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# SENSORY GARDENS AS A NEW FORM OF URBAN GREEN SPACE IN SMART SUSTAINABLE CITIES

## OGRODY SENSORYCZNE JAKO NOWE FORMY ZIELENI MIEJSKIEJ W INTELIGENTNYCH, ZRÓWNOWAŻONYCH MIASTACH

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### Abstract

Sensory gardens have been known since antiquity, but they are becoming more and more important in terms of smart city development. The article presents a literature review on the diverse functions of sensory gardens, the concept of a smart and green city, and the sensory garden as a new form of urban green spaces (UGS). The aim of the research was to identify expectations regarding the development of modern gardens in urban spaces, in the context of a smart city. The primary data collection method was social surveys on the expectations regarding the development of parks and city gardens, carried out among the inhabitants of Poland and Russia. The studied sample had a total of 230 people. The research was conducted in January 2021 using an internet survey. The questions were both open and closed, and related to issues such as: (1) the most important features of gardens and city parks; (2) the definition of a sensory garden; (3) the main functions that gardens and city parks should fulfil in the future. The results of the conducted research confirmed the adopted hypothesis that sensory gardens as green enclaves with different functions constitute new, prospective forms of development of urban green spaces in smart sustainable cities. The social needs for urban green spaces are clear and reflect current environmental problems regarding the quality of atmospheric air and access to green spaces in the vicinity. The respondents agree that the most important features of gardens and parks include fresh air and the possibility of resting.

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**Keywords:** green city, sustainable city, smart city, urban areas, sensory gardens; smart green city, smart green integration, and smart gardens.

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### Streszczenie

Ogrody sensoryczne znane są już od starożytności, jednak z punktu widzenia rozwoju inteligentnych miast (*smart city*) zyskują obecnie coraz większe znaczenie. W artykule dokonano przeglądu literatury dotyczącej zróżnicowanych funkcji ogrodów sensorycznych, koncepcji inteligentnego i zielonego miasta oraz ogrodu sensorycznego jako nowej formy miejskiej zieleni (UGS). Celem badań była identyfikacja oczekiwań dotyczących rozwoju nowoczesnych ogrodów w przestrzeni miejskiej w kontekście *smart city*. Podstawową metodą gromadzenia danych były sondaże społeczne przeprowadzone wśród mieszkańców Polski i Rosji na temat ich oczekiwań odnoszących się do rozwoju parków i ogrodów miejskich. Badana próba liczyła łącznie 230 osób. Badania przeprowadzono w styczniu 2021 r. za pomocą ankiety internetowej. Pytania były zarówno otwarte, jak i zamknięte i dotyczyły takich zagadnień, jak: (1) najistotniejsze cechy ogrodów i parków miejskich z punktu widzenia ich użytkowników; (2) definiowanie pojęcia ogrodu sensorycznego; (3) główne funkcje ogrodów i parków miejskich w przyszłości. Wyniki badań potwierdziły przyjętą hipotezę, że ogrody sensoryczne jako enklawy zieleni o różnych funkcjach są nowymi, perspektywicznymi formami rozwoju zieleni miejskiej w inteligentnych, zrównoważonych miastach. Zidentyfikowane potrzeby społeczne dotyczące zieleni miejskiej odzwierciedlają aktualne problemy środowiskowe tj. jakość powietrza atmosferycznego oraz dostęp do terenów zielonych w sąsiedztwie miejsca zamieszkania. Respondenci zgodnie twierdzili, że najważniejsze dla nich cechy ogrodów i parków miejskich to „świeże powietrze” i możliwość wypoczynku wśród zieleni.

**Słowa kluczowe:** zielone miasto, zrównoważone miasto, inteligentne miasto (*smart city*), ogrody sensoryczne, zielone inteligentne miasto, zielona inteligentna integracja, inteligentne ogrody.

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## INTRODUCTION

The concept of a *smart city* started to develop in the 20th century, and has been present today in more than 600–700 projects around the world (Colldahl et al., 2013; Zhang et al., 2021). Owing to statistics we can forecast the development of this social trend in the future, taking into account the movement of the world population, from rural to urban areas (Qin, 2014). The concentration of large numbers of people in one city highlights the problem of a comfortable, yet ecologically friendly, city lifestyle (Cameron et al., 2012). This objective is multidisciplinary, and integrated in engineering and IT solutions, ecology and landscaping, urban health, social spheres and Lifelong Learning (LLL) education.

Many researchers in the world, from multidisciplinary fields, investigate this topic and reach the same conclusions. Artmann, Inostroza, and Fan, in their re-

search, have stated that “...while urban systems are expanding at very fast rates all over the world, understanding their spatial development remains a complex and controversial issue, burdened with confusion in the literature. The physical growth of cities assumes different spatial patterns, usually in the form of urban sprawl, resulting from multi-dimensional drivers and causing multi-dimensional economic, social and ecological impacts” (Artmann et al., 2019, p. 3). In another article, by the same research group, the following ideas are presented: “However, in compact cities, it has been shown that a low proportion of green spaces jeopardises the efficient supply of urban ecosystem services. This suggests that there remains a deficiency in clear visions for operating compact and green cities” (Artmann et al., 2019, p. 10).

