bring edible character to the gardens. The sound-provoking 'Mella' collection attracts various bees and pollinators, making them busy around the bushes. The 'Pixie' collection includes two types of patio roses: miniature varieties that range from 20 to 35 cm in height and groundcovers ranging from 40 to 70 cm, making them ideal for container gardening, whether in large terracotta pots or small containers on windowsills, perfect for compact urban spaces. Lastly, the 'Winterjewel' collection, developed using advanced plant breeding techniques, is characterized by its exceptional hardiness, capable of enduring temperatures as low as −35 °C despite their delicate appearance. In addition to this resilience, these roses are known for their diverse colors, repeat blooming, and pronounced health.

3.2. Current State and Possibilities

3.2.1. Field Observations

The company's collections are currently planted unorganized (Figure 2), and a complete reconstruction is being planned as part of the conceptual design to meet the criteria of both the rosarium (rose garden) and the plant requirements. The specific species (both wild relatives and commercial ones) within the gene bank are located in the southern part of the plot and are not very noticeable, so emphasis should be placed on this area. These are old rose varieties (*Rosa hugonis*, *Rosa mundi*, *Rosa damascena*, *Rosa alba*, *Rosa viridiflora*, 'Gruss an Aachen', 'Rosarium Uetersen', 'Jacqueline du Pre' and many more) that are hard to find nowadays and will be used as plant material for propagation in the future if needed. The hill near the greenhouse is not fully utilized and thus could be arranged to highlight and showcase landscaping possibilities of elevated terrains. The fence in the southern part that separates the plot from the neighbors is made of wire and should either be concealed or replaced, while the small fence along the current path is interesting and made of natural materials. The lawn is also in very poor condition, so it will be reseeded during the reconstruction. Columnar roses are located on the periphery of the area, which is not common practice, so they should be planted in appropriate locations according to design principles (plants' assembly with taller plants not overshadowing the shorter ones).

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

Figure 2. Current rose garden state at the field plot of 'Pheno Geno Roses' company in Temerin (Serbia) with representatives of shrub (**a**) and climbing (**b**) rose cultivars.

3.2.2. SWOT Analysis

The performed SWOT analysis revealed that a future rosarium has more potential benefits than drawbacks and would be a significant advancement compared to the current state (Figure 3). Major strengths derive from a large, fenced area with diverse and interesting collections of roses (species, hybrids, elite material, and wild relatives) grown on suitable quality soil and the plot located in the suburban area of Novi Sad, the second largest city in Serbia and 100 km away from the capital city—Belgrade.

In the current state, there are some weaknesses that should be carefully considered. The furniture is not in bad condition, but it is heterogeneous and randomly positioned. The bench is very needed in the garden, but there is only one, and it does not fit in the space. The plot is completely fenced with wire and poles, but the fence lacks plant material like climbing roses that attracts more attention from both visitors and insects, concomitantly enriching the space. Additionally, there are patches of barren land, the presence of invasive weed species, and undefined paths without any pavement.

The new design has to overcome these weaknesses while harnessing all strengths and leading to opportunities. Some of the major novelties and uses would include the achievement of a harmonious green space, attraction of professional and amateur visitors, company events organization, occasional photo shootings, art colonies, the establishment of a living lab for research purposes as well as a living catalog for marketing purposes, better showcasing of rose collections, and similar.

In addition to the positive values, it is important to note the less valuable ones, due to the awareness of the possible threats that may arise, such as disease outbreaks in the monocultural field plot and possible low interest in this kind of green area utilization by citizens. There is an open question and concern about how public–private cooperation would function in long-term practice. Furthermore, visiting tours and fees, as well as the collected fundings' further investment, have to be defined in advance.

