Sustainable Urban Development: Spatial Analyses as Novel Tools for Planning a Universally Designed City

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Abstract: The aim of the research was to analyze the "design for all" concept as a key strategy for creating social sustainability. The paper attempts to answer the question: how can universal design contribute to the rational development of the city space? The author has taken part in participatory experiments. The research took into account various criteria, including the level of the city space's adaptation to the needs and capabilities of persons with different disabilities. Analyses included qualitative studies concerning the possibilities of developing the social capital as well as creating and preserving a cohesive social structure. The analytic process allowed determining the means of raising the quality of urban planning. Finding effective and reliable analytical tools enabling the development of healthy cities which are compatible with the principles of sustainability could become both a great chance and a great challenge for urban planners. Transition from the microplanning to the macroplanning scale and following the principles of universal design at the stage of the formation of urban concepts using spatiotemporal modelling methods will lead to the creation of harmonious accessible spaces adjusted to the needs of present and future users, which will generate sustainable development and lead to the healing of a city.

Keywords: urban planning; wellbeing; urban health; urban sustainability; spatial analytics; spatiotemporal modelling; universal design; social development

1. Introduction

The canon of contemporary city design, that is, sustainability, can be studied in different aspects; however, to date, the researchers' interest has been focused on its environmental and economic dimension. Social sustainability, a concept referring to the influence of space on the quality of human life, has often been neglected or ignored [1]. Paying respect to the built-up environment, the Young Foundation defines social sustainability as "a process for creating sustainable, successful places that promote wellbeing, by understanding what people need from the places where they live and work. Social sustainability combines design of the physical realm with design of the social world—infrastructure to support social and cultural life, social amenities, systems for citizen engagement and space for people and spaces to evolve" [2].

At the same time, the problem of social exclusion has become a current focus of attention in most agglomerations all over the world, especially in the USA. As a result of introducing novel European Union policies, the issue of social polarization, including marginalization of persons with various disabilities, sparked numerous debates, also in the European media and scientific communities. The aim of the research was to analyze the concept of universal design included in the United Nations Convention on the Rights of Persons with Disabilities, as a key aspect of creating a healthy city and building social sustainability [3]. The author continues the research conducted, among others, by Kadir and Jamaludin (Universiti Teknologi MARA, Shah Alam, Malaysia), and attempts to answer the

question: how can universal design contribute to creating social sustainability via building common living places and livable public spaces [4]?

The experience of architectural and urban planning practice clearly indicates that many efforts are currently being made in order to increase the accessibility of buildings and city spaces. However, these activities usually involve developments on a microscale (selected fragments of streets and squares, individual solutions in new and adapted buildings, lighting), and a complete realization of the concept of a universally designed, healthy city requires a comprehensive public space management plan. A variety of planning support tools have been described in the publications dealing with the issues of land use and transport infrastructure [5–14]. The foregoing studies concerning the assets and drawbacks of accessibility instruments reveal that despite the numerous theoretical investigations, the application of new tools in the planning practice still remains a big challenge. Moreover, in the author's opinion, there is a significant gap in the current research resulting from the lack of publications regarding the issue of computer tools for the holistic planning of a universally designed city in the context of the needs of users with various dysfunctions in mobility and perception.

Therefore, the purpose of the paper is to draw the attention of the organizations representing urban planners and experts in spatial economy, such as The Association of Polish Town Planners, to the possibility of applying spatial analyses as a promising tool to be used in the processes of city zone revitalization according to the principles of universal design, and to define the methodological problems connected with undertaking practical action in this area, inter alia, extending the information about spatial barriers in the currently created databases regarding accessibility. These ideas result from a simple observation that changing the character of a particular place often leads to changes in the behavior of its users; and has "making places" for people not currently become the main goal of sustainable urban planning?

2. Materials and Methods

The research material was obtained using the following methods:

- Literature research: analysis of the literature on the subject matter (national and foreign), through journals, internet data, and conference materials.
- Empirical methods (research walk, social interviews): watching the public space in Lodz and Warsaw (Poland) in terms of it being used by elderly and disabled persons. The research involved the participation of the representatives of the Foundation for Active Rehabilitation and inhabitants with auditory and visual perception disabilities (visually impaired and deaf people). The author analyzed the information about the residents' expectations concerning their functioning in the public space in terms of creating social sustainability.
- Case study: analysis of the completed and conceptual projects involving the revitalization of the public space in Lodz and Warsaw (Poland), taking into consideration the needs of elderly and disabled persons.
- Experience in using tools of spatial analytics on a local scale. The planned scheme of the research process is as follows: (Basic analyses of the accessibility of Lodz bus stops were conducted within the course project at the Technical University of Lodz.)

- Stage 1: Formulation of the research issue; defining the aim of the research.
- Stage 2: Programming: examination of the user groups and their problems and needs connected with the exploitation of the city space (extensive interviews with space users with different disabilities); own research with qualitative studies (using a wheelchair, etc.); analysis of the principles of universal design; analysis of the possibilities of implementing universal design principles in urban planning practice; regulations, standards, design norms, and guidelines; review of currently popularized methods and tools for spatial planning; inter alia, geographic information systems (GIS).
- Stage 3: Conclusions.

The author has taken part in the participatory experiments. The analysis involved various criteria, including the level of the city space's adaptation to the needs and capabilities of persons with different disabilities during different stages of their lives. Comparative analyses based on the principles of universal design included qualitative studies regarding, inter alia, the possibilities of developing the social capital, preventing social exclusion, and strengthening neighbors' relationships, as well as creating and preserving a cohesive social structure. The programming phase allowed determining the means of raising the quality in urban planning and architecture and choosing such a scheme of action which could meet the challenges of the perspective "strong and prosperous communities" proposed by the strategic British documents [15].

3. Results

3.1. Universal Design as a Crucial Component for Sustainable Life

3.1.1. Criteria for Social Sustainability

Standards for determining the degree of social sustainability within a selected community have become a subject of analysis of many researchers. According to Colantonio, traditional determinants, such as the degree of poverty or the employment scale, have become an integral part of urban planning practice and are currently being supplemented with or even replaced by subjective criteria, such as social participation, level of happiness, or sense of place [16]. Colantonio conducted a comparison of traditional and novel standards for determining social sustainability (Table 1).

