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BIODIVERSITY, HUMAN HEALTH AND WELL-BEING: NATURE-BASED SOLUTIONS IN THE CONTEXT OF THE EUROPEAN GREEN DEAL

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Summary: This article investigates the interconnections between biodiversity, human health, and well-being as the foundation for harmonious coexistence between humans and nature. The study aims to substantiate the role of biodiversity in enhancing physical, mental, and social health and to develop practical approaches for creating nature-oriented environments that promote societal well-being. The research involved an analysis of contemporary scientific approaches and the identification of effective strategies for developing garden-based apitherapeutic spaces that integrate aesthetic, ecological, and wellness functions. The findings indicate that combining nature-oriented solutions with social engagement can strengthen ecological stability, support health restoration, increase environmental awareness, and foster harmonious environments. The practical implementation of these approaches is relevant for the development of green public spaces, wellness tourism, and the rehabilitation of territories, contributing to the sustainable well-being of society.

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Abstract: The study is framed within the concepts of One Health and the European Green Deal. It emphasizes that biodiversity conservation is a key factor in maintaining physical, mental, and social well-being, while natural ecosystems underpin ecological resilience, recreational potential, and disease prevention. The research methodology combined analytical, systemic, and structural-functional approaches, allowing for the synthesis of scientific data (2020–2025) and the development of practical strategies for enhancing biodiversity in garden-based apitherapeutic environments. An integrative model of such spaces is proposed, highlighting their multifunctional role in providing aesthetic, ecological, and wellness benefits. Seven key strategies for biodiversity-friendly garden design were identified: use of native plant species; creation of spatially diverse habitats; minimization of intensive interventions; maintenance of soil biodiversity; incorporation of water features and shelters; promotion of ecological connectivity; and continuous monitoring and adaptive management. These strategies support ecosystem resilience, increase pollinator productivity, reduce psycho-emotional stress on humans, and foster harmonious natural environments. The practical application of garden-based apitherapeutic spaces within wellness tourism is

highlighted as a component of green community infrastructure. Tools such as the Garden Biodiversity Index and citizen science platforms (iNaturalist, eBird, PollinatorWatch, Global Pollinator Watch) are emphasized for enhancing environmental awareness and improving ecological management. The results demonstrate that implementing such spaces represents an innovative approach to green recovery, combining ecological security, social integration, and the therapeutic effects of nature. Biodiversity is presented not merely as a natural resource but as a source of health, harmony, and sustainable development for individuals and society.

Ключові слова: *biodiversity, human health and well-being, nature-oriented solutions, garden-based apitherapeutic spaces, One Health, European Green Deal, citizen science.*

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Тип статті – оригінальна наукова стаття

ЗДОРОВ'Я І ДОБРОБУТ ЛЮДИНИ: ПРИРОДООРІЄНТОВАНІ РІШЕННЯ В КОНТЕКСТІ EUROPEAN GREEN DEAL

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Резюме: У статті розглянуто вплив змін у землекористуванні та кліматичних чинників на стан кормової бази бджільництва в Україні та Європі. Показано, що вирубування лісів і розширення урбанізованих територій за стабільної частки сільськогосподарських угідь призводить до зниження різноманіття медоносної флори та сезонного дефіциту нектару й пилку. Європейська модель землекористування поступово переходить до сталого управління, де відновлення лісів і напівприродних угідь сприяє безперервності цвітіння та стабільності популяцій запилювачів. В Україні переважає аграрно-домінантна структура землекористування з низьким рівнем лісистості, що зумовлює короткі періоди медозбору, фрагментацію природних оселищ і підвищений ризик кормового дефіциту для бджіл. Доведено, що ландшафтна мозаїчність, наявність квіткових елементів у агроландшафтах і впровадження природоорієнтованих рішень (полезахисні смуги, квіткові буферні зони, агролісомеліорація) підвищують стійкість кормової бази та адаптаційні можливості бджільництва до змін клімату. Гармонізація земельної політики України з підходами Європейського Союзу в межах Common Agricultural Policy, Pollinator Initiative та European Green Deal сприятиме створенню збалансованих агроландшафтів, які забезпечуватимуть продуктивність агровиробництва, збереження запилювачів і екологічну стійкість довкілля.