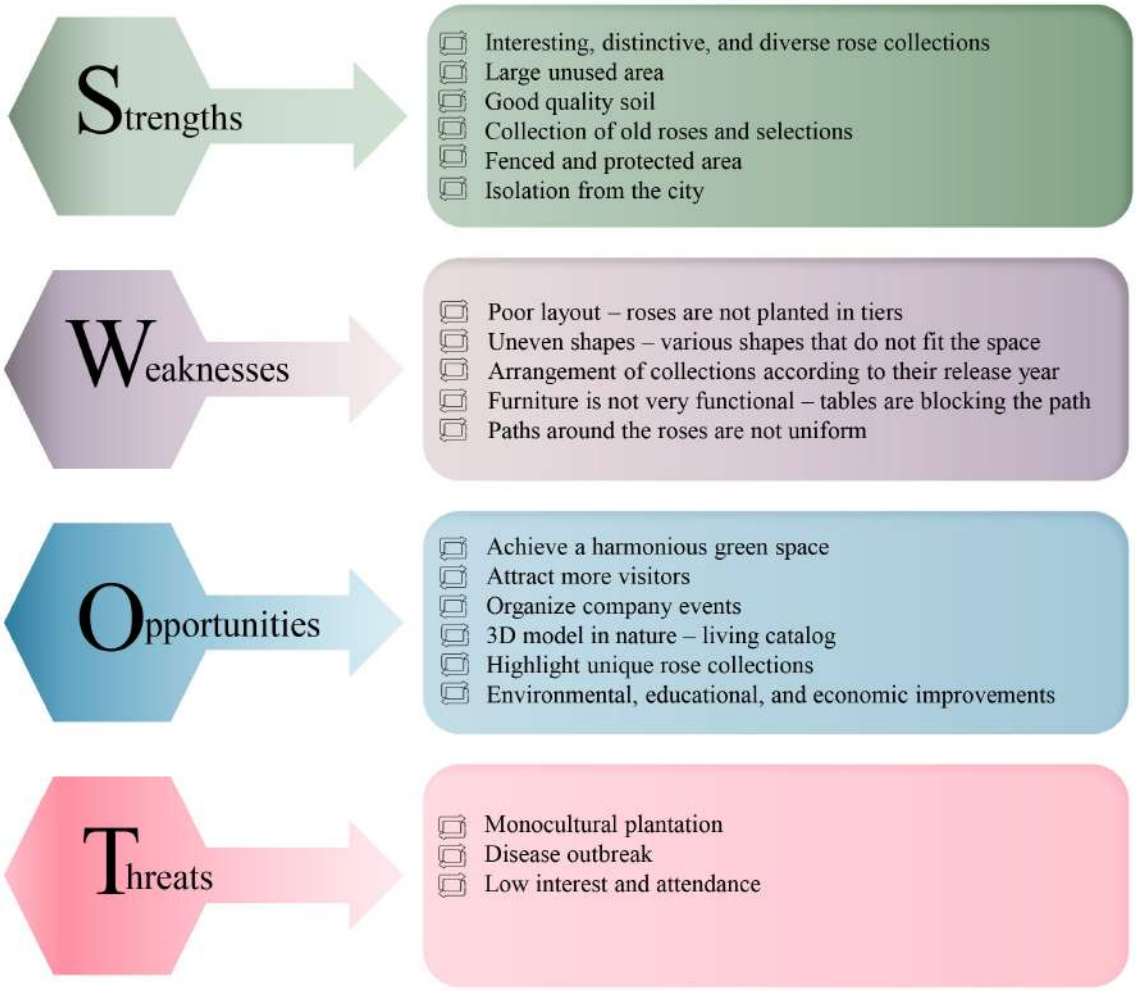

Figure 3. Major strengths, weaknesses, opportunities, and threats associated with the rosarium establishment.