Table 1. Traditional and emerging social sustainability key themes. Source: Colantonio (2009) [16].

Traditional Key Themes	Emerging Key Themes
Basic needs, including housing and environmental health	Demographic change (aging, migration, and mobility)
Education and skills	Social mixing and cohesion
Employment	Identity, sense of place, and culture
Equity	Empowerment, participation, and access
Human rights and gender	Health and Safety
Poverty	Social capital
Social justice	Wellbeing, happiness, and quality of life

The need to accept the subjective criteria of social sustainability was also recognized by Sharifi and Murayama [17]. They indicated new standards for assessing social sustainability, which are a collection of the results of analyses performed by international researchers over the last two decades (Table 2).

The content of Table 2 clearly indicates the repeating key criteria, such as community wellbeing, inclusion, adaptability, participation, and social interactions [17]. The participation studies as well as the interviews with the residents of Lodz and Warsaw conducted by the author allowed confirmation of some of the thesis statements of international researchers. However, it should be clearly indicated that the residents of Lodz emphasized the fact that due to the lack of the spatial accessibility of the city and facilities, their basic needs including housing, employment, and the right to social justice could not be satisfied (Table 3).

Table 2. Criteria for social sustainability. Source: Sharifi and Murayama (2012) [17].

Author(s)	Criteria Considered
Sachs, 1999	Equity; democracy; human rights, social homogeneity; equitable income distribution; employment; equitable access to resources and social services
United Nations Division of Sustainable Development UNDSD, 2001	Equity; health; education; housing; security; population
Spangenberg, 2004	Income; communication and participation; education; social contacts; social security; distribution of income and assets
Chouguill, 2008	Citizen participation; social interaction; feeling of belonging; interpersonal relations among the neighborhood residents; collective action; mutual support; access to facilities and amenities; safety
Bramley et al., 2009	Social equity; access to facilities and amenities; affordable housing; social interaction; safety/security; satisfaction with home; stability (turnover); participation in collective group/civic activities
Colantonio, 2009	Equity; inclusion; adaptability; security
Cuthill, 2010	Social justice; social/community wellbeing; human-scale development; engaged governance; social infrastructure; community and/or human-scale development; community capacity building; human and social capital
Dave, 2011	Access to facilities and amenities; amount of living space; health of the inhabitants; community spirit and social interaction; safety
Dempsey et al., 2011	Social interactions; participation; community stability; pride and sense of place; social equity; safety and security
Weingaertner & Moberg, 2011	Accessibility; social capital and networks, health and wellbeing; social cohesion and inclusion; safety and security; fair distribution (income, employment); local democracy, participation, and empowerment; cultural heritage; education and training, equal opportunities; housing and community stability; connectivity and movement; social justice; sense of place; mix use and tenure; attractive public realm

Table 3. Unfulfilled criteria of social sustainability, listed according to the scale of importance following the indications of different groups of users taking part in participatory experiments Source: the author's study.

The User's Profile	Unfulfilled Criteria of Social Sustainability Resulting from the Lack of City Accessibility
Persons with dysfunctions in mobility	Basic needs, including housing and employment; security; human rights; social justice; equity
Visually impaired and blind persons	Safety and security; social interaction; participation
Hearing impaired and deaf persons	Adaptability; equitable access to resources and social services; social justice
Mentally handicapped individuals (self-advocates)	Human rights; social justice; voice and influence
Elderly persons, over 70 years of age	Basic needs, including housing and environmental health; poverty and social justice

In the next stage of the participatory study, the same group of the surveyed pointed to the key factors of the city space which contribute to the low degree of social sustainability in Lodz (Table 4). The identified problems were connected with the inability of residents to move, see, hear, and understand, as well as with environmental sensitivity.

Table 4. Key factors of the public space which contribute to the low degree of social sustainability in Lodz, according to the indications of different groups of users taking part in the participatory experiments Source: the author's study.

The User's Profile	Key Factors of the City Space Which Contribute to the Low Degree of Social Sustainability
Persons with dysfunctions in mobility	Spatial barriers in the form of high curbs, uneven surface of pavements, lack of platforms, lack of ramps, or ramps which are too steep; park lanes without hardened surfaces; lack of banisters with a grip accessible to all users; blocking pedestrian passageways with bollards or other obstacles, narrowing the access roads to facilities and amenities (no adjustment of the width of obstacle-free pedestrian passageways); lack of relaxation sites set along the communication routes adjusted to persons in wheelchairs; urban furniture without supports; lack of supports for people waiting at the public transport stops; lack of playgrounds accessible to children with dysfunctions in mobility
Visually impaired and blind persons	Inconsistent use of parts of the system of tactile ground surface indicators (TGSI); lack of tactile contrast (differences in the texture of surfaces, e.g., between the even surface of a pavement and the rough surface of a TGSI signal board); uneven surface of communication routes; lack of clear distinction between the conterminous pedestrian and driving courses; too-wide pedestrian passageways which make it impossible to identify the space by means of a white cane and hearing; lack of proper indication of obstacles that cannot be eliminated; barriers not marked with color contrast; too-high light reflectance value (LRV): the level of light reflection from the surface; light sources placed below the pedestrians' line of sight; no voice information at the public transport stops and pedestrian passageways; lack of information in Braille; lack of tactile plans; lack of sound confirmation in the city devices panels
Hearing impaired and deaf persons	General lack of clear and readable marking and description of the city space and its elements, e.g., lack of building entrances which are clearly visible against the elevation; no visual signaling at the public transport stops and pedestrian passageways; lack of visual confirmation in the city devices panels (e.g., panels in elevators); passageways and access passages to buildings without proper lighting
Mentally handicapped individuals with caregivers	Lack of proper systems of spatial information (for example, boards with the names of public transport stops placed perpendicularly to the direction of movement); lack of information using illustrations and symbols for persons who cannot read; lack of clear plans and schemes of the city spatial layout; wrongly applied LRV; inappropriately designed space coloring which fails to expose sufficient contrasts between surfaces; lack of using proper materials ensuring the maintenance of the high level of contrast throughout the whole period of use; lack of use of special lamps providing additional light in places requiring particular attention; lack of clear distinction between the conterminous pedestrian-driving courses and cycling lanes; lack of proper indication of obstacles that cannot be eliminated; stairs with trimmings and nosings not marked with color contrast
Elderly persons, over 70 years of age	All shortcomings referring to spatial accessibility described above: accessibility barriers indicated subjectively by particular users depending on the spectrum of disability in terms of mobility and perception