Анотація: У статті розглянуто взаємозв'язки між біорізноманіттям, здоров'ям і добробутом людини в контексті реалізації концепції «Єдине здоров'я» (One Health) та Європейського зеленого курсу (European Green Deal). Обґрунтовано, що

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збереження біорізноманіття є ключовим чинником підтримання фізичного, психічного та соціального благополуччя, а природні екосистеми – основою екологічної стійкості, рекреаційного потенціалу та профілактики захворювань. Метою дослідження було наукове обґрунтування ролі біорізноманіття як чинника добробуту людини та визначення природоорієнтованих рішень, що сприяють реалізації стратегічних цілей ЄЗК у сфері сталого розвитку. Методологія дослідження поєднувала аналітичний, системний і структурно-функціональний підходи, що дозволило узагальнити сучасні наукові дані (2020–2025 рр.) та розробити комплекс практичних стратегій підвищення біорізноманіття в умовах садово-бджолотерапевтичних просторів. Запропоновано інтеграційну модель таких просторів як ефективних природоорієнтованих екосистем, що поєднують естетичну, екологічну й оздоровчу функції. У межах дослідження визначено сім ключових стратегій формування біорізноманітних садів: використання місцевих видів рослин; створення просторової мозаїки середовищ; мінімізація інтенсивного втручання; підтримання ґрунтового біорізноманіття; забезпечення водних елементів та укриттів; підтримка екологічної зв'язності; постійний моніторинг і адаптивне управління. Встановлено, що такі підходи сприяють зростанню стійкості екосистем, підвищенню продуктивності запилювачів, зменшенню психоемоційного навантаження на людину й формуванню гармонійного природного середовища. Особливу увагу приділено практичним аспектам застосування садово-бджолотерапевтичних просторів у системі оздоровчого туризму, як складової зеленої інфраструктури громад. Наголошено на ролі інструментів самооцінки (Garden Biodiversity Index) і платформ громадянської науки (iNaturalist, eBird, PollinatorWatch, Global Pollinator Watch) у розвитку екологічної свідомості населення та підвищенні якості екологічного менеджменту. Отримані результати свідчать, що впровадження садово-бджолотерапевтичних просторів може стати інноваційним напрямом зеленого відновлення, який поєднує екологічну безпеку, соціальну інтеграцію й оздоровчий ефект природи. Біорізноманіття розглядається не лише як природний ресурс, а як джерело здоров'я, гармонії та сталого розвитку людини і суспільства.

Ключові слова: *біорізноманіття, здоров'я і добробут людини, природоорієнтовані рішення, садово-бджолотерапевтичні простори, One Health, Європейський зелений курс, citizen science.*

1. Introduction

In the context of increasing ecological, social, and climatic challenges, the relationship between biodiversity, human health, and well-being has become particularly relevant. Biodiversity underpins essential ecosystem services, ranging from air and water purification to microclimate regulation and support of human psycho-emotional health. According to the One Health concept (FAO, UNEP, WHO, WOAH, 2022), human, animal, and environmental health are interlinked components of a single system, and the preservation of natural ecosystems is a key condition for sustainable development. These principles align with the European Green Deal (2019), which emphasizes the integration of nature-based solutions across all sectors of society.

Contemporary research underscores the significance of nature and biodiversity for human health. Marselle et al. (2021) demonstrated that ecosystem diversity positively influences mental health, emotional regulation, stress levels, and social integration, with nature effects being multi-layered. Similarly, Robinson et al. (2024) highlighted that biodiversity impacts health through multiple interconnected mechanisms, including ecological buffering, promotion of physical activity, social interactions, cognitive processes, and modulation of the human microbiota.

Beyond psycho-emotional benefits, biodiversity also affects pollinator health, which is critical for ecosystem functioning and food security. Garibaldi et al. (2022) identified floral diversity as a determining factor in bee physiology, resilience, and productivity, supporting the rationale for garden-apitherapeutic spaces that provide sustainable forage for pollinators.

Recent studies of landscape ecosystems further confirm the relevance of nature-based solutions. Delahay et al. (2023) demonstrated that structural complexity and species richness in gardens increase faunal diversity even in urban environments, while De Vrieze et al. (2025) showed that converting lawns into flower meadows in healthcare facilities enhances biodiversity and improves environmental quality for humans. These findings indicate the potential of garden-apitherapeutic spaces as instruments of ecological and social transformation.

The social dimension of natural spaces is equally important. Egerer et al. (2024) emphasized that urban and community gardens function as socio-ecological hubs, combining naturalness, recreation, and community building. This aligns with Korpela et al. (2018), who demonstrated that natural environments support emotional restoration and foster a sense of harmony.

The synthesis of these studies highlights that biodiversity provides not only conservation value but also therapeutic, social, and economic functions. Therefore, the development of garden-apitherapeutic spaces as an integrated model of nature-oriented solutions represents a promising area of contemporary research, combining the principles of One Health, the strategic objectives of the European Green Deal, and trends in green infrastructure development.