The topic of the new form of urban green spaces in smart sustainable cities is very up to date. For example, Wu et al. (2019) in their research noted that urban green spaces play a range of significant roles and have a positive influence on the quality of life in cities. To achieve this greener future (*Green Destinations Standard*, 2021), the government has developed a series of policies to improve urban greening coverage. “Because cities develop on many levels, at different rates and with different characteristics, it is difficult to point to one universal concept of a sustainable city. There are many approaches to this issue in the literature. Their review indicates some common features: effective and economical use of environmental resources and broadly defined limitation and inhibition of undesirable human activities” (Dembicka-Niemiec, 2021, p. 195). “Knowledge of the dynamics of urban green spaces in the city can assist in fostering an appropriate balance between urban development and environmental protection” (Wu et al., 2019, p. 1). Gonçalves, Castro Ribeiro, Maia, Nunes, Feliciano wrote, in their article, “... a growing part of the global population lives in cities, green spaces are an essential asset for improving the quality of life” (Gonçalves et al., 2019, p. 1).

This conclusion is particularly important today, in the context of the observed demographic changes, including the increase in the urban population, the ageing of the society, the increase in the number of people with disabilities, as well as the conditions limiting trips outside the city, e.g., as a result of the pandemic (Zajadacz, 2021). These changes indicate that urban green spaces in cities (in the vicinity of the place of residence) will be increasingly important for maintaining sustainable social and natural development. We formulate the hypothesis of our current research: sensory gardens as green enclaves with different functions constitute new, prospective forms of development of urban green spaces in smart sustainable cities.

## LITERATURE REVIEW

### Smart and green city

The study is based on the bibliography method. The keywords used are the following: smart city, green city, sustainable city, smart green city, smart green integration, and smart gardens.

Owing to the results of scientific publications analyses in the international citation database, Scopus, we can conclude that scientific interest in the topics of smart cities and sustainable (green) cities has been constantly growing over the last four years (Table 1).

**Table 1.** Statistics of publications in Scopus in the research field in key words between 2016–2021 (No. and % of publications)

Term	2016		2017		2018		2019		2020		2021	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Modern concepts of city development												
Smart city	1.286	3.671	186	4.167	13.5	5.118	22.8	4.318	-15.6	3.857	-10.6	
Sustainable city	471	647	37	776	19.9	1.155	48.8	1.267	9.7	1.446	14.1	
Green city	205	281	37	350	24.6	417	19.1	412	-1.2	543	31.8	
Smart sustainable city	114	238	109	264	10.9	479	81.4	440	-8.1	441	2.3	
Smart green city	68	130	91	122	-6.2	175	43.4	116	-33.7	104	-10.3	
Green city infrastructure												
Smart park	17	17	0.0	13	-23.5	33	154	25	-24.2	32	28	
Sensory garden	5	2	-60.0	4	100	5	25.0	3	-40.0	9	300	
Smart garden	3	6	100	4	-33.3	2	-50.0	6	200	6	0	

Source: developed by Vukovic from [www.scopus.com](http://www.scopus.com) (January 25, 2022).

Green economy and sustainable urbanism are parts of sustainable development (Georgesonet al., 2017). The alternate concept of a smart city is closely connected with the concept of Industry 4.0 (Lomet al., 2016). But these two concepts integrate into the idea of a smart sustainable city and smart green city (Sodhroet al., 2019).

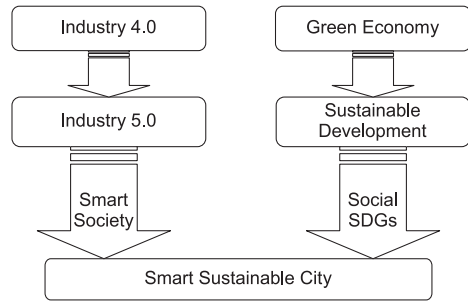
As can be observed from the research results in Table 1, these two concepts have positive trends in a number of publications during the last four years, more than 10% every year without 2020 (the pandemic year). Furthermore, the concept of a smart city evolves into a smart sustainable city, because in a number of publications about a sustainable city between 2016–2020 more than 10% of smart city research was connected with a smart sustainable city. It can be seen that the publication coverage about a smart city, connected with a smart park, is still very

limited and amounts to less than 1.5%, but it has a long-term growing tendency. The trend for multifunctional city zones has started to develop all over the world (Hassan, Lee, 2015) and is connected with resource integration and is multidisciplinary in new urban projects.