In the design process, the fundamental rule to be followed should become the accessibility of the city space, buildings and their interiors, means of public transport, events, and services including digital services. The basic condition for full accessibility is providing all residents with the possibility of independent functioning in a particular space, regardless of their limitations in abilities, mobility, or perception. The conducted participatory studies allowed indication of the following directions for the development of the ongoing city policy and a new range of urban planners' activities:

- setting the basic guidelines deciding about the fulfillment of required conditions for city space accessibility;
- improving and raising the level of coordination of design and execution processes in order to make the city space accessible to all residents;

- inspiring the creation of practical, modern and economically, culturally, and socially justified solutions;
- favoring the reduction of the number of decisions generating unnecessary costs of maintenance and modernization of public spaces;
- supporting rational and socially responsible decisions fulfilling the expectations of the stakeholders of the investment projects and users in terms of accessibility.

The improvement of the existing standards for arranging city spaces seems to be possible on condition that the universal design principles are implemented in the practice of programming the cities' development and planning on the urban level.

3.1.2. Principles of Universal Design

The concept of universal design was born at the time of expanding social movements for civil rights in the United States of America. The first regulations concerning the discussed issue were introduced in the USA at the beginning of the 1990s, based on the Americans with Disabilities Act (ADA). The executive acts drew on the principles of antidiscriminatory laws. The European Union is currently trying to fill the legal loopholes by introducing directives for promoting the ideas of universal design. Due to this changed perspective of lawmakers, a number of new initiatives and projects aimed at increasing accessibility have appeared in Europe. Nowadays, the regulations of the Convention on the Rights of Persons with Disabilities, adopted by the General Assembly of the United Nations on 13 December 2006, provide us with the framework of actions for protecting disabled persons by counteracting their discrimination caused by the reduced intellectual skills and functional limitations in terms of communication, perception, or mobility. According to the document, all forms of differentiation and exclusion, including the abandonment of the efforts to rationally adjust the environment to the special needs of persons with disabilities, are considered as a crime against the dignity and value of a human being [3]. Article 9 of the Convention states that: "To enable persons with disabilities to live independently and participate fully in all aspects of life, State Parties shall take appropriate measures to ensure to persons with disabilities access, on an equal basis with others, to the physical environment, to transportation, to information and communications, including information and communications technologies and systems, and to other facilities and services open or provided to the public, both in urban and in rural areas. These measures, which shall include the identification and elimination of obstacles and barriers to accessibility, shall apply to, inter alia: buildings, roads, transportation and other indoor and outdoor facilities, including schools, housing, medical facilities and workplaces . . . " [3].

The Convention presents a definition of universal design thus: "Universal design means the design of products, environments, programs and services to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" [3]. In this context, "design" is a common term used to describe all activities which refer to the processes of shaping the environment (planning within the local community, land use, architecture, construction works, production, and many others) [18]. The strategy of universal design can be applied for the creation of products and environments in all sectors and fields, where the term "environment" refers to all kinds of environments shaped by man and the term "products" covers, among others, products and software for new information and communication technologies as well as products in different kinds of services [18]. The possibility of them being used by everybody should be treated as a starting point of the design process; that is, products and environments should be designed in such a way that they can be used by persons of all ages, with different possibilities, skills, and degrees of ability.

An important role in this context is played by factors connected with moving around, seeing, hearing, understanding, and environmental sensitivity. A key aspect of the discussed strategy is searching for better solutions, as universal planning is an innovative idea. It is a dynamic process which reflects the need for further incorporation of new means for the reduction of the existing limitations. When universal design principles come into conflict with other statutory regulations,

such as security rules or buildings preservation principles, it is necessary to look for solutions that would fulfill the requirements of universal design to the highest degree possible [18]. While designing a product, the basic assumption involves a possibility of it being used by all people, taking into consideration the necessity of making use of personal technical support such as wheelchairs, hearing aids, and others. According to that rule, it is not recommended to introduce solutions designed especially for persons with disabilities [18].

The increasingly popularized idea does not represent a minimalistic approach that involves providing the accessibility in a modest form required by the effective regulations. According to the seven principles of universal design, developed in 1997 at the North Carolina State University by a group of designers and scientists under the directorship of the American architect R. Mace, the aim of the strategy is to ensure that everybody has access to the same standard of using the space and services. The promoted idea of equitable use can be considered as an absolutely obligatory attribute of the space [19]. Obeying this rule will allow avoidance of solutions which could deepen the divisions and stigmatization of the users and infringe their privacy, safety, and sense of confidence.

In the case of most facilities, the second principle of the discussed strategy, referring to flexibility in use, could happen to be particularly important [19]. It means that the design takes into account individual preferences of the users (depending on their capabilities in terms of mobility and perception), allows choosing the method of using the facility, and is planned in a way that ensures accuracy and precision as well as a different rate of taking advantage of the proposed solutions.

The full characterization of the future users of the space is in most cases not possible due to the variety of their psychophysical states. Health problems; independence deficits; a sense of fear; loss of a sense of physical and mental safety; and a sense of being lost, especially in new spaces, lead to a number of difficulties, which generate a necessity of developing a specific approach to the design of facilities which are intuitive in use, free of unnecessary complexities, and take into consideration the state of knowledge and skills of the users ("simple and intuitive use") [19]. For the same reasons, more attention is being paid to the creation of systems of perceptible information, whose elements are, inter alia, voice and tactile information, colored pictograms, and a possibility of taking advantage of individual devices being at the disposal of persons with sensory limitations [19].