The study aims to scientifically substantiate the role of biodiversity as a factor in human physical, mental, and social well-being and to identify nature-oriented solutions effective for creating garden-apitherapeutic spaces in line with contemporary European and global sustainable development policies.

To achieve the goal, it was necessary to solve the following tasks:

To analyze current scientific approaches and international policies addressing the relationships between biodiversity, human health, and the One Health concept in the context of the European Green Deal.

To examine nature-based solutions as effective tools for biodiversity conservation and enhancement of population well-being, particularly within recreational, garden, and agricultural landscapes.

To investigate the potential of garden-apitherapeutic spaces as models for integrating ecological, wellness, and social functions within nature-oriented territorial management.

To develop practical strategies for enhancing biodiversity in garden-apitherapeutic spaces, aligned with the European Green Deal and the EU Biodiversity Strategy for 2030.

To formulate recommendations for implementing environmentally oriented approaches to the design, management, and monitoring of garden-apitherapeutic spaces as components of green infrastructure and sustainable community development.

2. Materials and Methods

The methodological basis of the study was the integration of interdisciplinary approaches combining ecological, social, and health dimensions of sustainable development. The research employed analytical, comparative, systemic, and structural-functional methods, which enabled the generalization of empirical data, identification of patterns, and determination of strategic directions for the formation of biodiverse garden–apitherapeutic ecosystems.

At the first stage, a systematic analytical review of contemporary scientific literature for the period 2020–2025 was conducted, covering 118 full-text sources. Literature selection was based on the keywords: biodiversity, One Health, nature-based solutions, therapeutic gardens, pollinator health, green infrastructure, human well-being in international databases such as Scopus, Web of Science, PubMed, ScienceDirect, SpringerLink, Wiley Online Library, and Google Scholar, as well as in normative and analytical materials from international organizations (UNEP, FAO, WHO, CBD, European Commission).

The subsequent stage of the study involved systemic, comparative, and structural-functional analyses, which allowed for the identification of ecological, therapeutic, and social components of garden–apitherapeutic ecosystems. Scientifically grounded approaches were evaluated for the formation of mosaic garden structures, maintenance of soil biodiversity, ecological connectivity, and minimization of anthropogenic impact.

To analyze modern biodiversity monitoring tools, the potential of platforms such as the Garden Biodiversity Index (2025), iNaturalist, Global Pollinator Watch, eBird, and PollinatorWatch—widely used in citizen science programs—was examined.

Based on the integration of empirical and theoretical data, an integrated model for enhancing biodiversity in garden–apitherapeutic spaces was developed, relying on Nature-Based Solutions principles and evidence-based design approaches. The methodological foundation of the model included content analysis of strategic documents such as the European Green Deal, the EU Biodiversity Strategy for 2030, and the One Health Joint Plan of Action, alongside a comparative review of international studies (De Vrieze et al., 2025; Delahay et al., 2023; Staude et al., 2024; Munschek et al., 2023).

The obtained data allowed for the formulation of a set of strategic measures aimed at creating mosaic environments, utilizing native plant species, maintaining soil microbiota, establishing water features, ensuring ecological connectivity, and implementing adaptive management. The results were synthesized from the perspective of nature-based management in accordance with the European Green Deal, the EU Biodiversity Strategy for 2030, and the Sustainable Development Goals (SDGs 3, 13, 15). This approach ensured the comprehensiveness of the study, integrating scientific evidence, bibliometric tools, digital monitoring systems, and ecological modeling into a unified methodological framework.

3. Results

Enhancing biodiversity in garden–apitherapeutic spaces is considered one of the most effective nature-based solutions, capable of simultaneously strengthening ecological resilience, promoting human health, and advancing the objectives of the European Green Deal. These spaces integrate recreational, ecological, and therapeutic functions, acting as nodes within local ecological networks that maintain spatial connectivity of natural ecosystems at both urban and regional scales.

Analysis of recent scientific literature indicates that garden–apitherapeutic ecosystems are promising models for integrating the principles of *One Health*, as they combine biodiversity conservation with stress prevention, enhancement of psycho-emotional well-being, and the promotion of environmental awareness among the population. In this context, biodiversity plays a dual role: it both ensures ecosystem stability and enhances the therapeutic effects of human interaction with nature.

