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Visual Aid Systems from Smart City to Improve the Life of People with Low Vision

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Abstract: In the current time, the development of urban centers is a very complex process in terms of new residential or administrative building locations expansion, but also in terms of design and/or the combination of the constructions with the environment. In the same context, the various transport development, communication or social activities facilities require an important database and an infrastructure to ensure and satisfy the population needs at the highest level. Accordingly, interest has developed in the smart cities (SC) concept creation with connection possibilities over extended geographical areas. This paper addresses a problem related to the preparation and ensuring the development of Brasov city as a smart city, with the possibility of finding solutions for low-vision people's mobility and opening even more access to the city's infrastructure. The paper's main objectives and contributions are represented by the current considerations provision for ensuring functionality as a smart city by identifying the involvement points of the administrative system and, respectively, by introducing technical solutions for the low-vision people inclusion, having their mobility as a central element. The research results reveal the capacity and flexibility of permanent adaptation actions of public administrative and educational/research institutions to different population categories (with or without disabilities, active or retired, etc.) requirements regarding inclusion and mobility.

Keywords: smart city; visual disabilities; visual aid; low vision; digital healthcare

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1. Introduction

The term smart city (SC) introduced in various research papers [1–3] is relatively newly approached in the development of modern concepts related to the dynamics of urbanization growth and the modernization of the infrastructure of residential areas. In addition, urban development projects take into account some of the early design principles of smart city models but are still limited only to the integration of intelligent modules in the already existing structure.

Although there are, at present, many researchers who have developed a series of models and concepts related to the smart city field, nevertheless their results prove useful only from the perspective of quickly obtaining the answers of the systems used and perhaps less from the point of view of interconnections with the complex of integrated systems. That is why a smart city is not only composed of separate structures of smart systems, but these must be integrated as a unitary whole to create a complex system that is flexible, dynamic, possible to model and modulate, and also connected informationally with other similar systems built on similar principles and from different locations. A smart city is therefore constituted as an integrated structure with flexible development capacity and permanent self-control so that it does not become a closed, immovable, and difficult-to-integrate structure.

In general, a smart city must include, as established by theoreticians [1,4], a group of modules that are smart, which circumscribe the important properties of a smart city, as shown in Figure 1. In this work, the authors propose the completion of the analyzed model [5,6] with three submodules identified to be important in the development of the city of Brasov. An extremely important aspect it constitutes, in addition to the other smart modules, is the inclusion of this new urban form in the natural ecosystem of the analyzed geographical area. A smart city must be supported by a series of modules also included in the smart and digital features category that form an integrated system, to which can be added the special requirements, the associated ecosystem, and, respectively, the special development in relation to the local geo-characteristics. The theorized system can also contain other submodules specific to population areas, primary or special requirements, and, last but not least, regional development requirements.

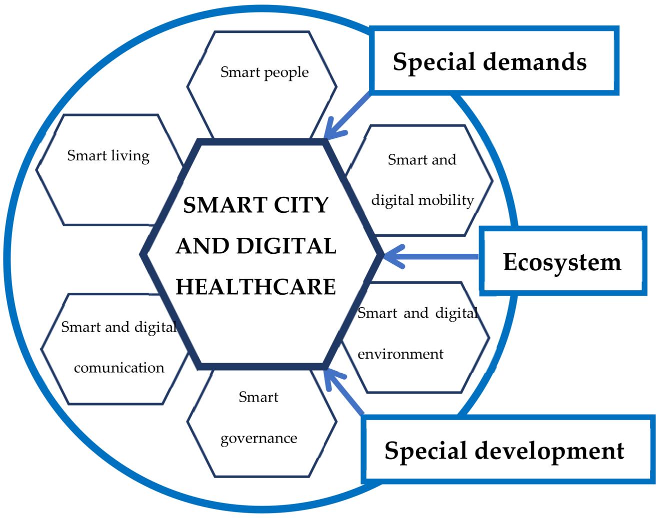


Figure 1. Smart city domains.

In order for a city to become smart, practically, it must be connected and developed based on digital communication technology (Figure 2) for real-time acquisition of active and reactive information from participants and also to offer options and mobility solutions, information transfer, and accessibility of all categories of citizens in different important areas, as well as fast and efficient inclusion.

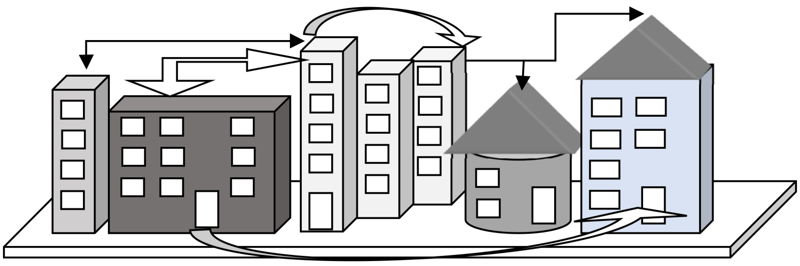


Figure 2. Smart cities with multiple data connections.

The special problems of citizens, such as disabilities, which can generate submodules of special requirements and development, can be approached from several points of view so that the solutions lead to the establishment of inclusive techniques and technologies that are beneficial for the integration in a smart city of an efficient healthcare system [5].

One of the forms by which a city can be transformed into a smart city is the introduction of functional features possible through digital information and interactive communication technologies, which allows (not only in the medical field) the transfer of data from various important urban centers (administrative, public or private) to users of any kind (with or without special requirements). In general, these centers must be grouped in an easily accessible area from the road or pedestrian area, with specific markings for orientation and positioning.

The most frequent such special problems of citizens are those related to disabilities and lack of mobility and are often associated with visual dysfunctions or auditory perception, thus determining that the effective solutions and options for solving these special requirements impose the character of an efficient smart city, accessible and inclusive with digital healthcare features.

The most important problem regarding mobility in this type of urban architecture is the access, movement and positioning of these people with different forms of disability in relation to areas of public or private interest (Figure 3). The concept underlying any urban arrangements methodology is based on ensuring a flow of mobility that does not restrain movement, does not allow the occurrence of blockages or random deviations from normal routes, and provides comfort to the participants, regardless of which category they belong to. The specialized research carried out in this field highlights a series of aspects that can be generalized at the macro level, but also some particular aspects, specific to the geographical area, corresponding to the diversity of the population or the regional socio-economic and cultural development.