3.3. Rosarium Design Proposal

The rosarium's conceptual design, completely presented in Supplementary Figures S1 and S2, followed the familiarization with the terrain (field observations), environmental conditions, plant characterization, SWOT analysis, and thoroughly researched literature. The newly designed concept would have environmental, scientific, educational, and social functions. At the very entrance, through a tunnel covered with climbing roses (area labeled as 1 in Figure 4), a path leads to the gene bank and living classroom (area 2 in Figure 4), an area designated for the company's needs, various workshops, gardening practices, and scientific gatherings, where the 'Sense of Love' collection is present, captivating attention with its fragrance.

The gene bank can also be accessed via a path from the greenhouse for the research conducted in the controlled environment. The gene bank of the most valuable cultivars is outdoors, and, reminiscent of roses under a glass bell, some rose genotypes have their own small portable greenhouse that can be removed if the plants are not grown in controlled conditions due to their environmental amplitude (Figure 5). In addition to being fully portable and foldable, small green houses possess opening windows to avoid overheating during the hot sunny days.

Figure 4. Rosarium conceptual solution for achieving the gene bank with environmental, scientific, educational, and social functions. Specific zones are labeled as 1–6, corresponding to: 1—Rose tunnel, 2—gene bank and living classroom, 3—resting area, 4—central garden, 5—swings and 6—green house.

Figure 5. Roses under a small portable greenhouse with multiple functions—controlled hybridization, germplasm preservation, abiotic and biotic stress factor mitigation, and similar.

A small fountain (Figure 6a) resembling the flower has been placed near the greenhouse, making it easily accessible from this facility while also being convenient for visitors, along with a resting area with a view of the 'Abundant Reka' collection (eng. 'River'), named for its numerous blooms (area 3 in Figure 4). The path from this fountain and resting area towards the patio living classroom is accompanied by the 'Winterjewel' collection, bringing the lesson on winter hardiness resistance. The greenhouse 'per se' serves multiple functions (area labeled as 6 in Figure 4); in addition to pollination and rose selection, it can be used for other indoor scientific experiments complementing the outdoor classroom. The educational purpose will be fulfilled through breeding and gardening practices, both in the greenhouse and on the green areas of the rose garden. To support a circular economy, renewable resources like plant waste from pruning and lawn mowing shall be composted and used as organic fertilizer in the following years. For non-composting materials, there are appropriate containers for separation of plastic, paper, glass, metal, and organic waste.

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

Figure 6. Water elements within the future rosarium—the smaller one complementing and associating on the 'Abundant Reka' (eng. 'River') collection and its flushing of flowers (**a**) and the larger fountain as a central area element (**b**).

The central part is occupied by a circular fountain (Figure 6b), which has a calming effect with its sound, surrounded by benches encircled by the rose collections (area 4 in Figure 4). The inner circle composition, resembling the flower, includes most dwarf roses from the 'Pixie' collection as the first story, followed by the most ornamental cultivars from 'Striped Freska' as well as 'Fragrant Frayla' collections and ornamental grasses. The outer circle is assembled from two mirrored 'Art Vaza' and 'Fashion' collections in the north as well as continuous edible 'Aurora' and 'Taste of Love' collections in the southern part, showcasing roses as not merely ornamental but utilitarian fruit species.

The area with swings is suitable for observing the entire space (area 5 in Figure 4), and behind them is the 'Mella' collection, which attracts pollinators, adding to the ambiance with its sound and natural character. Due to safety reasons, this pronounced pollinator-attractive collection is slightly detached from the rest of the garden, and visitors are warned about the abundance of bees in this area.

The lawn is established with a suitable grass mixture to fill the space properly and clearly define different areas, contributing to an appropriate aesthetic experience. The paving is made of stamped concrete, as are the plateaus, which are designed to visually separate the space, ensuring each part has its own function, while the lighting is intended to provide the final visual effect, showcasing the nighttime aspect in the right way.