Specifically, plant diversity provides a complete forage base for bees, supporting their resilience, immune activity, and colony productivity. Contemporary studies have demonstrated a direct relationship between floral diversity and the physiological condition of pollinators (Garibaldi et al., 2022). Simultaneously, the presence of diverse insect, bird, and flowering plant species positively affects human psychological well-being, as observations show that increased visual and acoustic environmental diversity reduces stress levels and enhances the sense of harmony with nature. Thus, designing therapeutic gardens according to biodiversity principles creates a synergy between human health, pollinator welfare, and ecological stability of the area (De Vrieze et al., 2025).

The study synthesized a system of strategies derived from the analysis of recent scientific publications, which demonstrate the effectiveness of nature-based approaches for conserving and restoring biodiversity in garden and apitherapeutic contexts. Implementing these strategies supports the harmonious integration of aesthetic, ecological, and therapeutic functions in garden ecosystems, providing a foundation for green infrastructure development, ecotourism, and the practical realization of European Green Deal objectives in Ukraine. Such strategies include the use of local (endemic) plant species; creation of complex spatial structures and habitat mosaics; minimization of intensive interventions; maintenance of soil biodiversity; provision of water sources, shelters, and refuges; support for connectivity with surrounding green areas; and continuous monitoring and adaptive management (Table 1).

Table 1. Key strategies for enhancing biodiversity in garden–apitherapeutic spaces

Strategy	Examples of implementation	Expected effect
Use of native plants	Trees and shrubs adapted to the local climate	Increasing survival, minimizing care, supporting local fauna
Creating flower meadows	Micro-meadows, nectariferous islands	Increasing the number of pollinators, improving soil structure
Mosaic landscape	Shade areas, open areas, bodies of water	Supporting different ecological niches
Organic care	Refusal of agrochemicals, use of mulch, compost	Preservation of soil microbiota, environmental safety
Infrastructure for pollinators	Insect houses, stumps, dead wood	Increase in the number of bees and entomofauna
Digital Monitoring	iNaturalist, eBird, Garden Biodiversity Index	Assessment of ecological changes in dynamics
Social interactions	Therapeutic groups, workshops, eco-trails	Increasing community involvement, forming an ecological culture

Implementation of these principles promotes not only the ecological resilience of garden ecosystems but also the creation of environments with high therapeutic potential, which positively affect human psycho-emotional well-being, support the vitality of honeybee colonies, and serve as natural indicators of environmental health.

Use of local (endemic) plant species – planting native crops supports natural trophic chains, provides a forage base for pollinators, birds, and other fauna, enhances ecological resilience, and reduces the need for additional irrigation or fertilization. This approach promotes the formation of balanced ecosystems in which interactions between flora and fauna ensure natural self-regulation and sustainable functioning of the garden biocenosis.

When designing a therapeutic garden with apitherapy elements, special attention should be given to the selection and composition of local (endemic) plants. Studies indicate that garden characteristics—particularly plant composition—can have a greater influence on pollinator diversity than the surrounding landscape. This implies that planning should consider not only the broader context but also careful selection of species and their placement within the garden. Applying this approach ensures more effective attraction of pollinators, strengthens ecosystem connectivity, enhances honeybee productivity, and, consequently, increases the therapeutic potential of the garden.

This emphasizes that careful design of plant composition and arrangements within a therapeutic garden is critical. Delahay et al. (2023) highlight that plant diversity and vegetation cover strongly correlate with the number of animal species visiting the garden—richer flora and denser vegetation create more attractive conditions for fauna. Therefore, in designing a therapeutic garden, it is advisable to select local species and aim for a dense, diverse, and multilayered vegetation canopy. This not only increases the likelihood of visitation by various species but also enhances the ecological potential of the site as part of a network of conservation areas.

Garden plants can not only maintain existing biodiversity but also actively contribute to its dispersal beyond the plot. According to Staude et al. (2024), garden agroecosystems can function as "dispersal stations" for species, facilitating natural plant migration into adjacent landscapes. Such spaces support the expansion of local species ranges, reduce interspecific competition, and maintain ecological balance in urbanized areas. Thus, when designing a therapeutic garden, it is important to consider its local ecological functions as well as its potential as a source of environmental renaturalization. Combining this approach with careful selection of native plant species and the creation of a multilayered vegetation structure (Delahay et al., 2023) allows the establishment of an environment that simultaneously supports local biodiversity and contributes to its restoration in a broader ecosystem context. Such a garden not only serves aesthetic and therapeutic purposes but also becomes an effective element of the area's green infrastructure.

Creation of complex spatial structures and habitat mosaics – involves designing garden spaces with multiple layers and types of microhabitats, providing a wide range of conditions for various groups of organisms. This structure includes combinations of trees, shrubs, herbaceous plants, flower meadows, natural clearings, as well as wet and dry areas, creating numerous ecological niches.