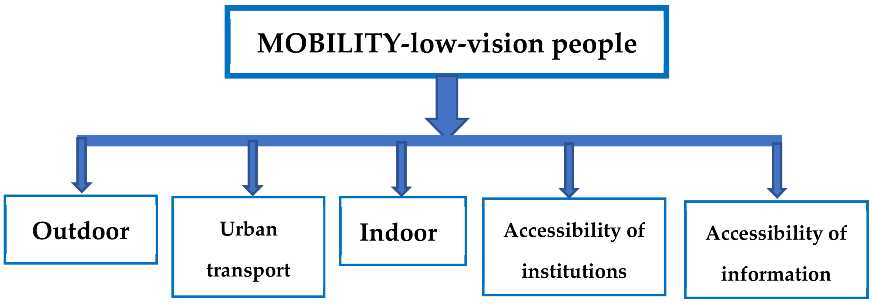


Figure 3. General aspects of low-vision people mobility.

2. Scientometric Analysis of the Development of Research on Smart Cities for Low-Vision People and Digital Healthcare

In the last period, the aspects related to the development of different forms of smart city (SC) have attracted a series of research and project designs both from the academic environment and from the economy due to a set of specific characteristics of urbanization, computerization and perhaps not least, globalization. Therefore, according to the European Commission [4], an intelligent city "is a place where traditional networks and services are made more efficient with the use of digital solutions for the benefit of its inhabitants and business", and the British Standards Institution BSI completes these aspects by creating a general smart city concept model SCCM (smart city concept model) "to describe a framework in which data flowing around a city, can be discovered and joined up", which a series of research adopts with the aim to make activities more efficient and to increase the quality of life [7]. In general, multiple reviews of the fundamental or applied research literature on the characteristics of smart cities have been carried out, but there is still a lack of quantitative and qualitative systematic investigation and a multidisciplinary examination of the structure and evolution of this field, especially the one oriented towards the population with special needs.

These scientometric techniques are combined to reveal the following aspects, which must:

- identify the intellectual division of this developing field using a broad approach,
- identify the basic research sub-modules in this field with references (ecosystem combined with smart city, special demands, etc.),
- identify areas of big data and digital transmission of information, especially in the field of digital healthcare through technologies for the planning and development of SC with economic, social and cultural specificity,

- demonstrate that smart and sustainable cities must contain the two emerging directions with the aim of efficiency and achieving the inclusion of all categories of the population to ensure an optimal level of digital healthcare and social integration [5].

Obviously, in order to implement a first emerging urban strategy, mechanisms must be generated to use digital technologies and large databases to help improve the quality of life of urban residents. In the last decade, more and more researchers have studied smart cities, and the amount of specialized literature in this field is growing rapidly, causing the creation of a cloud of big data structures [8].

That is why the authors of this work have set a clear objective, namely to study these studies in the field of the smart city concept, to identify the topics of major interest for low-vision people in these urban areas, and to find new solutions to their problems. In the same context and looking at the research as a whole, the main topics, as initiated by the researchers and presented in [8], can be divided into three priority areas:

- "the concepts and elements of the smart city", to which this research can be added accordingly,
- the smart city concept oriented towards the provision of visual aid systems for the population with low vision [9],
- the integrated smart city.

For this, even in these new priority areas, four important directions of action were identified:

- (D1) "research objectives and development strategy",
- (D2) "research to ensure technical support",
- (D3) "data processing and applied research",
- (D4) "management of inclusive activities and integrate through applied research" [8].

In this sense, but especially at this moment after the pandemic period of 2020–2022, another aspect of the development of smart cities has been highlighted, namely the resilience factor, which refers to continuous adaptation so that the smart city system and people can recover the necessary balance and performance, even when adversity and diversity of situations manifest in all its modules and forms [9]. As shown in various research papers [10–13], the characteristic of resilience appeared as an attractive and complex perspective, regarding urban settlements, often in the theorized form of highly diversified adaptive systems but with integrated flexibilization possibilities. Most researchers consider at this moment that resilience has only been taken into account in a theoretical and abstract way; therefore, it can be effectively guided, through the specific procedures of risk management, along with the combined use of planning and the practice of resilience based on principles of flexible and adaptive decisions, towards any changes or demands from the population. In addition, the concept of smart city resilience, through its defining parameters, is starting to become more and more important in terms of the need to identify development gaps, find effective solutions that can be particular or generalizable, quantify different levels, etc., representing at the same time possible open paths for future interdisciplinary research.

In order to better understand the context of smart city research, including topic distribution, knowledge bases, and research frontiers in the field, this paper draws on the Web of Science (WoS) core collection of published articles and uses the keywords of this work: smart city, visual disability, visual aid, low vision, digital healthcare, as shown in Figure 4.

The authors of this work established within the scientometric research a set of terms to define the research field, and the VOSviewer software application downloaded works with this profile from the Web of Science database. On the other hand, from the study, the specific studies of the authors in this field were analyzed, as well as other works published in specialized journals, in order to be able to cover as comprehensive an area of problems as possible.

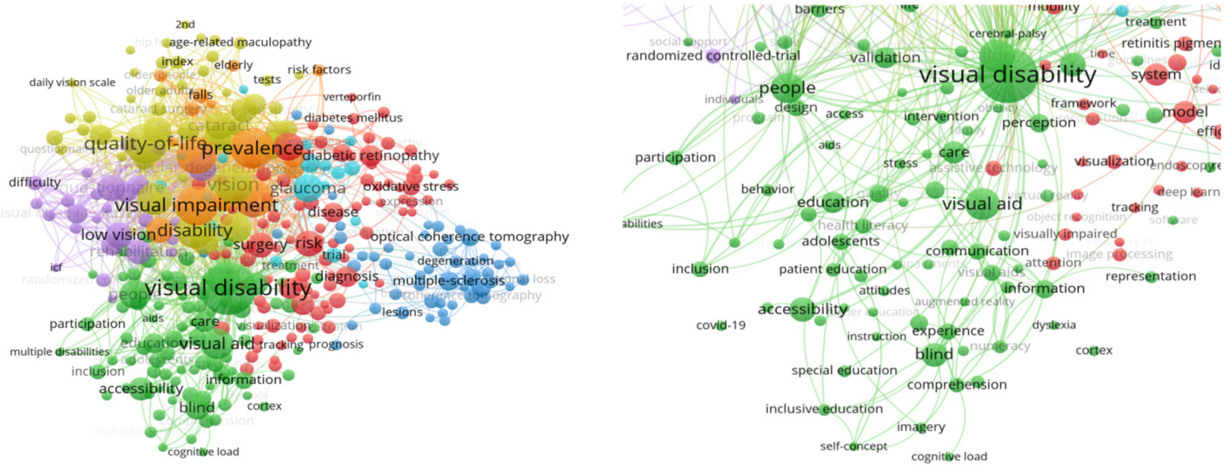


Figure 4. Scientometric analysis using WoS articles database.

The method used in scientometric identification is that of covering and comprehensive analysis using knowledge mapping in terms of diversity, time segmentation and activity dynamics, using the VOSviewer software application to study the literature in the field.