3.4. Possible Ecosystem Services Provided by the Plants within the Rosarium

With numerous specificities, diverse collections differently contribute to four groups of ecosystem services (Table 1). In the category of provisioning services, in addition to contribution to the gene bank, notable positive influence is expected from varieties that are derived from wild relatives, characterized by pollen and nectar abundance and concomitant quality hip formation—'Mella', 'Taste of Love', and 'Aurora'. The 'Fragrant Frayla' collection further contributes not only to food but also essential oil production, along with the 'Sense of Love' rose collection. Among the regulating services, all investigated roses contribute to environmental benefits like air purification and climate regulation, but again, 'Mella', 'Taste of Love', and 'Aurora', accompanied by 'Abundant Reka' and 'Freska', stand out as pollinators' habitats, while most tolerant cultivars from collections 'Mella', 'Taste of Love', 'Aurora', 'Abundant Reka', and 'Winterjewel' participate in disease control. This is also their supporting ecosystem service, along with nutrient cycling and soil enrichment, where all varieties have some extent of contribution. Being highly ornamental, roses at the end mostly provide very significant cultural services. All collections and cultivars within contribute to the aesthetics and ornamental value, represent educational material, provide spiritual inspiration, and can be used in landscaping eco-touristic and recreational areas. When observed from environmental, societal, or economic purposes due to their intertwining, services can be conditionally labeled as low, medium, or highly influential, as presented in Table 1. Possible low scores for environmental purposes derive from rose habitus—dwarf or medium-sized shrubs, while where present, their low scores for economic purposes come from the fact that roses are not commercial but minor fruit crops with lower yields. The best example of conditional labeling can be noted for gene bank influence on economic purposes. In the given moment, roses in the gene bank might have no role in increasing the economy, but with the novel unpredicted trends or unexpected disturbances, some traits deposited in the cultivars might gain added value. Other implications shall be discussed later in the appropriate section.

Table 1. The expected contribution of rose cultivars to the specific provisioning, regulating, supporting, and cultural ecosystem services with an emphasis on their environmental, societal, and economic relevance.

	Ecosystem Services	Mella Collection			Taste of Love Collection			Aurora Collection			Fashion Collection			Abundant Reka Collection			Art Vaza Collection			Fragrant Frayla Collection			Pixie Collection			Sense of Love Collection			Winterjewel Collenction			Freska Collection		
Provisioning	Gen bank	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L	H	M	L
	Honey production	H	M	M	M	M	M	M	M	L																								
	Food production	M	M	M	H	M	M	H	M	L										M	M	L				M	M	L						
	Essential oil sources																			M	M	L				M	M	H						
Regulating	Climate regulation	L			L			L			L			L			L			L			L			L			L			L		
	Air purification	L			L			L			L			L			L			L			L			L			L			L		
	Pollinators' habitat	H			H			H						H																		H		
	Disease control	H		L	H		L	H		L																			H		L			
Supporting	Tolerance to diseases	H		L	H		L	H		L																			H		L			
	Nutrient cycling	L	L		L	L		L	L		L	L			L		L	L		L	L		L	L		L	L		L	L		L	L	
	Soil enrichment	L	L		L	L		L	L		L	L			L		L	L		L	L		L	L		L	L		L	L		L	L	
Cultural	Aesthetic and ornamental value		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H
	Educational value	H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H		H	H	
	Spiritual or inspirational service		H			H			H			H			H			H			H			H			H			H			H	
	Ecotourism and recreation	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L	M	H	L

Different cell colors correspond to following purposes: environmental—green, societal—violet and economical—pink, with marks for their significance—low (L), medium (M), and high (H). Fields with no color are expected not to contribute to the specific outcome.