Multilayered and mosaic garden designs enhance ecological resilience, support the conservation of pollinators, birds, and small animals, and provide natural microclimatic regulation—reducing soil overheating, retaining moisture, and maintaining stable soil processes. Contemporary landscape ecology studies emphasize that a mosaic environmental structure is a key factor in increasing species diversity in urban and recreational areas (De Vrieze et al., 2025; Delahay et al., 2023).

Multilayered plant design – combining trees, shrubs, and herbaceous species – increases the number of ecological niches by providing varied conditions of light, moisture, and structure for fauna. According to Delahay et al. (2023), plant composition and vegetation cover positively correlate with the number of animal species visiting the garden: the more complex and denser the plant structure, the greater the opportunities for creating diverse microhabitats. Therefore, when designing a therapeutic garden, it is advisable to include tree, shrub, and herbaceous layers to maximize the number of living niches for insects, birds, small animals, and soil organisms.

Creation of diverse microhabitats – shaded corners, open sunny areas, moss patches, or sparsely vegetated zones – further enhances biodiversity. As Delahay et al. (2023) note, diversity of microhabitats provides more opportunities for different faunal groups to exploit the garden. Combining such microzones with a multilayered plant structure creates favorable conditions for colonization by insects, birds, small animals, and microorganisms, which improves ecosystem functions and strengthens the therapeutic effect of the garden.

Wang et al. (2024) emphasize the importance of functional diversity, ecological connectivity, and adaptive management – principles that can be directly applied to the planning and maintenance of therapeutic gardens. Functional diversity involves selecting plants with different ecological roles (e.g., root system types, flowering periods, height), ensuring ecosystem resilience to environmental changes. Ecological connectivity refers to linking the garden with surrounding green spaces to support organism migration and genetic exchange. Adaptive management implies a flexible approach to garden care, involving continuous monitoring, analysis of biodiversity dynamics, and adjustment of practices based on observed results.

Practical implementation of these principles in garden therapy and apitherapy may include selecting plants with diverse functional traits (e.g., early- and late-blooming, deep- and shallow-rooted), designing the garden as part of an ecological network with corridors or connections to adjacent natural areas, and systematic monitoring of flora and fauna with adaptive maintenance based on observation results. Applying these approaches transforms the garden from a passive "nature island" into an active element of green infrastructure with high ecological, recreational, and therapeutic potential.

Minimization of intensive intervention involves a set of ecologically oriented practices aimed at preserving the natural balance of the garden, reducing anthropogenic impacts on the biocenosis, and maintaining ecosystem health. This approach is based on principles of sustainable gardening, prioritizing natural regulatory processes, biocontrol, organic methods, and preservation of soil life.

The use of chemical pesticides and herbicides significantly reduces invertebrate populations, including pollinators, earthworms, and other soil organisms, disrupting trophic chains and ecosystem functioning. Munschek et al. (2023) report that excessive use of agrochemicals leads to biodiversity degradation even in small garden spaces. Therefore, preference should be given to natural pest control methods – biocontrol, compost preparations, companion planting, and polyculture systems that naturally limit the spread of pathogens and pests.

Organic mulching – with sawdust, bark, leaves, hay, or wood chips – supports soil microbiota, improves water retention, reduces erosion, and creates habitats for earthworms and saprophytic fungi. As noted by Gilmer et al. (2020), the use of organic mulches and natural fertilizers significantly enhances soil biodiversity, ensuring ecosystem stability without chemical growth stimulants.

Another effective approach is reducing mowing frequency and allowing areas of taller herbaceous vegetation. This creates habitats for pollinators, butterflies, and small animals. According to a UK national study reported by The Guardian (2024), allowing grass to grow nearly doubled butterfly abundance in gardens, enhancing forage availability and flower species diversity. This approach is not only aesthetically appealing but also ecologically justified, as it promotes the formation of natural microhabitats and stability of local fauna.

Minimization of intensive intervention involves creating a self-regulating garden environment where natural processes of recovery, symbiosis, and trophic interactions play a leading role. For therapeutic gardens and apitherapy areas, this approach has a dual significance: on one hand, it supports the health of bees and beneficial insects, and on the other, it preserves the natural harmony that fosters a sense of calm, balance, and positive psycho-emotional effects for visitors.

Maintaining soil biodiversity is fundamental to the ecological stability of the garden, as soil is a living medium where key biochemical processes occur, essential for plant growth, nutrient cycling, and ecosystem balance. Soil biodiversity includes a variety of bacteria, fungi, protozoa, arthropods, and earthworms, which collectively form a complex network of interactions.