Green zones have always been very popular and attractive for urban populations. Today, they have started to be implemented in cities, not only in classic but also in new forms, such as LLL education and cultural zones (Luzet al., 2019), the main reason being two main global trends, digitalisation and sustainable development. The case is presented in Figure 1.

The use of smart city infrastructure (Internet and social networks) for sustainable development can be proved by Roberts, Sadler, and Chapman who notice that “interactions between humans and nature are understood to be beneficial for human well-being” (Roberts, et al., 2019, p. 1). The same conclusion can be found in the research of Lim et al., who state that “green spaces are believed to enhance the well-being of residents in urban areas” (Limet al., 2019, p. 1).

The current situation with the Covid-19 pandemic gave a new impulse to multidisciplinary research of sensory gardens all over the world. In their latest manuscript, Souter-Brown et al. (2021) state that “a sensory garden effectively reduces stress, enhances wellbeing and improves productivity of ‘apparently well’ people in the workplace. Future wellbeing initiatives should explore opportunities for nature connection in their settings”. Krzeptowska-Moszkowicz et al. (2021) in their last publication point out that “public gardens with sensory features located in Krakow (Poland) have significant deficiencies, which make it impossible to fully exploit the potential of the sensory space”. Castro et al. (2020) in their research on sensory gardens notice that “...we interpret the fragrances of such private gardens as performances of power that gave presence to the hidden sites where elite Chilean networks were forged, and thus served as ephemeral signals of social exclusivity”.



**Fig. 1.** Influence of Industry 5.0 and sustainable development on the future city

Source: author (Vukovic).

### Sensory gardens as a new form of urban green space (UGS)

Under the influence of global digitalisation and sustainable development trends, the world is searching for new forms of urban green spaces. Ramaiah and Avtar state that “...some major downsides of urbanization are overcrowding and en-

vironmental degradation. In order to realize sustainable and environmentally friendly urbanization, there is an urgent need for comprehensive land use planning and of urban settlements by giving due consideration to create and sustain urban green spaces (UGS) such as parks, gardens, roadside vegetation, etc. UGS play a vital role in reducing air pollution, mitigating climate change, and providing various ecosystem services” (Ramaiah, Avtar, 2019, p. 1).

In 2019, the authors implemented the survey on the smart city concept in Saint-Petersburg, and a sizable part of the participants pointed out that for them the concept of smart city should be implemented concurrently with the concept of a sustainable or green city: “28% of interviewed residents said about importance of green zones in the city” (Vukovic, 2019, p. 5). The same results were obtained during the survey conducted in 2020 in Moscow and Saint-Petersburg (Markovic at al., 2021). A sensory garden is a new multidisciplinary direction in urban design. It includes elements from landscaping, art, digital entertainment, pedagogy, medicine, and social networking. In the increasingly urbanised world, humanity must go green as its huge and overpopulated cities suffer from a lack of closeness to nature. Sensory gardens are designed to meet these needs of the modern person, according to the multi-practical meaning of human contact with nature presented by Fetell Lee (Fetell Lee, 2018).

### **An outline of the evolution of the sensory garden concept**

The history of sensory gardens dates back to ancient times. This period is characterised by mono-oriented sensory gardens: tactile, gustatory, sound (Marchukova, 2003). It was believed that nature had healing properties, the elements of which, i.e., plants, sunlight, water, sand, birdsong, animals, and many other components were used as therapeutic additions to the traditional method of treatment. Throughout the development of mankind, cognition of space was a process of direct contact with the environment in order to gain sensory experience. Thus, in the ancient world, the art of healing included knowledge about the primary elements of nature. This doctrine was popular among natural philosophers of ancient India, Greece, and Rome. The washing in a river was part of a sacred ritual later adopted by the Arabs and Europeans.

The myths and ancient medical texts of many nations tell us about the treatment with music. The healing effect of the ‘true’ music of the ancients is reflected in the writings of ancient Chinese philosophers and doctors. In ancient Egypt, animals and plants were often called upon to help people for therapeutic purposes. The cult of a healthy lifestyle and a harmoniously developed person also affected the cultural side of human life.

The second wave of development of sensory gardens followed World War II, when they were actively used for the rehabilitation of people with disabilities and

hospital patients. Great Britain and the USA were the leaders in this process. For instance, Roger Barker from Stanford University made a valuable contribution researching the use of sensory gardens in the rehabilitation of visually impaired people (Barker, 1968). It should be noted that in Europe and the United States, this research trend has not lost its relevance in the 21st century (Furness, Moriarty, 2006; Hussein, 2010b; Porayska-Pomsta et al., 2012). At the end of the 20th century, a new healing trend appeared in the use of sensory gardens for the rehabilitation of older people (Borgen, Guldahl, 2011). This trend has its followers and is successfully implemented all over the world.