Although it is difficult to find a simple model of a "good" public space or building design, each concept requires developing methods for the reduction of anticipated and accidental threats and tolerance for error connected with the exploitation processes, which is being realized through appropriate warnings, localization ensuring the accessibility of solutions, and limitation of activities leading to physical and mental fatigue [19]. For commonly understood reasons, good practice involves using the means and tools that allow the users to maintain the most comfortable position of their bodies, which will not require excessive effort or the necessity of continuous repetition of activities demanding a lot of strength ("Low Physical Effort"), and provides proper space enabling every individual to perform a particular activity ("Size and Space for approach and user") [19]. Intriguing and innovative spatial solutions can be generated by the last supplementary principle of universal design, defined by K. Kaletsch as "perception of equality". It refers to a situation when an individual assessment of a solution can affect self-perception as well as the way in which our physical differences or disabilities are perceived by others as discriminating or disproportionately distinguishing features.

The key objective of the discussed idea is promoting equality and providing full accessibility and inclusion in social life for persons with reduced functionality, by eliminating the existing barriers, which in the opinion of the disabled persons, are particularly oppressive and stigmatizing, and are considered to be incompatible with the principles of universal design (Figure 1). Another aim is preventing the creation of new spatial barriers within the ongoing programs of cities' revitalization. The universal design concept has been gaining large popularity in the analytical discourse, because it indicates new pathways of thinking and is based on the idea of social egalitarianism to a broader extent than the general accessibility concept, due to the fact that "the principle of universal design assumes that the basic actions and solutions will by rule fulfill the needs of all users" [18].

Figure 1. Examples of the existing barriers in Lodz which are particularly oppressive and stigmatizing.

3.1.3. Relationships between Universal Design and Sustainable Social Development

Looking at the idea of sustainability from a wider perspective, it can be anticipated that universal planning might contribute to the sustainable life of an individual in the city environment, including its public and housing spaces. The British concept of the eco-town project, proposed by the Town and Country Planning Association (TCPA), seems to be in line with the assumptions made by the author of the paper. The "eco-town" concept is believed to provide a chance of creating a responsive housing environment, where all users, regardless of their age and degree of disability, can live and function with a sense of comfort and dignity [20]. Convenient living as well as full accessibility to amenities and facilities are the major tools for creating social participation and integration within a healthily developing sustainable community.

Social development can be understood as: "one that is concerned with the process of change that led to improvements in human wellbeing, social relations and social institutions, and that are equitable, sustainable, and compatible with principles of democratic governance and social justice" [21]. Among the social sustainability standards, the quality of which can be raised thanks to the implementation of universal design principles, one can mention, inter alia, health, wellbeing, increased security, social equity, inclusion, adaptability, flexibility, participation, and social interaction [22–26]. Duncan claims that universal design can be considered as an element of social sustainability due to its potential of creating accessible, supportive, and enabling environments favoring the phenomenon of social inclusion [27]. Four components of the social sustainability structure (amenities and social infrastructures, social and cultural life, voice and influence, and space to grow) were illustrated in relation to the concept of universal design in the studies by the Young Foundation [1] (Figure 2).

"The amenities provide support services for the community, while the infrastructures allow connectivity in a neighborhood or a city" [4]. The access to all elements of the social infrastructure generates visitability, which the National Center for the Dissemination of Disability Research (NCDDR) describes as "the ability of individuals to freely interact, navigate, and integrate within their environments" [28]. Woodcraft et al. point out that accessibility standards should be planned during the preliminary stages of designing the city infrastructure [1]. Despite the fact that contemporary universal design has been accepted in the architectural practice, it is often restricted to the design of

accessible elements of the buildings. However, in the future it should play an increasing role at the level of spatial planning, which can be supported by the development of the tools for spatial analytics and spatiotemporal modelling.
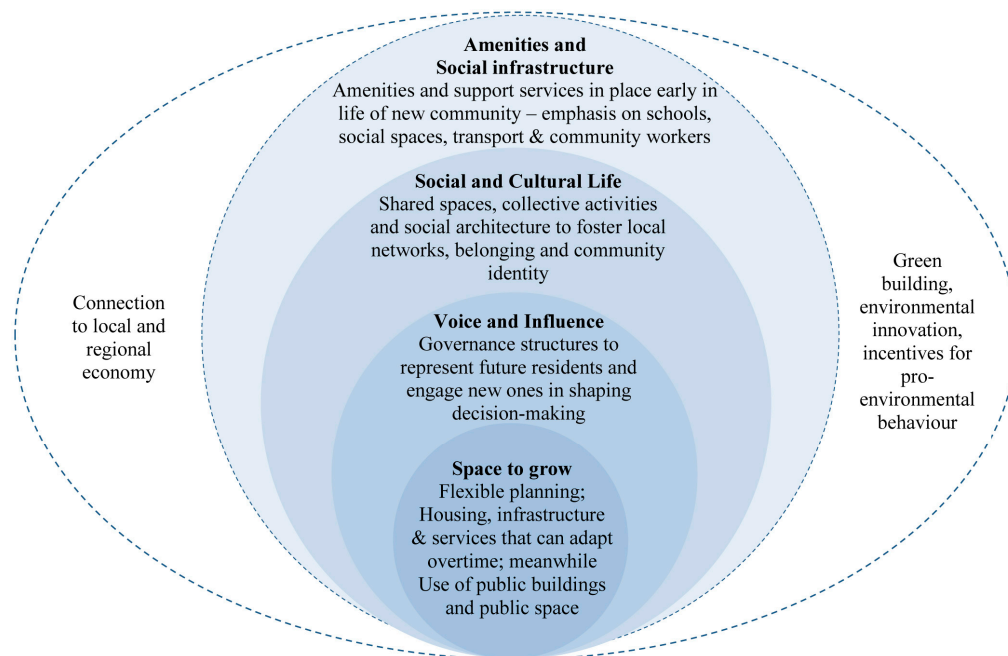

Figure 2. Illustration of Design for Social Sustainability Framework, Young Foundation. Source: S. Woodcraft, T. Hackett & L. Caistor-Arendar (2011) [1].