This paper approached a scientometric review of the progressively synthesized network derived from the use of 6753 keywords, and the terms that appeared at least 5 times were included in the research. Thus, the research was limited to 341 keywords used by bibliographic records from a search for topics related to smart cities, people with low vision, and visual aid systems. The concurrent analysis of the categories is carried out to explore the evolution of the fields involved in SC research for the population with special needs, the key points in each field and, of course, the connections between them.

Therefore, from all these forms of bibliographic research, it was identified that there is a lack of articles dealing with the research topic generated by the keywords visual needs in smart city, visual aid systems, and low-vision people, and that is why this article aimed to cover this need for information. This situation can also be explained by the fact that the field is very current and has only recently been approached at the level of fundamental and especially experimental research, and the dynamics of the development of smart city models and models of inclusion of low-vision people must find their way implementation in different areas, each with its own specifics.

3. Research Methodology for the Analysis of Visual Aid Systems for Low-Vision People in Brasov City as A Smart City

The main hypothesis and goal of the research in this paper were achieved by designing and developing an analysis methodology based on three complex modules that all have at their center the sample of low-vision people with special needs integrated into the smart city concept.

These modules, seen as the main research objectives, are:

- (O1) analysis of urban and administrative arrangements to ensure the mobility (outdoor/indoor) of these people with low vision in good conditions,
- (O2) analysis of the involvement of public and private institutions in the integration of people with special needs (inclusive visual aid systems),
- (O3) preliminary evaluation of the needs for the use of some specific facilities determined by the visual aid systems for people with low vision related to the characteristics of smart communication. This assessment is based on a questionnaire and an analysis of the answers of users in the category of people with low vision regarding the access and integration of low-vision people in current activities or in those dedicated to them, in particular.

The methodology used for the three main objectives is based on the principles of direct observation, the analysis of official documents in this field, the critical analysis of the visual aid systems, and, respectively, the analysis of the answers to the applied questionnaire. From the point of view of data sources, the authors accessed and studied the official documents of the Brasov city administration regarding the development of this area as a smart city and, respectively, the national and European projects in which the city of Brasov was involved [6,14–19], then the information was completed through scientometric research on the research fields related to the smart city concept, components or solutions. The content analysis of the documents, the critical analysis of the information, and the direct observations on the results of other research on the city of Brasov represented the key points that generated the identification of aspects related to the problem of low-vision people and their social inclusion by ensuring their mobility facilities.

Thereby, it was found that a series of research activities in which public administrative institutions are involved (Brasov City Hall, National Statistics Center, ADR Center—regional development center, etc.) took into account a range of aspects that concentrated in the Center Region Development Plan for the period 2014–2020, performing a socio-economic analysis of the Center Region, in which the city of Brasov in Romania is geographically located. This strategic plan analyzes, first of all, a series of demographic indicators through which the specifics of the population can be highlighted and, respectively, their needs (social, economic, health, educational, communication, transport, etc.) [15]. From the analysis of population samples from the Brasov metropolitan area, some important data emerged, such as a percentage increase of approx. 20% of the population over 65 years old and, respectively, a decrease of over 17% of the population under 19 years old [15].

That's why, as shown by this document produced at the level of the municipality of the city of Brasov, even if currently the active population sample is in a dominant percentage (over 70% of the total population), still, "trends in age groups reflect a decrease in this specific social category and an increase in the numerical and percentage levels of retirees, with direct consequences not only on the social security and health system but also on the city itself which will need to adapt to the retirees' needs" [6,15] or their special health needs and special ways to communicate and also their travel requirements. This demographic factor, viewed from the perspective of the future years, especially from the point of view of ensuring the inclusion of the population with special needs, but also of resilience, requires integrated approaches of the levers through which these desired goals can be achieved. All this cannot be achieved without massive and correlated involvement of the administrative institutions resident in this city, of public and private companies, the educational and health systems, f the media, social or field-specific non-governmental organizations, environmental organizations, etc.

3.1. Analysis of Urban Arrangements for People with Low Vision with the Aim of Ensuring Their Indoor and Outdoor Mobility

As can be seen from official documents and specialized literature [16], the main element that is emphasized in defining an urban center as a smart city in Romania is defined by the degree of intelligent mobility (with a number of 188 of projects), followed by intelligent governance (with a number of 130 projects). Obviously, the smart living projects with a number of 121 projects, smart medium with 42 projects, and smart people with 29 initiatives are for the 4 important cities in Romania (Brasov, Bucharest, Cluj-Napoca and Sibiu) and analyzed together [16], a development portfolio towards the established objectives.

In this paper, the authors started from the key phrase, which also defines the objective (O1) and materializes as an extremely important activity for low-vision people, namely movement/mobility in a state of comfort and safety. Through this analysis carried out in the urban space of Brasov, the aim was to highlight the development of certain facilities at the indoor/outdoor level, which will come to the support of these people and obviously to identify the areas of action towards which the efficiency process should be directed in the future.

The first example in this sense is the action of traveling with public transport and the accessibility (registration, information, etc.) of these mobility systems by people with low vision.

Consequently, in order to ensure easy use for all groups of people, the means of public transport are provided with appropriately marked boarding/disembarking ramps and, in case of need, when this is requested, operated by the driver of the vehicle, thus facilitating the boarding/disembarking both of people with locomotor disabilities and those with low vision, or mobility escalator, outdoor/indoor, as shown in Figure 5.

Figure 5. Arrangement of public transport for safe/comfortable boarding and traveling (outdoor/indoor).

Also, to ensure the accessibility of this population sample (with special needs), the parking areas (exterior and interior) of passengers using urban public transport vehicles, the means of information about routes/timetables, and payment of the trip are intended to be easily identified and used in optimal conditions, as shown in Figure 6.

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

Figure 6. Means of information and travel payment for low-vision people. (**a**) audio information means for outdoor/indoor travel. (**b**) travel payment systems.

In addition, the introduction of access to the urban internet network, provided in the means of transport, makes possible both quick information and the payment of the trip by using the QR code read by the smartphone and, respectively, self-pay. In the areas of pedestrian travel to or from a series of public or private institutions for people with low vision or with other different disabilities, we have placed options for signaling safe and useful spaces, such as those shown in Figure 7. Movement in pedestrian areas as well as crossings is also signaled by specific asphalt carpets and, respectively, by warning with road signs or sounds of the safe passage period and, respectively, the display of the traffic light color, according to those in Figure 8a,b.

The facility for people with low vision to interact with different public or private institutions (administrative, educational university, shop, hypermarket, mall, medical office, etc.) is not quantified only at the level of urban transport but also at the mode of access in these buildings.

