

# Towards Smart, Sustainable, Accessible and Inclusive City for Persons with Disability by Taking into Account Checklists Tools

Raed A. Salha<sup>1</sup>, Muain Q. Jawabrah<sup>2</sup>, Usama I. Badawy<sup>3</sup>, Amjad Jarada<sup>3</sup>, Abdelkhalek I. Alastal<sup>4</sup>

<sup>1</sup>Geography and GIS Department, Arts College, Islamic University of Gaza, Gaza, Palestine

<sup>2</sup>Architecture and Planning Department, Birzeit University, West Bank Palestine

<sup>3</sup>Engineering and Camp Improvement Department, United Nation, Gaza, Palestine

<sup>4</sup>Geography and GIS Department, Arts College, Islamic University of Gaza, Gaza, Palestine

Email: msalha@iugaza.edu.ps, mqasem@birzeit.edu, ubadawy@yahoo.com, amjadjarada@hotmail.com, abdelkhalek.alastal@gmail.com

**How to cite this paper:** Salha, R.A., Jawabrah, M.Q., Badawy, U.I., Jarada, A. and Alastal, A.I. (2020) Towards Smart, Sustainable, Accessible and Inclusive City for Persons with Disability by Taking into Account Checklists Tools. *Journal of Geographic Information System*, 12, 348-371. <https://doi.org/10.4236/jgis.2020.124022>

**Received:** June 27, 2020

**Accepted:** August 25, 2020

**Published:** August 28, 2020

Copyright © 2020 by author(s) and Scientific Research Publishing Inc. This work is licensed under the Creative Commons Attribution International License (CC BY 4.0). <http://creativecommons.org/licenses/by/4.0/>



Open Access

## Abstract

The main characteristics of potential smart cities in the future, smart citizens, smart energy, smart buildings, smart mobility, smart technology, smart healthcare, smart infrastructure, smart governance and education, and finally smart security are the aspects of smart cities. In the smart city, smart accessible infrastructure creates an inclusive environment for people with disabilities, in which they can integrate into the community and enjoy their civil, cultural, political, social and economic rights and entitlements. The aim of this study is to integrate disabled people into society so that they can actively participate in society and lead to a normal life. An integrated approach is needed to ensure that people with disabilities are not left alone. A combination of mainstreaming and targeted action is required for all interventions. People with disabilities have the same basic needs as everyone else: health protection and treatment, basic services, housing and income. Targeted intervention measures need to complement disability mainstreaming by addressing specific needs identified by general responses, including such interventions need not add materially to the overall cost, especially if the requirements of the maximum number of users are considered in the initial planning. This paper recommends how we can use an appropriate design checklist as a guide for our initial architectural concept and smart city planning to facilities reasonably accessible for people with disabilities in private and public buildings, making our cities smarter and more inclusive and helping to improve the quality of life for all people, especially people with disabilities.

---

## Keywords

Smart City, Disability Inclusion, Accessibility, Urban Design, Smart City Disability Inclusion Checklist, Architectural Design Checklist

---

## 1. Introduction

Is our main objective by doing this research to evaluate the targeted construction facilities for physical accessibility?

By giving an answer if the design ensures that places where you carry out, your services and activities are accessible?

When you look for new space to lease or use, do you make every effort to find space that meets accessibility requirements or can be altered to meet them?

When reviewing the program reports, the checklist tools give you a guide to ensure that people with disabilities are included in the program activities in a meaningful and effective way? Our subject is divided into two main parts: the first related to Smart City consideration and the second part related to urban planning and architectural design.

A smart, sustainable city uses technology to transform its core systems and optimize the use of limited resources. It is a knowledge-based system that provides stakeholders with real-time insight. To improve the quality of life of people in the city, all people without exclusion are based on financial or social status, skin color, religion, physical disability and mentality or otherwise [1].

There are six smart components (smart connections, smart economy, smart people, smart government, smart environment, smart living) that support building a smart city. No component can stand on its own, but concerted effort and collaboration can bring success and provide the strength needed to successfully embrace change. The Inclusive smart city is a new citizen-centered approach that aims to extend the experience provided by smart cities solutions to all citizens, which means including persons with disabilities and aging population.

Around 15% of the world's population, about 1 billion people, live with a disability; 80% of these live in developing countries, Between 110 million and 190 million adults have significant difficulties in functioning [2]. People with disabilities have less access to health care services and therefore experience unmet healthcare needs. Lack of access to infrastructure for persons with disabilities can be attributed to several factors [3], including:

- 1) Inadequate knowledge or understanding with decision-makers not understanding the implications of design and failing to understand the challenges and risks.
- 2) Lack of user input, with people with disabilities and reduced mobility not being brought into the planning, design and implementation process.
- 3) Missed Opportunities, with the potential for added value for universal

access to be missed.