According to Gilmer et al. (2020), the application of organic matter, such as compost, vermicompost, or plant residues, stimulates the development of microorganisms, earthworms, and mycorrhizal fungi. These organisms decompose organic matter, enrich the soil with nutrients, and improve its structural stability. In addition, organic amendments enhance water retention and reduce erosion, which is especially important for gardens located on slopes or sandy soils.

Applying compost or vermicompost not only enriches the soil with nutrients but also creates a favorable microenvironment for beneficial microorganisms that suppress pathogens, reducing the need for chemical plant protection. These natural processes create a “living soil” – a self-regulating system that supports plant resilience to diseases and environmental stresses.

Proper soil management is equally important. Gilmer et al. (2020) recommend mixing soil between plots, avoiding compaction (particularly during machinery use or irrigation), and maintaining optimal pH levels to ensure stable soil biocenoses. Excessive compaction or structural disruption reduces aeration and negatively affects soil organism activity.

In the context of therapeutic and apitherapy gardens, maintaining soil biodiversity has a dual value. Firstly, it ensures long-term fertility and plant viability, forming the basis of the garden’s healing environment. Secondly, biologically active soil produces phytoncides and natural aromatic compounds that enrich the air and enhance the therapeutic effect of garden visits. Maintaining soil biodiversity is therefore not only a component of ecological garden management but also an integral element of a restorative ecosystem that combines natural recovery, sustainable development, and human–nature harmony.

Provision of water sources, shelters, and refuges is another key component for maintaining ecological balance in therapeutic gardens. Such elements create favorable conditions for the survival, reproduction, and migration of various species of animals, insects, and microorganisms. Water and shelters act as microclimate stabilizers, providing moisture, shade, and protection from overheating or predation.

Creating small water bodies – such as ornamental ponds, rainwater collection areas, barrels, or wet “barriers” – encourages amphibians, aquatic insects, butterflies, and birds. Even small water sources serve as drinking and breeding sites, positively influencing trophic chains within the garden. In garden therapy systems, such water features not only enhance ecosystem functions but also provide psycho-emotional benefits, as water sounds, reflections, and movement promote relaxation and reduce stress levels.

Additionally, natural materials should be used as shelters – fallen trees, stumps, deadwood, branches, or logs with cavities. These create habitats for pollinators, small mammals, amphibians, fungi, and mosses, forming a complex ecological system. Such elements not only increase landscape naturalness but also enhance biodiversity by providing microhabitats with varying moisture and light conditions.

As noted by Munschek et al. (2023), artificial shelters for insects – such as bee hotels or insect boxes – can significantly increase the presence of specialized species, including wild bees and wasps, if properly designed and positioned according to species-specific requirements. Correct orientation of openings, choice of materials (bamboo, reeds, dry wood), and placement in sunny areas make these structures effective tools for supporting entomofauna.

In therapeutic and apitherapy gardens, such shelters and water bodies serve a dual function: they support the life cycles of pollinators and small animals, and they enrich the sensory environment, making the garden more attractive to

visitors. Observing living creatures, natural sounds, and water movement stimulates emotional recovery, reduces anxiety, and fosters harmonious human–nature interaction. The creation of water features, natural shelters, and specialized insect structures is thus both an ecologically sound practice and a therapeutic tool, combining ecological value with restorative effects on human psychophysiology.

Maintaining connectivity with surrounding green areas is a key principle of ecological planning, aimed at ensuring the movement, exchange, and interaction of organisms across different natural or semi-natural sites. Gardens integrated into broader ecological networks function as "green bridges" or "stepping stones" connecting fragmented habitats. Such connectivity enhances population viability, supports the migration of pollinators, birds, and small mammals, and maintains species genetic diversity.

Egerer et al. (2024) note that urban community gardens can serve as critical nodes in city green infrastructure, providing ecological connectivity between larger green spaces such as parks, forests, or riparian zones, and forming continuous habitat networks for organism movement. Even small green plots within dense urban areas are important "micro-biodiversity hubs" when designed with natural processes in mind.

For therapeutic and apitherapy gardens, ensuring ecological connectivity has both conservation and therapeutic significance. Such gardens create natural corridors for pollinators (bees, bumblebees, butterflies), small birds, and other organisms, supporting ecosystem stability and resilience to external pressures. Moreover, they foster a sense of spatial harmony and connectedness with nature in visitors, an important component of the garden's therapeutic effect.