3.2. Spatial Analyses as a Tool for the Development of a Healthy City

3.2.1. Tradition of Social Usage

The theses of the present paper derive from one of the traditional approaches to urban planning, with regard to the interpretation of the design idea itself as well as the assessment of a product of the design process [29]. This is the tradition of social usage, which was promoted by such authors as K. Lynch, J. Jacobs, and Ch. Alexander. It emphasizes the assessment of the value of the city environment as a common space accessible to everybody and the need of its identification by society in terms of aesthetics, form, and function [29,30]. The reaction to the worrying contemporary processes of city space degradation involved the implementation of urban planning, which became part of not only traditional architectural disciplines and landscape design, but also more distant areas such as social planning [31].

While discussing the spread and range of urban planning, Carmona et al. [29] found that they are determined by the following, partly overlapping dimensions: morphological, perceptual, social, visual, functional, and temporal. They include, among others, such issues as the form of streets and buildings, image, identity and mood of places, functioning of public spheres, social usage of space, safety and trust, visual impressions, spatial links and communication, environmental planning, forms of moving around, and temporal space governance. Simultaneously, other ideas have been developing, which moved even further. The outstanding contribution of Frey should be particularly emphasized. He claims that urban design is not and should not be a separate discipline placed somewhere between planning and architecture, but an operational instrument integrating all of the cooperating professions [32]. He also believes that the main task of urban planning is improving the quality of all urban space features to such an extent so as to minimize the significance of the negative aspects or even to eliminate them completely. Thus, in order to raise the value of a city and reduce its

disadvantages, urban planning cannot limit its influence to the level of particular buildings or streets, and apart from public spaces and some selected locations, it should deal with the formation of the city and its structure as a whole [32]. Of course, the process of urban structure design in this aspect must undoubtedly have an interactive character.

To sum up, it should be acknowledged that if urban design is to effectively support sustainable development through its influence on the proper formation of new urbanized places (spaces) or revitalization of the existing ones, it is necessary to preserve its interactive character and make it evolve. Design suggestions should be a result of friendly and well-organized civil participation. A key role in this issue is played by the requirement to conduct the process in a tight cooperation between designers, who represent the local authorities, and stakeholders including, inter alia, representatives of so-far marginalized social groups and nongovernmental organizations. This cooperation must continue from the beginning to the very end of the design process and during the realization of the project.

Fighting the phenomena of discrimination and setting up the processes of revitalization of socially degraded city areas have become a commonly recognized priority obligation of the social and economic policy at the local authorities' level. Unfortunately, it was not very often that the decision-makers realized that contemporary urban design could be one of the most important and effective tools facilitating and accelerating the improvement of not only the aesthetics, but also the functioning of these areas as a whole, resulting in the lasting improvements in the quality of life of their residents, including those with various limitations of their body functions.

3.2.2. Spatial Accessibility in City Development Planning: New Design Tools

According to the results of the conducted analyses, inhabitants of cities developing in a sustainable way have the right to the space being adapted to their needs. Therefore, the authorities controlling the development of cities have to answer the question of how to effectively create the space to make it maximally accessible to its users. The answers are provided by network analyses and examination of spatial accessibility. Nowadays, geographic information systems (GIS) provide metainformation about geographic locations and make it possible to associate specific properties with the topological data; such information provides a basis for assistance with spatial problems, such as spatiotemporal planning [33]. Temporal constraints include the durations and temporal order of activities which take place in the city space, whereas spatial constraints encompass particular places and the distances between them [33].

Examination of spatial accessibility is a key element in the processes of planning the city's development. It allows for proper arrangement of particular constituents of the functional–spatial system in a way which is most beneficial for the users and enables identification of the existing barriers. One of the typical examples, which the author presents in the paper, is locating public transport stops in such a way that they can be accessible to all residents. Spatial accessibility can be verified according to different methods. The simplest way is creating simple buffers, that is, areas indicating rectilinear distances from the analyzed elements. However, they do not depict real spatial accessibility, as normally, people do not move in the space freely.

While performing spatial analyses, it is necessary to take into consideration the movement of people which most closely resembles the real one, including the situation of persons with different disabilities, along pedestrian courses such as pavements, passages, pedestrian lanes, or shared spaces, among others. Such a possibility is provided by the tools of network analyst (NA). NA is an extension of ArcGIS enabling the performance of network spatial analyses, which cover such issues as tracking the routes, marking the nearest locations and collisions, or defining the areas of accessibility in the accepted measure, which is the cost of moving around that might depend on the distance and time (it is recommended to pay special attention to the real possibilities of individual users) [34]. Network analyses should be considered as a good method of examining spatial accessibility, because they enable mutual connections between vectorial points reflecting the elements of spatial development (pavements, stops, etc.) and the analyzed way of moving around in the space.

Performance of network analyses requires building a coherent network of vectorial spatial data. This process involves collection of data followed by their verification and aggregation. For conducting spatial accessibility analysis, the researchers can use OpenStreetMap (OSM), completing it with the obtained spatial information systems of a particular city. It will enable aggregation of data layers and checking them in terms of topological correctness. The first stage of the analysis could involve, for example, green and water areas as well as locations of public transport stops. The next stage will consist in the verification of the roads network obtained from OSM in order to be able to create a topologically correct network of pedestrian courses, including pavements and lanes crossing the green areas and yards. However, the abovementioned vectorial layers do not constitute a complete set of data. Therefore, many of them must be supplemented manually, based on orthophoto maps and urban inventory. Another aggregated layer could include altitudinal and address points, which will allow distinguishing residential buildings and service facilities.