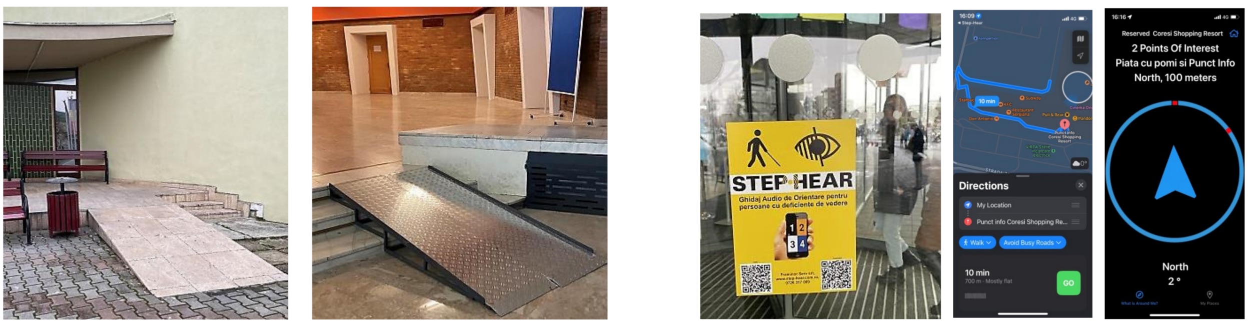
An example in this sense is offered by Transilvania University in Brasov, which has arranged the spaces of interest with ramps for going up/down between different areas both at the entrance and inside, according to Figure 9a. In addition, in the city of Brasov, there is a complex shopping center ("Coresi" mall) that people with low vision can access and navigate to different locations in this space thanks to a system based on a STEP-HEAR smartphone application and sensors placed in the building, as shown in Figure 9b.

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

Figure 7. Markings and signaling for crossing roads specifically for low-vision people. (**a**) asphalt carpet marked for pedestrian crossing. (**b**) signalization crossing for blind pedestrians.

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

Figure 8. Markings and signaling for crossing roads specifically for low vision. (**a**) sound signaling of the safe crossing period. (**b**) sound signaling of the traffic light display when blind pedestrians cross in urban development.



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

Figure 9. Access systems outside and inside some public or private institutions. (**a**) external and internal access systems in the Transilvania University of Brasov. (**b**) guidance system for low-vision people in the shopping center (Smartphone application).

As stated by the vice-president and spokesperson of the Brașov Blind Association, the STEP-HEAR software application is "designed for guiding people with visual disabilities through smartphones, complements the classic guidance systems, having the advantage that it can be easily adapted to the needs of users by adjusting the parameters in a short time" [17].

This type of application is useful for visually impaired people because it is a system that directs low-vision people exactly to the point they are looking for (if they cannot manage the map); they also use a "virtual compass", as in Figure 9b. In addition, through this application, it is possible to detect all the devices available around (about 33 of such devices) and transmit to the user, in the headphones, how far he must go and in which direction. In this way, the pharmacies, Info points, toilets and all the shops in the shopping center are signposted by name.

In the same sense, within this analysis, it is possible to identify an average level of adaptation and only where necessary, of the constructions in the residential areas, for people with low vision, by using the transmission of information with the help of the Braille alphabet (elevator, floor, etc.) as shown in Figure 10a,b.

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

Figure 10. Access systems outside and inside using information in Braille alphabet. (**a**) external and internal access system signaled in Braille alphabet. (**b**) access system written in Braille alphabet.

By analyzing these problems related to transport and mobility, information and accessibility in the city of Brasov indoor/outdoor regarding the field as a whole and making a report on the program [18] developed by the administrative institution of the town hall (MOBILITAR), they could separate a series of important aspects summarized like (1) Transport—outdoor/indoor information, access in/from the car; (2) Road markings; (3) Signaling and safe mobility; (4) Access to buildings of public and private institutions (exterior/interior); (5) Appropriate information for low-vision people; (6) Internet in means of transport and in institutions; (7) Institutions adapted to the needs of low-vision people.

Therefore, the following conclusions can be drawn from these aspects analyzed within the objective (O1), which have as their central point the modes of travel/mobility in a state of comfort and safety for low-vision people (Figure 11):

- Public transport is provided by electric and hybrid vehicles, which contribute to the protection of the urban environment and the implementation of smart transport in Brasov;
- In a very large proportion and corresponding to residential areas, public transport vehicles are equipped with ramps for boarding/disembarking, thus facilitating movement in safe and comfortable conditions;
- Road markings for low-vision people are made in areas with heavy traffic, commercial areas, or important public institutes;
- For efficient and useful information for all traffic participants (regardless of whether or not they belong to the category of those with special needs), the use of the Internet in areas of interest and in the respective means of public transport, sound signals, markings visible at any time is the most practical and efficient way to ensure the safe and comfortable movement of all traffic participants;

- In addition, public and private institutions adapt to the requirements of people with special needs by introducing signs, information, and methods of interaction corresponding to the requirements.

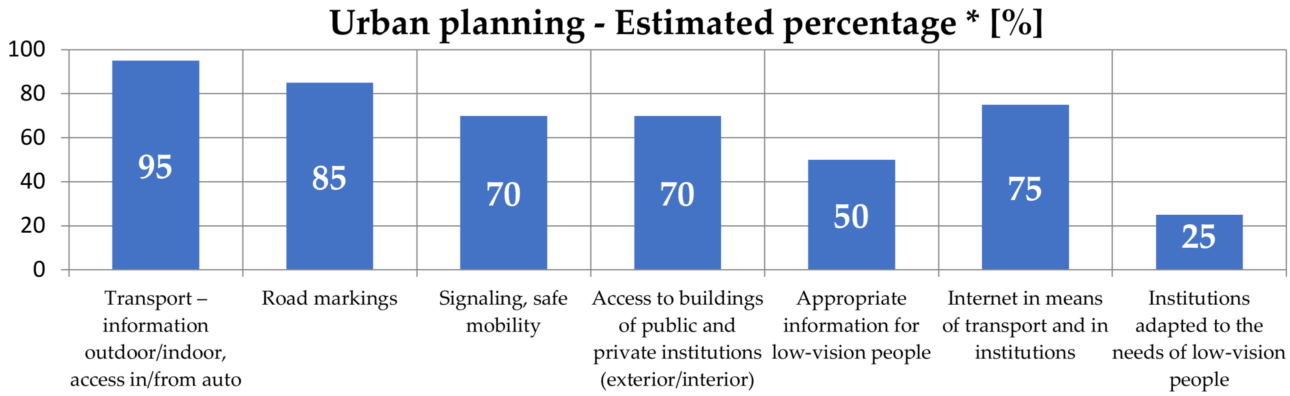


Figure 11. Estimated percentage analysis of the relevant aspects of urban arrangements corresponding to the indicators of the objective (O1) (Note: * values determined by direct observation and analysis of public information).