4. Discussion

Botanical gardens differ greatly in design and function, but they are generally linked to environmental conservation, education, or historical interpretation [35]. The listed study explored how botanical garden visitors connect garden attributes to their personal values, revealing that both students and non-students find stress relief, relaxation, and an improved quality of life as key outcomes of their visits. The findings suggest that botanical gardens should focus on providing a relaxing and enriching experience while maintaining diverse plant collections that encourage learning and new experiences. Specialized botanical gardens—rosariums—might play an even greater role when it comes to education (abundant and focused research and knowledge database), relaxation (active and passive relaxation due to therapeutic effects), conservation (traits present in a large number of diverse roses), and economic development. In their study, Chen and Sun [36] emphasized that Kunming Botanical Garden primarily concentrated on the ex situ conservation of plants from Southwest China, with a particular focus on endangered, endemic, and economically significant native species. While Golding et al. [37] concluded that socio-economic factors contribute to shaping patterns in the species richness of the living collections of the world's botanic gardens, well planned and designed gardens can reversely influence society and economy. The rosarium proposed by our study could serve as a showcase for interested nurseries, small-scale functional food producers, flower shops, or gardeners that would become aware of new cultivars and expand their marketing and utilization. Vice versa, those actors could participate in the co-design and co-creation of new verities, suggesting possible future needs and trends in a developing and dynamic rose market. Having in mind that in 2021, roses ranked as the world's 1058th most traded product, with trade valued at USD 3.3 billion, conservation and breeding new varieties is a sustainable and reliable activity. The export of roses experienced a 14.6% increase from USD 2.88 billion in 2020 to USD 3.3 billion in 2021, accounting for 0.00015% of global trade [38]. Given the significant economic, landscaping, and health-related benefits of roses, the gene bank that envelops such added-value-providing genotypes is important from a local to global level.

Regarding the economy, it is important to note that in addition to the traditional role in the income increase, botanical gardens, including the proposed rosarium, can play a pivotal role in the circular economy awareness and application improvement. In the most recent study by Turner-Skoff et al. [39] on the example of Longwood gardens, it was shown that in addition to germplasm preservation and ornamental value, gardens can showcase the sustainability and circular economy approach, advancing both environmental and societal roles. Promoting abiotic and biotic tolerance, sustainable practices like composting and recycling, multiple provisioning, regulating, supporting, and cultural values instead of mere decorativeness, our envisioned rose gene bank can contribute not only to the circularity but sustainable development goals as well. Royal Botanic Gardens, Kew (Kew) set the manifesto for change in 2021, striving to contribute to multiple SDGs [12], like SDGs 1, 2, 3, 4, 9, 13, 15, and 17, highlighting the fact that the actions within the garden are aligned with the SDGs rather than that the work itself achieves exact targets within the global goals. Another such example includes Mt. Cuba Center that addresses several SDGs, especially 4, 8, 11, and 15 [40]. Similarly, cultivars planted in the pertinent rosarium in Serbia were previously elaborated on their contribution towards different SDGs. Namely, the proposed roses play a vital role in several areas: they support honey production, provide food for both humans and beneficial insects, and offer genetic material for future rose breeding and improvement. They also contribute to regulating the environment by purifying the air, providing habitats for pollinators, and aiding in disease control. Culturally, roses offer spiritual and inspirational services and enhance aesthetic value. Additionally, they support ecosystem functions like disease tolerance, nutrient cycling, and soil enrichment. These contributions, both directly and indirectly affect society, help in eliminating hunger, improving food security and nutrition, and promoting sustainable agriculture (SDG 2), as well as in creating inclusive, safe, resilient, and sustainable cities and human settlements (SDG 11). Moreover, sustainable garden rose

production in nurseries can advance gender equality by empowering women and girls through self-employment opportunities (SDG 5) [30].