For the examination of the spatial accessibility of public transport stops, it can be assumed that an average person moves at a speed of 3 km/h (mostly this value reaches approx. 5 km/h). Reducing the average speed makes the analysis closer to reality. The marked areas of public transport stops accessibility are much more accurate than those created by a simple buffer. They take into account a simple movement of pedestrians within a topological network of pedestrian courses. However, upon a closer examination, it can be noticed that it is necessary to aggregate and include in the network another layer of data containing spatial and architectural barriers, which requires detailed investigation of the area (by conducting an audit of accessibility). After completing the process, a significant change can be noticed in the range of the spatial accessibility areas; taking into consideration that the barriers, to a large extent, bring the image closer to reality. As a result, properly constructed analyses can be obtained and spatial accessibility zones can be distinguished.

Audit of accessibility should be conducted as a participatory study and in close cooperation with city planners and users with a various spectrum of disabilities (the field of analyses should not be restricted to examining the barriers relevant to persons with dysfunctions in terms of mobility). It is necessary to make an assumption that it is the residents that are the experts and main users of the public space, and therefore the design processes should be preceded by analyses performed in order to recognize their needs. The Association of Polish Town Planners expressed an interest in taking part in a detailed, participatory investigation as well as using new tools in city development planning. They also positively assessed the idea of taking into account the detailed data from spatial analyses while developing the planning documents on the national, regional, and local levels. "On numerous occasions during the spatial design process, there arises a question about the purpose, and at the same time, the cause of activities. In my opinion, the main target of spatial design should be a human being and such a way of shaping the environment that could allow creating the best and most appropriate living conditions. In this aspect, both the public interest and individual needs must be taken into consideration. It is fundamental not to forget about persons with reduced abilities due to their age (both the oldest and the youngest ones) or health condition (e.g., people in wheelchairs or blind persons, etc.). Integrated spatial design both on the strategic level and first of all, on the local level, where it is expressed by the local law, should in a balanced way provide a possibility of using the space by all members of the community" (an authorized statement by Dr Maria Dankowska, President of The Association of Polish Town Planners, Łódz section, 24 April 2018).

Examination of spatial accessibility is an essential element supporting the process of planning, and first of all, indicating the areas which require intervention. Network analyses have a significant potential in enabling the sustainable development of cities, and their application is very wide. Spatial accessibility examined with the use of GIS tools could enhance the decision-making processes resulting from the need for the rational planning of services or other elements of the functional–spatial system. It is worth noticing that network analyses are a result of modelling, and therefore might generate some mistakes (i.e., penetration through indicated spatial barriers, etc.), but they do not affect the possibility of interpreting the obtained results. Network analyses are not the only method of examining

spatial accessibility; there are others which involve, for example, analyses in the Grid structure (Grid computing is the collection of computer resources from multiple locations to reach a common goal). Regardless of the methodology used, it is important to conduct all kinds of analyses enabling the rationalization of and exerting a positive influence on city development processes.

A simple example of the spatial accessibility of public transport stops proves the potential of spatial-analytic tools. On the other hand, the analyses of other researchers rightly point to a number of difficulties in designing practical tools for measuring and modelling accessibility developed to be run under a GIS environment [10]. Papa et al. [14] emphasize that the application of tools referred to as accessibility instruments (AI), which have recently been developed for measuring and modelling accessibility, should be considered a complex task, because "AI outputs are difficult to communicate to target end-users, in particular, because these users are professionals from several disciplines with different languages and areas of expertise, such as urban geographers, spatial planners, transport planners, and budgeting professionals". In the context of the issues discussed in the paper, despite the limited ability of the professionals to use these instruments, it seems necessary to promote the cooperation between planners and residents to continue developing spatial–temporal planning tools and to radically specify the databases by adding information about the elements which make access to the selected fragments of the spatial structure impossible or difficult to the inhabitants; that is, about factors reducing the level of city universality and thus inhibiting the process of its sustainable development.

4. Discussion

The present study could contribute to popularizing the knowledge concerning the significance of social sustainability and the new tools for urban planning in accordance with the principles of accessibility, because a universally planned environment ensures its comfort of use, flexibility, and adaptability, which inspire all city inhabitants to participate in social life. Implementation of universal design principles in the spatiotemporal modelling practice will allow fulfilling of the needs of the current users of the space as well as maintaining the status of inclusivity for future generations of city residents. The analyses performed by the author of the paper clearly indicate that the spatial-analytic methods applied to date have not been taking into consideration the necessity of collecting and processing data regarding the real accessibility of city spaces and facilities. At the same time, a dynamic development of spatiotemporal modelling tools and building systems without the information about various barriers could make it impossible to develop a city in a controlled way in terms of the accessibility and safety of its spaces, according to the principles of universal design. From today's perspective, a key role should be played by the local authorities, which in cooperation with nongovernmental institutions and organizations of persons with various disabilities, are capable of creating detailed datasets based on the audits of the accessibility of city spaces and facilities; at least, those which are crucial for the city and its citizens.

An equally important role is played by urban planners, programmers, and researchers in other fields including spatial-analytics and cooperating with the residents and space users with various dysfunctions of their bodies. It is suggested to accept the following phases in the future research projects within the field of spatiotemporal modelling:

- The first phase should involve a systematic review of literature and design connected with the process of urban planning using the spatiotemporal modelling methods. Based on the evaluation of the obtained knowledge, it should be attempted to identify the successes and mistakes in this field, both in terms of theory and practice.
- In the second phase (involving field studies), it is suggested to conduct a critical assessment of the realization of the projects, based on their analysis (which can be done using the method developed by the Commission for Architecture and Built Environment in 2000). It should include landscape developments on the micro- and macro-scale (arrangement of squares and streets, new and adapted buildings, lighting), wheel and pedestrian traffic with infrastructure, totality of

governance of the subject public space with the participation of the local community, particularly of persons with various disabilities, when conducting the audits of architectural facilities and public spaces.

- The next phase involves direct interviews (with residents and space users with various restrictions of mobility and perception) and indirect interviews (with institutions and organizations consociating these persons). This phase should provide an empirical basis for the recognition and assessment of the local views not only about the quality of public space, but also about the principles and purposefulness of the community participation in and their influence on this process.