The future development of other facilities or the improvement of the existing and already verified as useful constitutes the next step, especially taking into account the demographic evolution and the demands expressed by the citizens through dialogues with the representatives of the public administration.

The implementation on a larger scale of visual aid systems and specific digital applications, expanding the communication system between different public and private institutions, and even solving specific problems in the field of ensuring the inclusion of low-vision people stand out as the most effective methods efficient in the sense of integration into the smart city category of the city of Brasov.

3.2. Involvement of Public and Private Institutions—Public Administration, University, Association of the Blind from Brasov, Media Institutions, Municipal Library

3.2.1. The Involvement of the Public Administration of the City of Brasov

In the same context, the competent bodies of the Brasov municipality, through the development of the MOBILITAR project, as a platform where a series of "sessions dedicated to accessibility, mobility culture and integrated mobility, then various research workshops for the development of prototypes for the main roads and intersections are held, communication and education tools for transit behaviors, digital mobility services" adapts and connects to the special requirements of the citizens, to the development requirements, and to the implementation in an efficient ecosystem of the city of Brasov. Each of these prototypes, as shown in the project documents, "will have to be introduced in stages in the coming years at the level of the city and the metropolitan area and will be linked to local development strategies", as the smart city of the Brasov area [18,19].

As mentioned in the public documents of this project, "in the long term, MOBILITAR wants to influence the behavior of citizens and tourists by promoting sustainable mobility, and this would benefit the environment, improving the quality of life at the same time." At the same time, they hope for "the promotion of active citizenship, in processes of encouraging cooperation based on cohesion, empathy, sustainability, professionalism and integrity between local authorities and interested parties".

This project, integrated into the TOMMOROW platform [18] and including the city of Brasov in a group of six other European cities from France, the Netherlands, Belgium, Romania, Serbia and Spain, mainly aims to increase the quality of life of citizens by achieving the objectives of climate neutrality, but also by improving the mobility of all citizens regardless of whether or not they are from vulnerable categories. In the same sense, there are sustained concerns for ensuring outdoor/indoor access to public and private institutions materialized through different forms of access (ramps, elevators, special spaces, etc.) and information synthesized in public documents of the Institute for Public Policies [19].

From these analyses, the city of Brasov is in an above-average position compared to the other cities in Romania, with all the criteria analyzed, and for this reason, it continues to improve where lower values were found [19]. Therefore, the concentration of the actions of public or private institutions, local administration units, the Transilvania University of Brasov, non-governmental organizations in the field of social assistance, and other social partners constitutes the necessary, possible, and appropriate solution to achieve the goal (O2) proposed by this research, namely the analysis of the involvement of public and private institutions for the integration of people with special needs.

3.2.2. Analysis of University Research Involvement in the Visual aid Systems Development

Starting from the general strategy and the long-term vision of the development of the city of Brasov as a smart city and in accordance with the strategic development plan of the Transilvania University of Brasov, this institution, through the research work carried out over time by a series of teaching staff and researchers, got involved in concrete analysis on the smart city modules on the way to solve specific problems, but also on the main aspects of this research, namely the creation of applications for people with special needs.

In this sense, the permanent interest of the group of authors of this research work is to develop visual aid systems for low-vision people, strategies, and evaluation procedures through screening of the degree of visual dysfunction manifested in different categories of the population or even in training to specialized staff (optometrists), guidance, and support of specialists who will contribute to the integration process of the entire category of low-vision people.

The studies dedicated to this field were directed, first of all, to the knowledge of the requirements and needs, from the point of view of the visual function, of these population categories and to their permanent goal, the development of efficient, useful, reliable and accessible visual aid systems.

These visual aid devices are the subject of experimental research to identify those variants that satisfy the needs of mobility, information, and access to public administrative, economic, financial, or cultural institutions and that offer users that personalized level of independence, safety, and comfort occupational. Visual aid systems, such as those shown in Figure 12, are currently supporting those people with low vision by offering a smart environment and which can also lead to the increase and improvement of the quality of life of the users, i.e., to a form of smart living—an essential element of the smart city complex, as previously mentioned.

These visual aid systems, created and developed within the laboratories of the university's research institute and now in the experimentation and optimization phase, start from three basic principles regarding their efficiency:

- the principle of ensuring accessibility;
- the principle of determining safety and comfort in use;
- the principle of flexibility (customization) in relation to each user.

These principles, in turn, are quantified through a series of functional, financial and informational criteria through which specific variants can be established and adapted to the needs and levels of effectiveness requested by each user.

The first criterion taken into account in the analysis of these systems was that of the constructive and functional complexity, a criterion that could sometimes limit the use of these devices efficiently and in a state of comfort. Figure 12 shows some such devices created and currently being optimized.

The second analysis criterion was that of the simplicity of the way of use by low-vision people, an essential criterion in the implementation of such systems. According to the results obtained from the tests carried out, all the proposed systems do not require too complex specialist knowledge, but only a clear understanding of how to store, use or identify faults during use.

(**a**) (**b**) (**c**) (**d**) (**e**)

Figure 12. Variants of visual aid systems [20–24]. (**a**) smart cane (IC). (**b**) stick for traveling on variable terrain (MVC). (**c**) cuff with sensors mounted on the arm (SC). (**d**) eye-tracking system (ETS). (**e**) sensory system placed on the body and leg for easy movement (SSB).

Therefore, before use, subjects with low vision are trained on how to work with these devices, the environmental and space conditions in which they can be used, and last but not least, the efficiency in different activities (normal and/or fast walking, climbing/descent, entry/exit, etc.).

The third criterion of analysis was that of the interconnection of these devices with each other or with software applications that can be used on smartphones or other IT devices. This criterion, essential in customized constructive solutions, allows the creation of diversified, flexible options, easier to adapt and use in relation to the needs of low-vision people.

All these principles of development of visual aid systems, stated previously and defined by the three criteria, were applied and analyzed on the devices presented previously and on two more variants under development, resulting in the information in Table 1.

The two devices under development (DS1 and DS2) are essentially based on the use of sensors that can be attached to the body, leg, hand, and head, respectively, to free the user from handling a dedicated cane or another device that occupies his upper limbs and limit current activity.

From the values resulting from the graphs of the calculation of the percentage values of the principles introduced in the analysis of the objective (O2) applied to the involvement of specialized research for the creation of devices dedicated to the visual aid field, several relevant aspects can be deduced:

- The systems developed up to this point have an above-average percentage (considering 50%) of ensuring the performance criteria established within the objective (O2);
- From the seventh variants analyzed, there are substantial percentage differences (>40%) compared to the performance criteria, indicating the need to design systems that are as specialized as possible, easy to use, and customized in relation to the needs of low-vision people, so such as those marked DS1 (system attached to the body and the upper part of the body-hand) and DS2 (system attached to the head and the lower part of the body-leg);
- Any other visual aid system that can be developed (in relation to the users' requirements) will have to meet the criteria applied to the principles in the objective (O2) at a higher level or at least equal to the levels already determined in order to be included in the range of systems of the smart living module.