The third wave of development of sensory gardens brought the wider use of polysensory gardens for all categories of citizens to prevent stress and develop ecological culture in the 21st century cities (Midden, Chambers, 2000; Malone, Tranter, 2003; Hornecker, Bruns, 2004; Hussein, 2012). Many scientists (Matovnikov, Matovnikova, 2011; Sikorskaya, 2013; Yarygina, Dovganyuk, 2016), are productively researching the issues of sensory gardens in a polysensory context. In our opinion, this new and promising direction of the development of sensory gardens offers a solution to a set of complex problems focusing on the needs of mass groups of the urban population. "Based on the previous data, sensory gardens are a good possibility from both sides: they improve ecological standards in the society and they are profitable in the long run" (Vukovic et al., 2017, p. 9).

In view of growing urbanisation, one of the primary tasks of modern landscape architecture is to preserve and organise as many new natural zones and complexes as possible within the urban space. The sensory garden is a new and rapidly evolving approach to the concept of horticulture and urban greening. It is a specially organised natural area, where favourable conditions have been created for close communication with the natural environment. Sensory gardens aim at stimulating the human senses, which will allow improving the condition of people, both the healthy and the disabled through the interaction with the landscape elements of the garden.

Hussein's observations (2010a) are of particular value here, as she recommends "to integrate green areas that will allow an enhanced sensory experience, which will make for a more sustainable and inclusive approach rather than making 'special' provision for disabled people" (Hussein, 2010a, p. 117). She draws attention to cooperation with landscape architects who can plan a universal space with clearly defined zones.

### **Modern functions of sensory gardens**

Sensory gardens can therefore be seen as places with many different functions. Visiting the garden will assist in stress recovery and provide a visitor with a feeling of satisfaction and security. It also facilitates social interaction and improves

the quality of life (Diamant, Waterhouse, 2010; Adevi, Mårtensson, 2013), for people with mental health (Clatworthy et al., 2013) and neurological (Söderback et al., 2004) difficulties. The purposeful design stimulating the senses creates a place endowed with special properties. These places have already proved their importance on many occasions, for instance in dementia care (Ory Hernandez, 2007; Gonzalez, Kirkevold, 2014, 2015;), healthcare (Reeve et al., 2017; Azlina et al., 2019), and special education (Hussein, 2009). It is quite obvious that a competently organised artificial environment should resemble as much as possible a natural one, i.e. the concept of creating sensory gardens should emulate natural harmony and sensory gardens should be organised in a landscape style. This approach may be reflected in the current trend towards locating sensory gardens in city parks (Zajadacz et al., 2015; Zajadacz, Lubarska, 2020).

Among many gardens, Harrison (2011, p. 18–39) mentioned their following types: for pleasure, for medicinal, utilitarian, and botanical purposes, as well as those with meanings and ideas. In addition, Harrison (2011, p. 39) stressed the importance of public parks that serve various needs of a large number of city residents. These parks offer green paths for walking and exercising, and also memorials, playgrounds, recreational areas, sports fields and equipment, benches, gazebos, food outlets, toilets, and so on.

However, Harrison (2011) did not take into account pocket gardens, intelligent gardens of the future, and sensory gardens in his classification. Pocket gardens are a special formula for small rest areas located in built-up spaces. Such gardens can act as spatial landmarks by using one type of fragrant plant in a given place and can be a form of pleasure gardens. Smart gardens of the future play a therapeutic and preventive role, especially in city spaces. These include parks equipped with memory gyms, i.e. memory training devices, aimed mainly at elderly people with signs of dementia, which can be also attractive for other groups of users, if skillfully applied. They can also be equipped with “moto-sensory paths, i.e. a place intended to serve the elderly and people who experience limitations in mobility as a result of illness or injury. The proposal of the various available solutions is to help maintain or increase the mobility of the beneficiaries” (Haupt et al., 2019, p. 24). Moto-sensory paths serve as places for various kinds of therapy (Haupt et al., 2019, p. 22–23), including passive therapy, physical therapy, kinesitherapy, psychotherapy, and active hortitherapy, alongside garden work used for healing purposes, treating depression, addictions, etc. as well as for promoting active lifestyle among the elderly with cognitive disorders that are common at this age. It also works for people with intellectual disabilities and emotional disorders. However, taking into account the specificity of sensory gardens, they can be associated with several types of gardens, such as those for pleasure and healing, and those with meanings and ideas, which are part of city parks, as well as with intelligent gardens of the future, including pocket ones in the urban environment of smart cities.



Sensory gardens perform various functions (Table 2) of which three are the main ones (Zajadacz, Lubarska, 2020; Wajchman et al., 2021):

1. Sensory gardens are, by definition, accessible to people with disabilities, which is associated with their historical, therapeutic, and educational function. As a result, parts of the city become more accessible in the spirit of universal design. They can be used by people requiring increased accessibility, such as the elderly and families with children. This increases the integration value of the area and thus contributes to reducing the feeling of alienation that is common in urban spaces.
2. Creating a space that engages different senses not only allows for more effective rest, but also for the acquisition of new information through extra-visual channels, which makes it possible to learn in pleasant conditions.
3. Sensory gardens give relief to the senses. They are zones excluded from the usual urban bustle. It has already been shown how beneficial it is to relax in green spaces and how therapeutic the sensory garden has been for human health, especially mental health. A sensory garden has the advantage over an ordinary park that it somehow forces interaction between an individual and the garden.