However, establishing a sole rose garden can be challenging due to the monocultural character similar to cropping in agricultural production. The recent outbreak of rose rosette disease in Michigan was regarded as a 'death sentence for roses'. Namely, rose rosette disease (RRD) is a devastating viral disease that affects rose plants, primarily caused by the rose rosette virus (RRV). The disease is spread by the eriophyid mite *Phyllocoptes fructiphilus*, a tiny, wingless insect that feeds on the sap of rose plants. These mites are so small that they can easily be carried by wind currents, making the disease highly contagious and difficult to control [41]. According to the same authors, all major commercial rose cultivars were susceptible to RRD but varied in susceptibility severity responses. Due to the high level of diversity among RRV isolates [42], the long-term roses' sustainability is concerning. As the disease continues to spread, it poses a significant threat to rose cultivation in many regions. Although RRD is not present in Serbia, it reminds us that disease tolerance/resistance is of utmost importance in breeding efforts. Research is ongoing to develop RRD-resistant rose varieties and to better understand the biology of the rose rosette virus and its mite vector [43]. However, until more effective solutions are found, managing RRD will remain a critical challenge for rose growers and the rose gardens' management and durability. RRD is only one reminder among many diseases and pests threatening the rose cultivation.

Given the listed uncertainties associated with in vivo botanical garden preservation, a combined conservation approach is the most effective method, ensuring both resource availability and longevity. This is where twinning between academia and the private sector gains the highest significance and where the combined model of in situ and ex situ preservation is the most appropriate. Yang et al. [44] noted that human activities, rather than genetic degradation, are the main factor causing Rosa rugosa to become endangered in China. This underscores the importance of prioritizing both in situ and ex situ conservation efforts. Conversely, cryopreservation at −196 °C has emerged as an effective method for long-term storage of plant germplasm, leading to a rise in the number of species preserved using this technique [45]. In their work on *Rosa* sp. cultivars, Halmagyi and Pinker [46] employed a protocol that involved dehydrating pre-cultured shoot tips, directly plunging them into liquid nitrogen, and then rapidly rewarming them. Similarly, Halmagyi et al. [47] tested two rapid cryopreservation techniques—droplet-vitrification and encapsulation–dehydration—on three *R.* × *hybrida* cultivars ('Ioana', 'Mariana', 'Vulcan'), yielding high regeneration rates. Overall, advancements in new cryopreservation protocols, such as droplet-vitrification, are expected to facilitate the conservation of an increasing number of horticultural crops [48].

With the conducted SWOT analysis, it was shown that strengths and opportunities outweigh weaknesses and threats, accounting for some specificities. Similar to our study, a very diverse collection of plants and location proved to be major strengths in the Bogor Botanical Garden (Indonesia), but support needs to be invested towards the visit increment [49], which we also envisaged as a possible threat if overseen. According to the same authors, future efforts should encompass thorough plant maintenance, enhancement of attractions, improvement of amenities, and the integration of technology to ensure an engaging and memorable experience for visitors.

Rosarium as a gene bank (biodiversity and environment preservation), living lab (research and education), living catalog (marketing and economic purposes), and green area (active and passive recreation) complements city green infrastructure and bonds crucial stakeholders on the principles of the 'quadri-helix' model, where academia, society, and the private sector act together upon biodiversity and nature improvement.

5. Conclusions

The proposed rosarium design within the available confined area and very limited number of accessions is only a first attempt to raise public awareness towards possibilities that ornamental species can provide. This is a unique place and cultivar assembly that, in one place, gives insight into inseparable environmental, societal, and economic roles traditionally regarded as mutually exclusive. With raised knowledge regarding ecosystem services and added values that proposed genotypes and rosary as a total carry, society and economy can advance as well. The envisioned germplasm would include edible, disease-tolerant, winter-hardy, wildlife-attractive, biochemically active compounds, and oil-rich, sense-provoking roses with high ornamental and landscaping utilization possibilities. Aligning with global trends respecting the sustainability issues in the pertinent study, we recommend the following types of roses for the rosarium establishment as a case study and example for larger projects of global relevance: old varieties, wild relatives, fragrant and edible, tolerant to pests, diseases, and temperature fluctuations, abundant in color, nectar, pollen, shapes, and sizes.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/jzbg5040040/s1, Figure S1: Conceptual solution for the first rosarium in Serbia. Figure S2: 3D conceptual solution for the first rosarium in Serbia.

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