Our general aim of this study is to integrate disabled people into society in order for them to take an active part in society and lead a normal life. To be active, a disabled person should be able to commute between home, work and other destinations. The technical aim is to provide a barrier-free environment for the independence, convenience and safety of all people with disabilities [4]. Our initial design checklist should address the technical considerations and design requirements or measures that must be considered when planning the built environment. This includes questions related to the design of several complementary main lines: open spaces and recreation areas, local streets and paths, the immediate vicinity of buildings, building entrances and the interior of buildings. The checklist is expected to be a stimulus that will lead, in the long run, to the establishment of building and planning guidelines covering access for disabled people. When the building is occupied, behavioral mapping determines how people use certain spaces, where movement occurs, and possible congestion locations. As a result, various users should be integrated into the design process in order to create more accessible environments from the beginning, while learning and enhancing past design solutions.

## 2. Definitions

### 2.1. Definitions of Smart City

- A Smart Sustainable City is a city with good performance in six characteristics, which is based on the “intelligent” combination of foundations and activities of self-determined, independent and conscious citizens [5].
- Based on the exploration of a wide and extensive array of literature from various disciplines, we identify eight critical factors for smart city initiatives: management and organization, technology, governance, political context, people and communities, economy, built infrastructure and nature environment [6].
- A smarter city uses technology to transform its core systems and optimize finite resources. When mature, a smarter city is a knowledge-based system that provides stakeholders with real-time insight and enables decision-makers to proactively manage the city’s subsystems. Effective information management is at the heart of this ability, and integration and analysis are key elements [7].

Therefore, we can say that the conceptualization of smart cities differs from city to city and country to country, depending on the specialization, perspective and the elements with which smart cities are concerned. This means that the concept of a sustainable smart city includes a number of important elements, including vision, solutions, integration, cooperation and continuity [8].

### 2.2. Definitions and Categories of Disability [9]

- Physical

- Total or partial loss of a part of the body.
- The malfunction, malformation or disfigurement of a part of the person's body.
- The presence in the body of organisms causing disease or illness.
- The presence in the body of organisms capable of causing disease or illness.
- Cognitive
  - Total or partial loss of the person's bodily or mental functions.
  - A disorder or malfunction that results in the person learning differently from a person without the disorder or malfunction.
- Sensory
  - Total or partial loss of the person's bodily or mental functions.
  - The malfunction, malformation or disfigurement of a part of the person's body.
- Social/Emotional

1) disorder, illness or disease that affects the person's thought processes, perception of reality, emotions or judgment, or that results in disturbed behavior.

Disability is an evolving concept that results from the interaction between persons with impairments and attitudinal and environmental barriers that hinders their full and effective participation in society on an equal basis with others. These definitions highlight that disability is not a fixed concept. The condition of disability strictly depends on the impairment on one hand and on contextual factors on the other [10]:

- The environmental characteristics (among them: social attitudes, architectural characteristics, social and legal structures).
- Personal characteristics (among them: gender, age, coping styles, social background, education, profession, past and current experience, temperament).

When this encounter between the people's functioning and the environment is not balanced, it can lead to limitation of activities and restriction in participation.

2) Why it is important to involve people with different disabilities in smart cities projects [11]:

- The manner in which cities are designed for too long has failed to consider the unique ways that physical and social barriers limit the participation of persons with disabilities in public life.
- Even though governments have been making extensive technology investments in smart cities, little explicit focus has been put into technological products and services that are inclusive of all citizens and end-users.
- Most smart city programs have failed to establish policies that are making sure that the offered services are accessible to the aging people and people with disabilities.
- If smart city services are not accessible, they will maintain the exclusion and isolation of people with disabilities.

- People with disabilities are already widely excluded from the reliance on technology in the daily life. In all countries, they have much less access to technology than the rest of the population.
- By developing and enforcing accessibility standards in smart city, for example, new transportation systems, pedestrian pathways, and information systems could open unprecedented opportunities to realize social inclusion of persons who have difficulty seeing, hearing, remembering, or moving around without assistance.
- There is also a need for non-discrimination policies that protect the rights of persons with disabilities to ensure the right Access to all in a smart city service themselves unimpeded, achieving equality and sustainability for all. See **Figure 1**.

### 2.3. Challenges Facing Smart City Inclusive Accessibility [13]

- Lack of awareness of disability and ICT (Information and Communication Technologies) accessibility by city leaders and IT professionals.
- Lack of policies & laws making accessibility a requirement in Smart Cities programs and investments.
- Limited financial resources to support the focus on accessible technology and digital inclusion.
- Lack of data both about persons with disabilities to use in defining Smart Cities solutions and programs.
- Lack of leadership across all sectors, i.e. government, industry, and civil society.
- Lack of professionals with ICT accessibility training.