**Table 2.** Sensory gardens located in urban areas and their primary function (examples from Poland)

№	Town/City	Name of sensory garden	Location	Primary function
1	Gdańsk	Doraco Sensory Garden	City park	Rest/recreation
2	Kraków	Stanisław Lem Science Garden	Independent facility	Education (science)
3	Lublin	Sensory Trail in MCSU Botanical Garden	Botanical garden	Education (ecology)
4	Muszyna	Muszyna Bible Gardens	Independent facility	Education (religion/cult)
5	Muszyna	Muszyna Sensory Gardens	Independent city park	Rest/recreation
6	Muszyna	Muszyna Magical Gardens	City spa garden	Rest/recreation
7	Poddębice	Garden of Senses	City park	Rest/recreation
8	Powsin (Warsaw)	Botanical Garden in Powsin/ Ceramic Botanical Garden	Botanical garden	Therapy/education (ecology)

Source: own elaboration based on the results of own study (Zajadacz, Lubarska, 2020). The research covered all the sensory gardens existing in Poland at that time.

## KNOWLEDGE GAP, RESEARCH AIMS, AND METHODS

Given the presented development directions of both cities and sensory gardens, the expectations of city dwellers regarding the development of green areas in modern cities are an information gap. The aim of the research was to identify the expectations as to the development of modern gardens in urban spaces. The primary data collection method was social surveys among the inhabitants of Poland and Russia on the expectations regarding the issue in question. The studied sample had a total of 230 people (Table 3). The research was conducted in January 2021 using an internet survey. The questions were both open and closed and related to issues  $Q_1$ – $Q_3$  (Table 3).

**Table 3.** Research methodology

Research aim: Identification of expectations regarding the development of modern gardens in urban spaces in the context of a smart city				
Research questions	Research objectives	Research method	Instrument	Expected outcome
$Q_1$ : The most important features of gardens, city parks	Recognising the importance of the features of city gardens and parks from the point of view of their potential users	Survey research	Software QDA Miner 6 and Wordstat 7	Identification of the most important contemporary features of parks and city gardens from the point of view of their potential users
$Q_2$ : Defining a sensory garden	Recognition of understanding and interpretation of the concept of a “sensory garden” taking into account various social perspectives	Survey research	Software QDA Miner 6 and Wordstat 7	Contemporary, social definition of the term „sensory garden”
$Q_3$ : The main functions that gardens and city parks should fulfil in the future.	Forecasting socially desirable functions performed by green areas in cities	Survey research	Software QDA Miner 6 and Wordstat 7	Identification of desirable features of gardens and city parks relevant to their design in the future

Source: own elaboration.

The sample of the respondents from Poland and Russia who took part in the internet survey was diverse in terms of demographic features (Table 4).

**Table 4.** Characteristics of the respondents

Characteristics of respondents [n = 230]	%	Characteristics of respondents [n = 230]	%
<b>Age</b>		<b>Benefits</b>	
25–45	23.9	old-age pensioner	11.7
46–65	26.1	disabled pensioner	0.4
over 65	17.8	disabled person	0.4
<b>Sex</b>		maternity allowance	0.8
male	47.0	leave/paternity leave	0.8
female	53.0	child care	4.3
<b>Education</b>		<b>Place of residence</b>	
secondary education	6.5	city	53.5
higher education	80.0	suburb	46.5
scientific degree	13.5	<b>Number of people in household</b>	
<b>Employment</b>		<3	20.0
yes	71.0	3–5	67.0
no	29.0	>5	13.0
<b>Type of employment</b>		<b>Character of housing development</b>	
self-employment	8.2	modern apartment house	36.5
employment in company (full-time, contract for specific work or commission)	62.8	apartment in “old buildings” in old part of city	13.9
<b>Currently performed profession</b>		low-rise house	23.5
manager	15.2	own house (house with garden)	26.1
entrepreneur	10.9		
specialist	17.0		
civil servant	4.3		
others	23.5		

Source: own research, January 2021.

Text mining techniques were used to analyse the content of open-ended questions. With regard to text mining methods, the respondents’ statements were subjected to text mining analysis in order to identify the most frequent phrases and keywords. Their identification may indicate a general tendency dominating in the way parks are perceived by the respondents. The analysis was performed using QDA Miner 6 and Wordstat 7. The input data processing consisted of several stages.