- In the last phase, which closes the research project, it will be necessary to summarize the conclusions and assess them in the context of the objectives of the project. On this basis, the final results of spatial planning should be presented in accordance with the principles of universality. It is recommended to develop guidelines for the basic phases of the design process using spatial analytics methods and prepare a set of indicators pointing the way towards obtaining solutions which would be considered optimal from the point of view of universal design and sustainable development.

The realization of the research project and its implementation in the practice of spatial planning in Poland is currently in the first phase. The task has been taken up by a team of specialists in different fields and is being developed on the example of the city of Łodź. To date, the participation in the project has been declared by three local scientific research institutes: the Department of Regional Economics and Environment (Institute of Spatial Economics, Faculty of Economics and Sociology, University of Lodz), the Department of Architecture and Urban Planning (Faculty of Civil Engineering, Architecture and Environmental Engineering, Technical University of Lodz), and the Spatial Economy College (Technical University of Lodz). The general conclusions discussed in the paper were presented by the author at the international scientific conference of the fifth City Space Forum, which has become a national platform for the exchange of ideas and experience of all parties responsible for the quality of life in urban spaces: local authorities, urban planners, sociologists, contractors, and entrepreneurs. At the present moment, the preparations for the second and third phase of the project are underway; the participation in which has been confirmed by The Association of Polish Town Planners, the Office of the Main Architect of Łodź, and the local section of the Foundation for Active Rehabilitation, which is running a program of social and professional rehabilitation for disabled people in wheelchairs who had suffered a spinal cord injury.

5. Conclusions

Respecting the principles of social equality and introducing universally designed elements into city spaces can have a considerable influence on raising the level of participation and integration of residents, through ensuring flexible and adaptable zones designed for all users and for various activities. Thus, in order to make the city tissue develop in a sustainable way, the process of its conscious creation should follow the rules of full accessibility for all users, including the groups which so far have been spatially discriminated against. The attention of the representatives of urban planners and specialists in spatial economy as well as the local authorities should be directed to all kinds of typologies of city users: citizens, residents, and tourists, with particular care devoted to all weaker categories including persons with dysfunctions in mobility and perception, mentally handicapped individuals, elderly persons, children, and pregnant women. The factors connected with the ability to move, see, hear, and understand, as well as environmental sensitivity, are of paramount importance. Implementation of the principles of universal planning is a necessary condition for the creation of healthy urban communities developing in the right direction. In the opinion of the author, obligations enshrined in the statutory goals of national associations of town planners should be immediately supplemented with the standards for creating full accessibility, so that the proposed solutions for the Polish space would not be harmful for persons with reduced functionality. Uncompromising

implementation of all universal design principles in the design practice is not always possible or necessary. The history of 20th century urban planning proves that social equity ideas have a great power and influence on people's imagination, although they might sometimes seem to be excessively dogmatic. However, there is a necessity to develop an open attitude and increase the knowledge concerning potential space barriers, which in the future will allow making rational and socially responsible decisions to ensure that the level of the autonomy of each person could become their choice. The basis for all activities should be the perception of all residents as active participants of city life, whose discrimination becomes a serious obstacle in the realization of the strategic idea of social sustainability and its goals, inter alia, creating equity, democracy, social homogeneity, and equitable access to resources and social services. It should be emphasized that the research conducted by the author revealed that both traditional and emerging indicators of social sustainability in such cities as Lodz are considerably under-reported.

Finding effective and reliable analytical tools which will enable conscious and perspective development of healthy cities in accordance with the idea of sustainability has become both a chance and a challenge for contemporary planners. The analyses of international researchers show that the main obstacle for the implementation of the discussed idea in the planning practice is the current limited ability of the professionals to use the novel tools for modeling accessibility. In the opinion of the author, an additional difficulty will be posed by the lack of knowledge of contemporary planners concerning the needs of persons with disabilities and potential spatial barriers, leading to a situation in which residents are unable to make a proper use of the city space. Thus, it seems crucial to keep raising the issues discussed in the paper and trying to develop multidisciplinary cooperation regarding persons with disabilities, because it is going to extend the citizens' awareness of their rights and inspire the professionals to take advantage of the new tools for the examination of spatial accessibility. Transition from the micro-planning to the macro-planning scale and following the principles of universal design at the stage of the formation of urban planning concepts using spatiotemporal modelling methods may lead to the creation of harmonious accessible spaces adapted to the needs of present and future users, which will generate sustainable development and lead to the healing of the city in its social aspect.

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References

1. Woodcraft, S.; Hackett, T.; Caistor-Arendar, L. *Design for Social Sustainability: A Framework for Creating Thriving New Communities;* Future Communities. 2011. Available online: http://www.futurecommunities.net/files/images/Design_for_Social_Sustainability_0.pdf (accessed on 8 January 2018).
2. *Design for Social Sustainability*. Future Communities (n.d.). Available online: http://futurecommunities.net/design-social-sustanability (accessed on 9 March 2013).
3. Convention on the Rights of Persons with Disabilities. 13 December 2006, A/RES/61/106. Available online: http://www.un.org/en/development/desa/population/migration/generalassembly/docs/globalcompact/A_RES_61_106.pdf (accessed on 2 May 2018).
4. Kadir, S.A.; Jamaludin, M. Universal Design as a Significant Component for Sustainable Life and Social Development. *Procedia Soc. Behav. Sci.* **2013**, *85*, 179–190. [CrossRef]
5. Axhausen, K. Accessibility: Long-term perspectives. *J. Transp. Land Use* **2008**, *1*, 5–22. [CrossRef]
6. Brömmelstroet, M. Performance of planning support systems: What is it, and how do we report on it? *Comput. Environ. Urban Syst.* **2013**, *41*, 299–308. [CrossRef]
7. Brömmelstroet, M.; Curtis, C.; Larsson, A.; Milakis, D. Strengths and weaknesses of accessibility instruments in planning practice: Technological rules based on experiential workshops. *Eur. Plan. Stud.* **2015**, *23*, 1–20. [CrossRef]
8. Curtis, C.; Scheurer, J. Planning for sustainable accessibility: Developing tools to aid discussion and decision-making. *Prog. Plan.* **2010**, *74*, 53–106. [CrossRef]

9.   Curtis, C.; Scheurer, J.; Burke, M. Using new accessibility tools to guide policy innovation. *Built Environ.* **2013**, *39*, 454–472. [CrossRef]

10. Hull, A.; Silva, C.; Bertolini, L. (Eds.) *Accessibility Instruments for Planning Practice*; COST Office: Porto, Portugal, 2012; ISBN 978-989-20-3210-8.