A crucial condition for maintaining connectivity is coordinated planning with neighbors and local communities. Jointly designing garden boundaries, preserving natural passageways for small animals, using permeable fences, greening fences with ivy or climbing plants, and regulating artificial light levels help create a continuous natural space without barriers. This is particularly relevant for gardens adjacent to forest strips, riparian zones, or urban parks. Maintaining connectivity with surrounding green areas transforms a garden from an isolated ecosystem into an active element of the landscape ecological network, supporting species exchange, enhancing ecological resilience, and simultaneously increasing recreational and therapeutic value.

Continuous Monitoring and Adaptive Management is a key element of sustainable development in therapeutic and apitherapy gardens, ensuring ecological stability and long-term effectiveness. This approach involves continuous observation of biodiversity, analysis of collected data, and flexible adjustments to maintenance, structure, or species composition based on real outcomes. Unlike static systems, adaptively managed gardens can respond to changes in climate, the appearance of new species, or emerging ecological risks, remaining dynamic and living ecosystems.

Tools for self-assessment, such as the Garden Biodiversity Index (GBI) (Felgentreff et al., 2025), allow for quantitative measurement of ecosystem conditions, evaluation of changes in species composition, vegetation structure, or pollinator activity. Such approaches help identify weaknesses in garden planning and maintenance, pinpoint areas where biodiversity requires enhancement, and support evidence-based decision-making rather than relying solely on observation. This is particularly important for gardens that combine recreational, therapeutic, and ecological functions.

Equally important is public engagement through citizen science programs, including platforms like iNaturalist, Global Pollinator Watch, eBird, and PollinatorWatch, which allow for the recording of new plant, insect, or bird species. Citizen participation not only enriches the scientific database but also fosters environmental awareness, social cohesion, and responsibility for local ecosystems. In therapeutic and apitherapy gardens, such engagement can become part of the therapeutic experience itself, involving visitors in shared care for nature.

Adaptive management implies that every garden intervention should be based on monitoring results: which plants thrive best, which areas attract the most pollinators, where excess moisture accumulates, or where soil degradation occurs. Revising practices – such as mowing frequency, irrigation regimes, species composition, or flowerbed placement – helps maintain ecosystem balance. This can be seen as a form of "learning through observation," where the garden and its management evolve in response to natural signals.

Thus, combining scientific monitoring, public participation, and adaptive management creates a system in which the garden becomes not just a place for nature observation but a living laboratory of ecological interaction. This enhances ecosystem resilience, optimizes maintenance, and simultaneously strengthens therapeutic effects, as participation in observation and care has restorative and health-promoting benefits.

Several successful models in the European Union and neighboring countries already demonstrate the integration of green design, biodiversity, and therapeutic practices, showing measurable impacts on health, well-being, and ecosystem stability. One of the most renowned is the Nacadia Therapy Garden (Denmark, near Copenhagen), designed according to evidence-based design principles within the Nature, Health & Design Lab program. The garden combines mosaic natural patches, water features, forested areas, enclosed and open spaces, specifically designed for therapy and psychological rehabilitation. User studies revealed that participants with severe stress disorders experienced reduced anxiety, improved psychological state, and overall well-being after a 10-week stay (Sidenius, 2017).

Another example is the Maggie's Centres network in the United Kingdom. Gardens at Maggie's Centres are designed as supportive spaces for patients in oncology facilities, featuring perennials, trees, aromatic and ornamental plants, open terraces, courtyards, and microzones with different functional purposes. Such spatial organization creates an

environment conducive to stress reduction, emotional improvement, and calm restoration during treatment (Maggie's, n.d.).

At a national scale, Green Care Finland illustrates how a country can implement nature-based, therapeutic, and social service approaches. Green Care Finland ry provides nature- and animal-oriented methods for medical rehabilitation and preventive health promotion, engaging various age and social groups in landscaping, therapy, and support through nature (Green Care Finland ry, n.d.).

These examples demonstrate that therapeutic garden spaces can be integrated into both medical and socio-community contexts, combining aesthetics, ecology, and restorative functions.

4. Discussion

The obtained results confirm that therapeutic and apitherapy garden spaces represent a promising model of nature-based solutions, simultaneously ensuring ecological sustainability, supporting pollinators, and promoting human psycho-emotional recovery. The established patterns regarding the role of floristic diversity, spatial mosaicism, and functional diversity indicate that the complexity of garden ecosystems significantly enhances their resilience and restorative potential. These observations align with global trends in the development of Nature-Based Solutions, emphasizing the relevance and scientific validity of our findings.