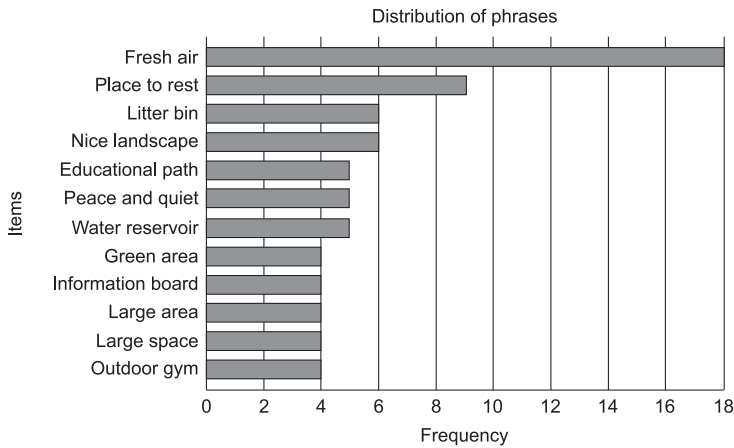
In the first step, the notation was normalised by eliminating the differences in the use of lowercase and uppercase letters in favour of a uniform notation using only uppercase letters and the elimination of irrelevant information, e.g. single letters. Then, an exclusion dictionary was implemented, including words with a

high occurrence frequency that are irrelevant for further analysis. In the next stage, the lemmatisation procedure was applied, which consisted in reducing the words to their basic form; the procedure allowed for grouping words with a similar meaning.

The procedure included the identification of relevant data. The minimum frequency criterion was used, amounting to a minimum of five times for keywords and a minimum of four times for phrases. The charts show the frequency of key words and phrases.

### FINDINGS: SOCIAL CONSULTATIONS ON THE DEVELOPMENT DIRECTIONS OF PARKS AND GARDENS IN THE CITY SPACE

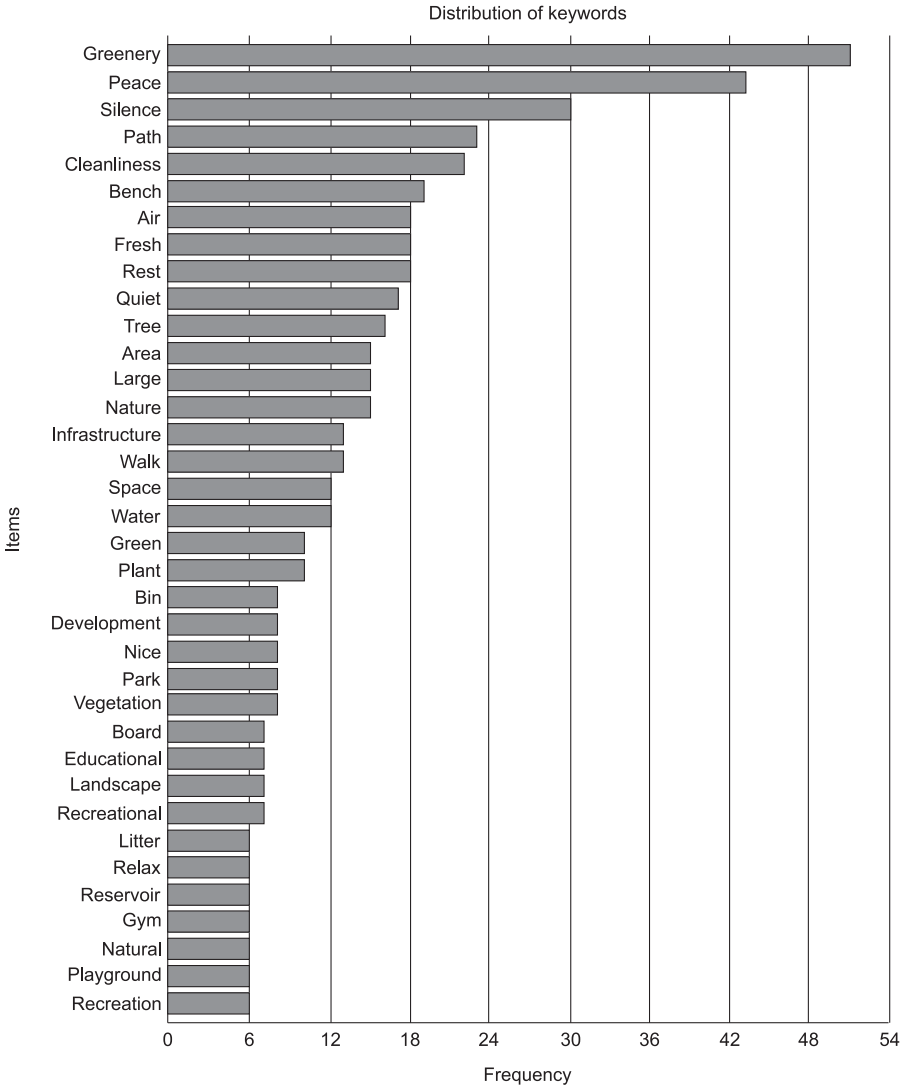
The distribution of the responses to the closed question “What features of gardens, city parks are most important to you (please list three)?” was the following: quiet rest and walking zone (62.6%), active recreation and sports area (21.3%), creativity zone (9.1%), educational recreation and development area (7.0%). The respondents could also provide their own answer to the same question. The results of the open statements, according to the text mining analysis (distribution of phrases), suggest very important factors, such as fresh air and place to rest (Fig. 2).