Table 1. Analysis of devices for low-vision people *.

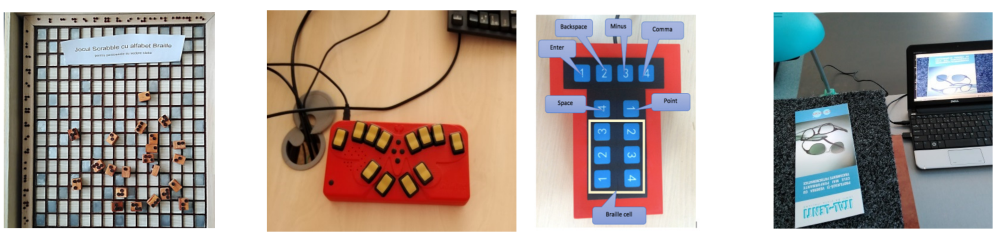
	IC	MVC	SC	ETS	SSB	DS1	DS2	Average
Principle 1—ensuring accessibility [%]								
Criterion 1 *low constructive and functional complexity*	70	80	75	85	85	90	90	82.14
Criterion 2 *simplicity of use*	95	85	90	50	80	85	80	80.71
Criterion 3 *interconnection of these devices*	15	45	50	25	70	75	70	50
TOTAL	60	70	71.67	53.33	78.33	83.33	80	70.95
Principle 2—establishing safety and comfort in use [%]								
Criterion 1 *low constructive and functional complexity*	50	75	75	50	80	85	85	71.43
Criterion 2 *simplicity of use*	90	85	85	50	85	90	90	82.14
Criterion 3 *interconnection of these devices*	25	50	40	20	85	80	80	54.29
TOTAL	55	70	66.67	40	83.33	85	85	69.29
Principle 3—flexibility (customization) in relation to each user [%]								
Criterion 1 *low constructive and functional complexity*	50	75	75	40	75	90	90	70.71
Criterion 2 *simplicity of use*	80	85	85	50	90	90	90	81.43
Criterion 3 *interconnection of these devices*	15	40	60	30	80	85	85	56.43
TOTAL	48.33	66.67	73.33	40	81.67	88.33	88.33	69.52
Average total values	54.44	68.89	70.56	44.44	81.11	85.55	84.44	69.92

* Percentage values determined by ascending evaluations (small values—low percentage of fulfillment, high values—high percentage of fulfillment).

In the same sense, the applications created for recreational activities and information transmission for low-vision people complement this range of visual aid systems and start to penetrate more and more into the daily routine.

Therefore, the analysis methodology based on the three principles and three criteria proves useful in establishing the most effective constructive solutions in relation to the needs of these people and flexible options, and they are easy to adapt and be integrated into visual aid systems that can be used simply and with beneficial effects in daily activity.

Thus, scrabble-type games were created with inscriptions in the Braille alphabet, as in Figure 13a; computer communication systems also based on Braille code access modules in Figure 13b; or video systems able to read different documents becoming, at this moment, accessible systems for low-vision people with different degrees of visual dysfunction, as in Figure 13c.



(a) (b) (c)

Figure 13. Games and Braille alphabet access systems or autofocus videocams connected with PC. (**a**) Scrabble game. (**b**) access system in Braille alphabet [25]. (**c**) videocam connected with PC.

3.2.3. Analysis of the Involvement of Non-Governmental Organizations, Media Institutions and the Municipal Library

The most important structure of involvement in the knowledge of the problem of low-vision people is represented by the "Association of the blind from Romania Brasov branch" [26,27]. Through this organization, a series of important activities are carried out for people affected by visual dysfunctions, involving different public and private institutions, individuals without visual disabilities, and specialized staff in the field in awareness, support/support, and information activities.

All these actions are intended for the development of an active and dynamic mechanism for the integration of people with visual problems in activities that offer them social and economic independence, creating those smart living and smart environment modules and acting in the sense of the special development and special modules demands. Looking as a whole, even during the pandemic, the involvement of this association, supported by other non-governmental organizations and specialists in the field, is rich, dynamic, and diversified, being focused on the transmission of useful information to its members, on training sessions, and on actions to raise awareness of the entire community about the level of special needs of this population category.

In this way, low-vision people are involved in actively participating in the development of the smart living mode, together with the other members of society, as well as in the improvement of the smart people module and, last but not least, the smart environment module. For the development towards a higher stage of these activities to support low-vision people and with the aim of increasing the integration rate in the smart city criteria, a number of three main objectives were identified, which the authors of this research analyzed according to the degree of possible, current and future implementation.

The first objective identified which can offer in the near future a greater degree of accessibility to specialized services is the specialization of a larger number of optometry centers in activities of prevention, information, rehabilitation, visual training, or even the development of specific products for people likely to become low-vision people.

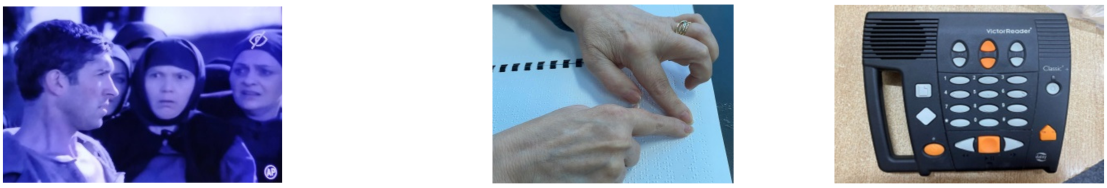
This is perfectly possible due to the existence of a very large number (>200) of optometry and medical optics centers in the Brasov metropolitan area, some of them with real professional possibilities to specialize in this direction. With this objective, the possibility of the specific development of these centers and their training in visual screening campaigns to identify early possible situations in which low vision can be established among different population samples has been highlighted through this research.

A second objective that was analyzed consisted of the need for more intensive involvement of the media, video, audio, or printed media in different specific activities and in which the person specialized in this field, together with low-vision people, develops information mechanisms, communication, and integration in support actions to obtain a state of safety and comfort for the whole community.

Even if there are currently television networks that offer the possibility of viewing some cinematographic productions (Figure 14a) for low-vision people and even if the municipal library in the city of Brasov offers an adequate service for this population sample (books in Braille alphabet, audiobooks, etc.), they are at too low a level and too little popularized so that they reach a high standard of utility, as shown in Figure 14b. An emphasis on these activities is thus required to create an appropriate framework for the integration and accessibility processes of all people already detected with low vision, but also for those who will have to adapt to the new situation in the near future.