11. Klosterman, R.E. Planning support systems: A new perspective on computer-aided planning. In *Planning Support Systems: Integrating Geographical Information Systems, Models and Visualization Tools*; Brail, R.K., Klosterman, R.E., Eds.; ESRI: Redlands, Canada, 2001; pp. 1–23.

12. Meadows, D.H.; Robinsons, J.M. The electronic oracle: Computer models and social decisions. *Syst. Dyn. Rev.* **2001**, *18*, 271–308. [CrossRef]

13. Papa, E.; Silva, C.; Brömmelstroet, M.; Hull, A. Accessibility instruments for planning practice: A review of European experiences. *J. Transp. Land Use* **2016**, *9*, 57–75. [CrossRef]

14. Papa, E.; Coppola, P.; Angiello, G.; Carpentieri, G. The learning process of accessibility instrument developers: Testing the tools in planning practice. *Transp. Res. Part A Policy Pract.* **2017**, *104*, 108–120. [CrossRef]

15. *Strong and Prosperous Communities. The Local Government White Paper*; Presented to Parliament by The Secretary of State for Communities and Local Government by Command of Her Majesty. October 2006. Available online: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/272357/6939.pdf (accessed on 8 January 2018).

16. Colantonio, A. Social Sustainability: Linking Research to Policy and Practice. Available online: http://ec.europa.eu/research/sd/conference/2009/papers/7/andrea_colantonio_-_social_sustainability.pdf (accessed on 27 January 2013).

17. Sharifi, A.; Murayama, A. Changes in the traditional urban form and the social sustainability of contemporary cities: A case study of Iranian cities. *Habitat Int.* **2012**, *38*, 126–134. [CrossRef]

18. *Universal Design—Clarification of the Concept*; The Norwegian Ministry of the Environment. November 2007. Available online: http://www.universell-utforming.miljo.no/file_upload/uniutf%20a4%20polsk-eng_v8.pdf (accessed on 28 December 2017).

19. North Caroline State University, College of Design (NCSU). The Center for Universal Design. 1997. Available online: http://www.design.ncsu.edu/cud (accessed on 21 May 2010).

20. Town and Country Planning Association (TCPA). Applying Inclusive Design Principles to eco-Town Development: Ecotowns Inclusive Design Worksheet. 2009. Available online: https://www.tcpa.org.uk/eco-towns-advice-worksheets (accessed on 2 January 2018).

21. United Nations Research Institute for Social Development (UNRISD). Social Development in an Uncertain World (UNRISD Research Agenda 2010–2014). 2011. Available online: http://www.unrisd.org/80256B42004CCC77/(httpInfoFiles)/43BFA3387807E7E680257920004253C7/$file/ResAge10-14a.pdf (accessed on 2 January 2018).

22. Choguill, C.L. Developing sustainable neighbourhoods. *Habitat Int.* **2008**, *32*, 41–48. [CrossRef]

23. Bramley, G.; Dempsey, N.; Power, S.; Brown, C.; Watkins, D. Social Sustainability and Urban Form: Evidence from five British cities. *Environ. Plan. A* **2009**, *41*, 2125–2142. [CrossRef]

24. Dave, S. Neighbourhood Density and Social Sustainability in Cities of Developing Countries. *Sustain. Dev.* **2011**, *19*, 189–205. [CrossRef]

25. Dempsey, N.; Bramley, G.; Power, S.; Brown, C. The social dimension of sustainable development: Defining urban social sustainability. *Sustain. Dev.* **2011**, *19*, 289–300. [CrossRef]

26. Weingaertner, C.; Moberg, Å. Exploring Social Sustainability: Learning from perspectives on urban development and companies and products. *Sustain. Dev.* **2011**, *22*, 122–133. [CrossRef]

27. Duncan, R. *Universal Design—Clarification and Development*; A Report for the Ministry of the Environments, Government of Norway. March 2007. Available online: http://www.universell-utforming.miljo.no/file_upload/udclarification.pdf (accessed on 8 January 2018).

28. National Center for the Dissemination of Disability Research (NCDDR). *Accessibility in Our Built Environment: Visitability*; Focus. Technical Brief Number 8; 2004. Available online: http://www.naric.com/research/rehab/download.cfm?ID=100998 (accessed on 17 May 2012).

29. Carmona, M.; Heath, T.; Oc, T.; Tiesdell, S. *Public Spaces-Urban Spaces*, 2nd ed.; Architectural Press: Oxford, UK, 2010; ISBN 978-1856178273.

30. Alexander, C. *Notes on the Synthesis of Form*; Harvard University Press: Cambridge, MA, USA, 1971; ISBN 978-0674627512.

31. Kozlowski, M. The Emergence of Urban Design in Regional and Metropolitan Planning: The Australian Context. *Aust. Plan.* **2006**, *43*, 36–41. [CrossRef]

32. Frey, H. *Designing the City-Towards a More Sustainable Urban Form*, 1st ed.; E & FN Spon: London, UK, 1999; ISBN 0-203-37501-7.

33. Seifert, I. Collaborative Assistance with Spatio-Temporal Planning Problems. In *Spatial Cognition V, Proceedings of the International Conference Spatial Cognition 2006, Bremen, Germany, 24–28 September 2006*; Barkowsky, T., Knauff, M., Ligozat, G., Montello, D.R., Eds.; Springer: Berlin/Heidelberg, Germany, 2007; pp. 90–106.

34. Sevtsuk, A.; Mekonnen, M. Urban network analysis. A new toolbox for ArcGIS. *RIG* **2012**, *22*, 287–305. [CrossRef]