**Fig. 2.** The most important features of gardens and city parks. Text mining analysis (distribution of phrases)

Source: own research.

On the other hand, the analysis of the answers to this question according to the keywords present in the statements revealed the dominant importance of such features as: greenery, peace, and silence (Fig. 3).

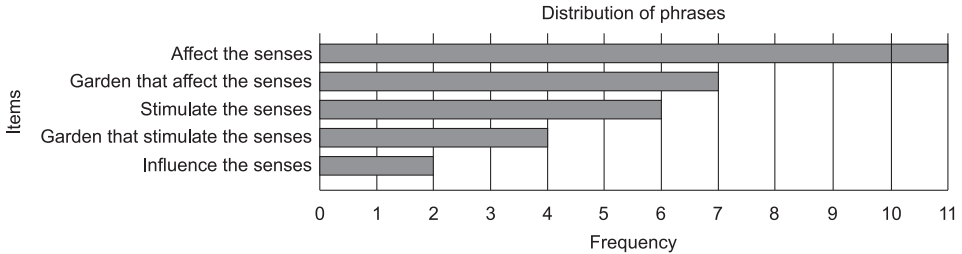


**Fig. 3.** The most important features of gardens and city parks. Text mining analysis (distribution of keywords)

Source: own research.

The concept of a sensory garden was not known to most of the respondents (64.8%), only part of them (29.2%) confirmed that they knew the term and some were not sure if they understood it correctly (6.0%). The distribution of the answers to the closed question “What is a sensory garden to you?” was as follows: a garden that intensely affects all the senses (15.7%), a smell zone (8.2%), a tactile zone (6.5%), a colour and light zone (visual effects) (6.9%), a sound and acoustics

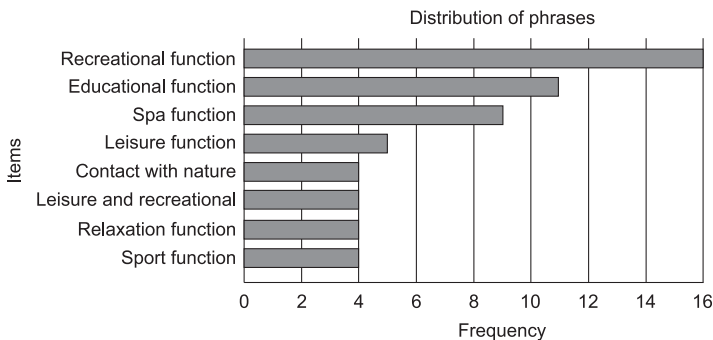
zone (4.3%), a physical activity and gravity zone (3.0%), a zone of tastes (2.2%). The analysis of the respondents' answers to this question with the text mining technique carried out according to the phrases used showed mainly such associations as: affects the senses and a garden that affects the senses (Fig. 4).



**Fig. 4.** Defining a sensory garden. Text mining analysis (distribution of phrases)  
Source: own research.

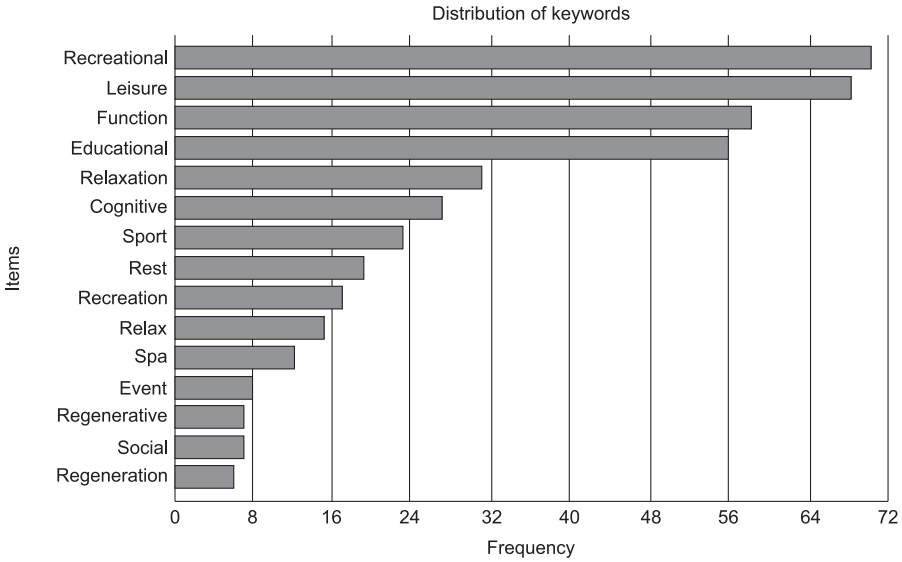
The distribution of indications for the question “What should parks and gardens in cities be primarily (choose one answer)?” with variants of answers was as follows: oases of nature in which the body can regenerate through contact with the natural environment (77.4%), green areas conducive to education through real experiences (16.1 %), green areas equipped with intelligent devices and programmes (e.g. QR codes for reading information, RFID – Radio-frequency identification, VR – virtual reality, AR – augmented reality, etc.) (6.5%).