The third important objective that was identified and analyzed for this type of involvement is the development of socialization processes and actions, support, and access to information that can be carried out jointly between non-governmental organizations, public or private institutions, scientific personalities, or cultures [26,27].

In this sense, it can be observed that a series of beneficial activities are already taking place for low-vision people, but also for the entire community of the city of Brasov, complex and combined cultural activities, as shown in Figure 15a, scientific activities, sports, as shown in Figure 15b, or thematic contests, as shown in Figure 15c, through which the process of social and economic inclusion can be achieved as quickly, easily and with benefits from all directions.



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

Figure 14. Mass media and books for low-vision people. (**a**) TV production for low-vision people. (**b**) books in Braille alphabet and audiobook system.

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

Figure 15. Various cultural, sports, and competitive activities [27]. (**a**) Concert in the dark at multicultural center of the university. (**b**) Sport activities with low-vision people. (**c**) Thematic competitions to integrate low-vision people.

But even here, the average percentage of these activities is still very low (approx. 15 events/year), possibly due to external or random causes (pandemic, economic recession, etc.). It is therefore foreshadowed, as an obvious conclusion on these situations, the fact that they must first be analyzed under all aspects, then those action strategies can be implemented and obviously overcome the forms of blockage in order to act appropriately within the special development and smart city modules as a whole, as shown in Figure 1.

The involvement of the community, of different forms of organization, seen as a whole, is a complex, long-lasting, sensitive and multi-tasking process that requires multiple, interdisciplinary approaches with specialized, social, economic, and cultural components, but also a unitary and complete strategy developed on all these levels. This type of thinking and action means the whole community is an extensive process through which all members of the community are given the same chances and opportunities to eliminate discrimination of any kind and in any situation [28–34].

3.3. Preliminary Evaluation of the Needs for the Use of Some Specific Facilities Determined by the Visual aid Systems for People with Low-Vision Related to the Characteristics of Smart Communication

Taking into account the above and from the multitude of observations collected over time, the authors of this research probed the level of understanding of visually impaired people's problems with regard to the accessibility and the possibility of information and the acceptance and use of assistive technologies to know and understand more precisely the needs of these people [35].

The qualitative research applied in this case sought answers to questions such as *why?*, *which?* and *how?*, aiming at understanding the fundamental causes of the attitudes, behaviors, preferences, and opinions of "consumers" as well as identifying the subjective, emotional, or unconscious factors that underlie them.

Subjects who answered the set of questions from 31 people from the category of low-vision people were aged > 15 years old (25.81% aged 15–20; 35.84% aged 21–24; 9.68% aged

25–30 and 29.03% over 30 years old), from both gender categories (56.67% masculine and 43.33% feminine), and with different educational levels, in order to cover as wide an area as possible of low-vision people.

The level of education was an important parameter analyzed through this questionnaire and which can indicate a very special parameter in terms of knowledge, understanding and acceptance of certain aspects of the situation in which they are and also of collaboration with specialists in the field.

Considering the high level of education of the sample (approx. 93.55% representing the summation between the college level and the university level, the rest are from the gymnasium level), the answer to the following question, "Do you use assistive technology in the learning process?" is confirmed by the maximum percentage of 100% of YES variants. These percentages reveal the importance of education and knowledge for the understanding by the users of the specialized information related to these visual aid systems.

In the same context, the answer to the following two questions confirms this need and understanding of the use of assistive technology tools under the guidance of a specialized framework (optometrist) that provides as much information as possible that personalizes the way of use or even improves the perception of low-vision people often—about the benefits of assistive technology.

The participants in this questionnaire answered in a percentage of 83.87% that it is very important to be guided by a specialist (optometrist) when choosing their mobile applications because the information is concrete, clear, and even personalized, and they can quickly understand what is useful or what is newer; and only 16.13% do not request the specialist's help (of these, 10% previously knew that application, 63.33% accepted the recommendation of a colleague/friend, and 26.67% are specialized and informed users).

The method most often used for low-vision people to transform images into information is auditory transformation, the method most often used to transform a text into voice through various IT applications. Regarding the categories of mobile applications that the authors have identified in this research and that are used by low-vision people to convert text to voice very easily, a very large percentage is represented by NVDA-non visual desktop access (61.29%), followed by voice-over with a percentage of 29.03% and other much less used variants (JAWS-job access with speech and other, approx. 9.68%).

Problems in the use of these devices and applications also arise due to the lack of proper training, aspects that are very important in ensuring direct and effective communication between all participants. The most frequent problems encountered by low-vision people are those related to the interpretation of images (64.52%) or the writing of symbols (12.90%) when communicating via computer and/or smartphone (both devices being discussed when analyzing this activity, in a proportion of 74.19% of the respondents being users of these two tools).

Therefore, these aspects can create certain states of retention of the way of communication, certain frustrations, or even manifestations of denial of the usefulness of some visual aid devices to improve everyday life and can develop feelings of discrimination in relation to low-vision people with the other members of the community. As the data were obtained from the answers to the questionnaire, the percentage of situations in which respondents to the questionnaire stated that they feel discriminated sometimes and often (54.84%) is higher than that for people who never felt discriminated (45.16%), and it also indicates a low level of understanding that the community gives to these members [35]. That is why a careful and concrete approach is required from the institutions and various organizations in the field to carry out activities to raise awareness among all members of the community with the aim of creating specific methods and ways of acceptance, integration, and elimination of differences between social categories and to develop those modules that characterize a smart city, namely smart people and smart environment.

As such, the permanent actions of communication, understanding, and development of more effective ways of interacting with a greater impact on all members of the community, through more dedicated knowledge strategies, through the stronger involvement of specialists, cultural, social or economic personalities and obviously also of other entities in society, stand out as the main ways of development, improvement, and obtaining what is meant by smart city with smart living and smart people [35].

4. Discussion

Following the scientometric analysis of the research works that determine the characteristics of visual disabilities or low vision or visual aid systems, a series of pertinent conclusions were drawn that indicate a constant concern to develop methodologies made up of procedures and technological analysis systems or visual aid that can come to the support of those people who present visual dysfunctions in correlation with the integration in the concepts of smart city and healthcare [28–34].

As shown in the official documents [36] of the World Health Organization (WHO), globally, "at least 2.2 billion people have a visual deficiency in near or far vision. In at least 1 billion—or almost half—of these cases, the vision impairment could have been prevented or has not yet been detected and investigated. Most people with vision impairment and blindness are over 50 years old, but even so, vision loss can affect people of all ages." That's why the signal of concern that manifests itself at the global level is the growth and aging of the population, aspects that represent even greater risks for even more people to suffer from vision disorders. The impact of these causes and limiting states of activity that low-vision people can present is strong, long-lasting, and can modify certain personal, functional, social, and even economic characteristics.