### 2.4. Characteristics of Smart Cities

Features that smart cities could offer to improve the experience of people with disabilities in urban areas [14]:



**Figure 1.** Smart city solutions to everyday problems make cities more manageable for all citizens. Source [12].

- Adapt information and digital services available in urban spaces, making them suitable to different formats.
- Adjust urban technologies and mobility solutions in accordance with different people's abilities.
- Retrofit traditional assistive technologies with new features.
- Support the navigation/exploration of the urban landscape.
- Identify and describe objects and locations.
- Help people with disabilities find urban facilities and appliances.
- Anticipate unexpected events and/or dangerous situations.
- Make it easier to find people who are willing to help.
- Provide efficient communication channels to allow the interaction between people with disabilities and local authorities/public agents.

### **2.5. Requirements of Smart Inclusive and Sustainability City [15]**

- Object interoperability: Objects should be able to communicate and perform a kind of calculation.
- Sustainability: architectures should include sustainable policies related to environmental, economical, and social aspects.
- Real time monitoring: essential feature to provide relevant information to predict events.
- Historical data: all data picked up from the urban space has the potential to become relevant. Thus, architectures must include efficient storage and retrieval mechanisms for such data.
- Mobility: mobile technology is responsible for capturing information from/to the environment.
- Availability: the smart city centralizing infrastructure must be highly available to the capture data task. Cloud Computing infrastructure is largely used so far to satisfy the availability requirement.
- Privacy: privacy policies explaining what data will be captured and what will be done with it, preventing users and organizations to provide certain critical data. Due to the high relevance of this requirement, all smart city architectures should satisfy it.
- Distributed sensing and processing: the dispersion of heterogeneous sensors and smart objects over the urban space is the basis of the digital layer of smart city initiatives.
- Service composition and integrated urban management: services should be developed with the flexibility to be reused, grouped and able to participate in composition with other services.
- Social aspects: smart city architectures should express the main purpose of SC initiatives, the citizens' quality of life.
- Flexibility/Extensibility: the diversity and the dynamics of cities should be expressed in smart city architectures. Changes, adaptations, and extensions should be foreseen in the architectures.

### 3. Fundamental Components of Smart Cities [16]

1) Technology factors:

- Physical infrastructure.
- Smart technologies.
- Mobile technologies.
- Virtual technologies.
- Digital networks.

The physical infrastructure is a hardware platform that supports services within the Smart City. Intelligent, mobile and virtual technologies include logical software technologies that enable intelligent services. Digital networks connect all other technological components within Smart City.

2) Institutional factors:

- Smart policies and regulations.
- Smart administrative environment.
- Government and non-government institution communicate.
- Smart growth.

Although technology factors are key to smart cities, it would not be possible without the support of the institution and the government. The institutional factors include smart community and smart growth. Building, developing, and managing Smart City requires that government and non-governmental institutions communicate with each other, create government policies and regulations.

3) Human factors:

- Smart community.
- Smart educated.
- Inclusion of all society categories.
- Participation people.
- Raise awareness.

Smart City requires not only technological infrastructure, but also so-called human infrastructure. It means human engagement in Smart City, its education and collaboration. We can say that people help shape the services and values of Smart City [17]. Where do citizens define how the city should be developed, what are the problems, what are the needs of Smart City? People who participate in Smart City have the characteristics flexible, educated, willing to learn etc. In the context of Smart City, we refer to the people who help shape Smart City as “Smart People”. Intelligent people are an important part of Smart City.

#### 3.1. Roadmap for Increasing Accessibility

- Involving persons with disabilities in Smart Cities program design.
- Providing awareness training for IT (Information Technology) teams and managers.
- Complying with international ICT accessibility standards.
- Allocating government and industry financial resources to accessibility.
- Requiring accessibility as an implicit to Smart Cities programs.

- Building public-private partnerships for accessible Smart Cities solutions.
- Requiring accessibility as part of public sector ICT procurement.
- Assessing the current accessibility of current Smart Cities programs.
- Using open and accessible datasets that include info by and about persons with disabilities.
- Aligning Smart Cities programs with international human rights and development commitments.