In the case of the request “Please list three main functions that gardens and city parks should fulfil in the future” the distribution of responses was as follows: recreation and entertainment for all segments of the population (52.2%), environmental education (30.9%), anti-stress therapy for adults (30.4%), family leisure



**Fig. 5.** The main functions that gardens and city parks should fulfil in the future. Text mining analysis (distribution of phrases)  
Source: own research.

(23.0%), a sports, physical activity area (11.7%), rehabilitation of people with disabilities (8.2%), early childhood development strategies (3.9%). Text mining analysis of respondents' statements on the functions of sensory gardens according to the phrases used showed that the most commonly used terms were: recreational and educational function (Fig. 5). The analysis according to the keywords used showed that the most frequently used terms were recreational, leisure and educational function (Fig. 6).



**Fig. 6.** The main functions that gardens and city parks should fulfil in the future. Text mining analysis (distribution of keywords)  
Source: own research.

## DISCUSSION

The conducted review of the literature in the field of modern concepts of city development has shown the most considerable increase in the interest of researchers in the subject of a smart sustainable city over the last dozen years (Table 1). Sustainability includes natural, economic, and social issues. With the growth of the urban population and shrinking green areas in cities, sensory gardens with their intense somatic and psychological impact are the appreciated and developed direction regarding urban green areas arrangement. Their multifunctionality is conducive to the implementation of the assumptions of sustainable development, especially in the natural context, and to social inclusion. The research has shown (Zajadacz, Lubarska, 2020) that sensory gardens are in many cases very

well adapted in terms of accessibility to people with disabilities, but also favour creativity, relaxation, entertainment, and learning by supporting experiments in the public sphere in the LLL process. Also, it has been proved that sensory gardens can be a modern unit of the sustainable and smart city concept as urban green spaces (UGS) (Vukovic, 2017).

The results of the research carried out in Poland's and Russia's (Vukovic, 2020) main cities have shown that the most desirable features of urban gardens are the provision of fresh air and a place to rest. These statements correspond to other results of studies conducted among the inhabitants of large cities during the pandemic (Vukovic, 2019; Zajadacz, 2021), which indicated the need to relax in the fresh air, close to nature and a place of residence.

The most important features of gardens and city parks, defined as greenery, peace, and silence, correspond to the 'joyful' conditions presented by Fetell Lee (2018). The concept of a sensory garden was most often explained by the respondents as "affecting the senses" and was associated with the recreational and educational function. Furthermore, when describing the functions that sensory gardens should have in the future, the terms such as recreational, leisure, educational, relaxation were most often used, which in general corresponds to important functions related to improving the quality of life (Diamant, Waterhouse, 2010; Adevi, Mårtensson, 2013). After the Covid-19 pandemic, an important feature of sensory gardens regarding the well-being of the urban population can be connected to a new form of eco-entrepreneurship and local tourism (Vukovic, 2017).

## CONCLUSION

A review of the literature on the concept of urban development, the many functions and evolution of sensory gardens, as well as the results of the conducted research confirmed the adopted hypothesis that sensory gardens as green enclaves with different functions constitute new, prospective forms of development of urban green spaces in smart sustainable cities. The social needs for urban green spaces are clear and reflect current environmental problems regarding the quality of atmospheric air and access to green spaces in the vicinity.

It is significant that respondents from both Poland and Russia agree that the most important features of gardens and parks include fresh air and the possibility of rest. The presented opinions, taking into account the duration of the research (the Covid-19 pandemic), were undoubtedly influenced by the conditions related to the Covid-19 lockdown and the discomfort resulting from the "shutdown" effect, severe limitations to the possibility of rest in public spheres, as well as restrictions limiting recreational trips. Therefore, the studies should be repeated in the post-pandemic period to verify the results obtained. Important recommendations, useful from a practical point of view in the design of gardens and city parks



in the future, relate to the sustainable arrangement of primarily recreational and educational functions, including spa and sports functions. The presented results may contribute to the implementation of the principles of sustainable development in smart cities of the future. Sensory gardens, as a new form of urban green zones, will positively influence the city brand and will increase local well-being tourism. We are planning to develop and investigate this topic in our future research.

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