The identified role of multi-layered garden structure and the use of autochthonous plants directly corresponds with the results of Delahay et al. (2023), who demonstrated that species composition and vegetation density determine the level of faunal diversity in private and public gardens. Accordingly, our results confirm that increasing the structural complexity of a garden creates conditions for stable trophic interactions and supports numerous organism groups. A similar pattern is described by Staude et al. (2024), noting that garden spaces can act as hubs for the dispersal of local plant species and strengthen the ecological connectivity of landscapes. This correlates with our conclusions on the importance of positioning therapeutic and apitherapy garden spaces as part of broader ecological networks.

Equally significant is the confirmed role of flower and structural diversity in supporting pollinator populations. Our findings are consistent with the conclusions of Garibaldi et al. (2022), who showed that plant diversity directly influences the physiological condition and ecosystem functionality of both honeybees and wild bees. Thus, the proposed model of therapeutic and apitherapy garden spaces not only enhances the recreational component but also plays a critical role in pollinator conservation, which is essential for ecosystems and food security.

Our results regarding the minimization of anthropogenic intervention also confirm the findings of other researchers. In particular, our data align with Gilmer et al. (2020), who demonstrated the necessity of maintaining soil microbiota through organic practices, and with Munschek et al. (2023), who showed the negative impact of agrochemicals on biodiversity even in small plots. Therefore, nature-oriented garden management that reduces human interference and employs organic approaches is not only ecologically justified but also supported by contemporary scientific evidence.

Summarizing the results, it is important to note that our model aligns with modern approaches to green urban planning, as defined in the studies by Egerer et al. (2024). These authors emphasize the social significance of urban and community gardens as elements of green infrastructure, enhancing local ecological networks and promoting community engagement in environmental practices. This fully corresponds with our approach, in which therapeutic and apitherapy garden spaces are considered not only as natural but also as social structures, capable of integrating environmental restoration, human health improvement, and intra-community interaction.

An important component of our findings is the role of adaptive management and modern digital biodiversity monitoring tools. The use of the Garden Biodiversity Index (Felgentreff et al., 2025) and citizen science platforms, such as iNaturalist, eBird, and Global Pollinator Watch, allows garden maintenance to become an interactive, scientifically oriented process that integrates local observations into global research networks. This not only provides a reliable basis for decision-making but also fosters environmental literacy, which is critical for the sustainable development of communities.

The alignment of our findings with other scientific data allows for the outlining of expected social, ecological, and economic effects of implementing therapeutic and apitherapy garden spaces. The social effect involves strengthening the psycho-emotional health of the population, reducing stress levels, and enhancing social cohesion, consistent with the studies by Marselle (2019) and Korpela et al. (2018). The ecological effect consists of restoring ecosystem connectivity, improving pollinator population status, and creating fauna- and flora-rich environments, corresponding with the conclusions of De Vrieze et al. (2025). The economic effect involves reducing maintenance costs of green spaces through the use of autochthonous species and ecological practices, as well as developing the health and ecotourism potential of the territories.

Thus, the results of our study consistently align with international scientific trends and confirm that therapeutic and apitherapy garden spaces can serve as an effective model of green restoration, capable of integrating ecological functionality, social benefits, and economic efficiency.

5. Conclusions

Biodiversity is a key factor for human physical, mental, and social well-being, and its conservation forms the basis for implementing the One Health concept and the objectives of the European Green Deal. Based on the conducted research, therapeutic and apitherapy garden spaces are proposed as an innovative type of nature-based ecosystem that combines ecological sustainability with high therapeutic potential. Such spaces create conditions for stress reduction, psycho-emotional restoration, immune balance support, and the development of human–nature social interactions. Their design is based on Nature-Based Solutions (NBS), promoting a harmonious integration of aesthetic, ecological, and restorative functions. The use of local plant species, the creation of mosaic environmental structures, the maintenance of soil biodiversity, and the establishment of water elements and ecological corridors have been shown to enhance ecosystem stability and their therapeutic value.

The proposed therapeutic and apitherapy garden spaces can serve as hubs of local ecological networks, support pollinator conservation, and foster environmental awareness among the population. The development of such spaces aligns with the EU Biodiversity Strategy for 2030 and the United Nations Sustainable Development Goals (SDGs 3, 13, 15), combining benefits for the environment, the economy, and public health. The implementation of adaptive management and environmental monitoring systems ensures increased efficiency of conservation measures and engages the public in nature protection.

Thus, therapeutic and apitherapy garden spaces are proposed as a new model of green restoration, integrating ecological, recreational, and therapeutic aspects of territorial development. In this context, biodiversity is considered not only as a natural resource but also as a source of health, harmony, and sustainable human well-being.

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