As such, screening analysis strategies of the visual function must be approached through which the installation and development of vision disorders can be prevented; interventions can be carried out in sensitive areas (nutrition, hygiene, education, etc.) or even recovery/rehabilitation procedures for visual function through assistive technologies or correction and visual aid systems customized and specific to each type of dysfunction.

All these actions and methodologies can be "assembled" with other modules that define the smart city characteristic, such as smart living, smart and digital environment, eco-system, special demands, and special development, and become elements of complex urban development. The forms and ways of implementing these desired are specific to each geographical area, population sample, and level of social and economic development.

Following the analysis carried out in this research, the authors consider that by involving all the important factors in these strategies, an effective implementation standard and alignment with the requirements of a smart city structure could be generated in the metropolitan area of Brasov, a structure that will be able to be developed in the future period through complex and integrated projects.

The analysis carried out in this research still indicates the need to pay more attention to the needs of people with different dysfunctions (motor, visual, auditory, etc.) to prepare and prevent future situations, effectively using the existing professional resources now and reducing the subsequent, social and economic costs.

Regarding the achievement of the objectives proposed by this research (O1–O3), the analyses have identified a series of important aspects that can indicate the most sensitive areas, areas that require wider involvement, or areas that are still unexplored and unused. These areas are determined by the mobility systems and the visual aid systems used both in mobility and in different activities, and, respectively, the inclusion strategies of low-vision people, all of which need to be developed in the smart city principles.

Hence, through objective (O1)—the analysis of urban arrangements and administrative arrangements to ensure the movement of these people with low vision in good conditions, the importance of these arrangements and the need for expansion in other areas of the city were highlighted, thus providing safety and comfort in movement and access to and from at different institutions.

From the analysis of the seven criteria related to objective (O1), public transport and road markings present the highest estimated percentages, according to official documents, and are in continuous improvement, especially in the central area of the town. However, there is still a deficiency in the implementation of the same forms in the peripheral residential areas of the city and also in the introduction of appropriate signage and information for low-vision people.

In addition, a low percentage of the adaptation of institutions to the needs of people with disabilities was found, an area in which intervention must be done in relation to the specifics of their activity and, respectively, the possibilities of structural and functional modification.

The objective (O2) identified by this research, namely the analysis of the involvement of public and private institutions in the integration of people with special needs, proves to be more strongly anchored in the actions to cover the special needs and requirements of the population with different forms of deficiencies, using adapted information and integration mechanisms. For example, through the detailed analysis of the visual aid systems developed through applied research at the university level, it was possible to highlight the importance given to these requirements, the way to solve them, the options to be optimized, and last but not least, the wider research on population samples and of the environment in which it carries out its activity, taking into account all functional, economic or social aspects.

Following the analysis carried out within this objective (O2) of the present research, another contribution of the studies is the proposed methodology for defining the criteria related to the principles of the applications.

The described work method proved to achieve its goal: to quickly develop useful applications that satisfy the needs of clients (users). In addition, a process of making the devices more flexible and improving the variants until they reach a qualitatively acceptable version was proposed.

The objective (O3) oriented to the preliminary evaluation of the needs for the use of some specific facilities determined by the visual aid systems of users in the category of people with low vision in terms of their access and inclusion in current activities or, in particular, in those dedicated to them demonstrated once again that the need for information, education and involvement at all levels, is the most effective integration solution, but in which the whole society must engage.

In the case of objective (O3), the study included a relatively small number of respondents and showed a reduced number of their representativeness, an aspect that could be one of the limits of the analyses performed. However, in essence, the information obtained from the sample that answered the questionnaire proved to be useful in identifying the specificity of the aspects related to the use of some visual aid systems, especially those in the category of IT applications. Thus, future research could focus on more extensive tests (with more participants and from more categories of disabilities, various variants of methodologies, etc.), also involving people (specialist optometry) who work directly with low-vision people in a special way.

5. Conclusions

In the specialized literature, there are no articles dealing with research on improving the quality of life of people with disabilities in smart cities. The authors presented a practically validated method of evaluation and analysis of a city from this point of view. The proposed objectives were analyzed through the method of observation and critical analysis, and a questionnaire was also created to which people with very poor vision answered to understand what their specific aspects of them were.

In addition, from the analysis of the specialized literature, even if it is limited, in this field that connects the smart city problem with that of low-vision people and, respectively, with those of visual aid systems, the analysis carried out by the authors of this article identified a fundamental aspect, namely that there is currently a very limited number of researches focused on this complex topic.

At the same time, it is shown that their results are dependent on interactivity, and the quality and quantity of information, as well as their integration with other information, is very complicated, sometimes heavy, depending on a multitude of factors.

As a general conclusion of bibliographic research and also based on the findings from this research compared to other research in the field [37], the authors recommend the following strategies for the effective management of smart cities with the new modules included in the model of smart city (ecosystem, special needs, special development):

- Establish a research and technological goal,
- Involve important stakeholders,
- Connect all management levels (strategic and operational),
- Permanent adaptation of current legislation in the field of standards for smart cities,
- Permanent modification of the smart cities model to include different and specific modules.

Another aspect mentioned in this chapter of conclusions is the design of visual aid systems, a field in which the authors have started a series of experimental applications but which they want to develop in the future to support low-vision people, an aspect highlighted both from the analysis of the questionnaire and from the direct interaction with these people and their needs.

Obviously, these developments of visual aid systems must diversify and harmonize with the particular requirements of users and use technology that is friendly to both the environment and low-vision people. The visual aid systems (DS1 and DS2) pre-conceived to offer a higher level of use are now in the experimentation stage, and the results are gratifying because the achievement of the criteria from the application of the established principles rises to a higher level than all other devices.

Future studies will have to test different combinations of these elements and create optimization applications so that this increasingly diverse information can be used efficiently to validate the city of Brasov, through all the modules at the optimal level, in the category of smart cities.

Obviously, the study does not cover all aspects, being a field of great complexity and continuous dynamics, but one of the limits noted during the analysis and which sometimes restricted the complete study of the data consists of the multitude of information that is still uncorrelated in a database with much more accessible data.

Obviously, what was found at the end of the analyses carried out, the results and conclusions of the obtained research, can also support other researchers in their endeavor to develop similar systems. It also means the identification of sensitive areas where you can intervene quickly and efficiently to obtain a smart city with all its components, or you can adapt and correct certain situations that have not reached an optimal level, which is another important aspect of this research and can be the subject of future analyzes focused on finding solutions and forms of intervention (projects, applied research, etc.) [37].

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