### **3.2. Smart City and Urban Design Considerations**

There are several factors that influence the city's intelligence, such as technology, people and communities, economic governance, planning and infrastructure. Overall, there is a bit of information and research on urban planning principles and tools in creating and contributing to the smart city's smartness. The most important thing is to clarify the importance of urban planning for a smart city context and vice versa. It is important to get an overview of the concept of smart cities from the perspective of urban planning in order to find and highlight the important points of contact, relationships and roles of urban planning in creating smart cities. This would lead to sound principles for smart cities that would enable sustainable development, efficient urban growth and a better urban landscape. The key role of Urban and Landscape design in the creation of the smart city is based on the merge of technological aspects along with the physical city including its residence and public spaces, politics, economy, ecology, etc. Smart technologies (ICT's) combines with urban design principles and strategies could be a great tool for a proper coordination and management of complex issues. Smart city sees urban design as strategy in action, focused on results, help people envision a better future and get inclusive smart city goals successfully. As well, urban design help them leverage design's power to generate innovative solutions that affect real transformation. By developing a deeper understanding of the connection between design, business and human experience. Through a combination of research and partnerships urban design seek insights that will help solve the city's most pressing challenges.

### **3.3. Urban Design Characteristics**

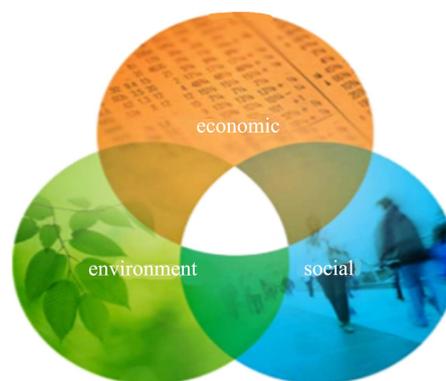
What are the defining characteristics of urban planning? Urban design includes the design and coordination of everything that defines cities: compact, accessible places are the most sustainable way of life. The combination of urbanism on a human level with a mix of uses and services, a range of housing options, extensive train systems and the ability to walk and cycle in everyday life ensure a sustainable, environmentally friendly life. Add safe, clean, renewable energy and real sustainability results, inhabitants of futuristic architecture. Urban design is the process of giving groups of buildings, entire districts and the city shape, shape and character. It is a framework that orders the elements into a network of streets, squares, and blocks. Urban design blends architecture, landscape architecture, and city planning together to make urban areas functional and attrac-

tive.

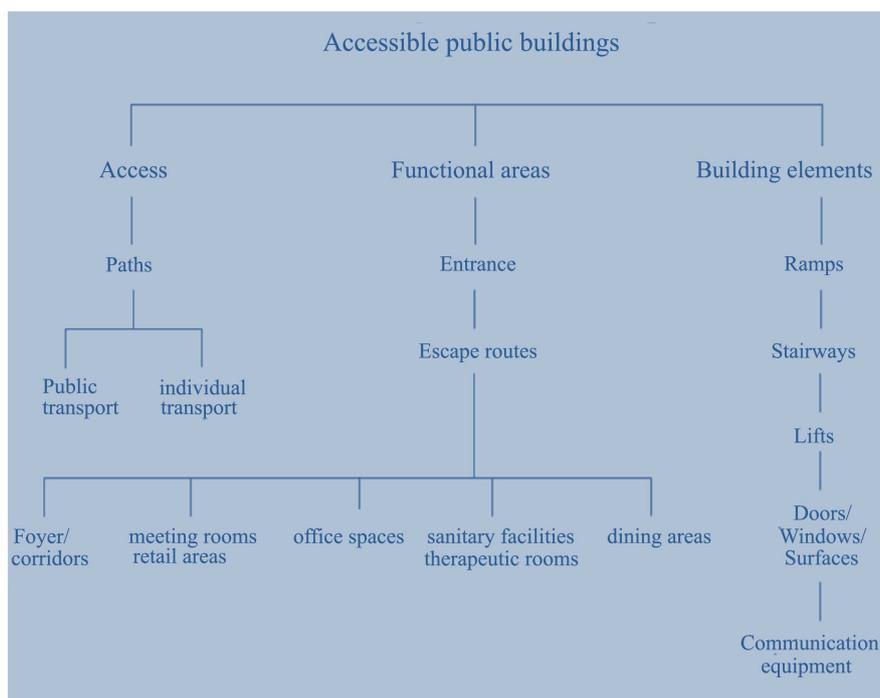
**Buildings:** are the most distinctive elements of urban planning, they shape and articulate the space by forming the street walls of the city. Well-designed buildings and groups of buildings work together to create a sense of place [18].

**Public-Space:** Generally, in public spaces and buildings, the required precautions are taken according to the physically disabled people like wheel chair users, visually or audible impaired individuals and the like; but, there are space solutions also for mentally and cognitively disordered people. In some country, some built environment preservation are taken only for the physically impaired people. However, some space solutions have to be searched and provided for the people who have autism, dementia or the other similar disabilities. In order to realize this, the society have to accept the behaviors that include disabled people and contribute to the formation of a fair built environment for all.

In architectural terminology, the use of public expression in general is sometimes used for both buildings and open/urbanized areas. Advertising means openness for everyone. The public space is neither a closed nor an open urban space and means permission for general use [19]. Great public spaces are the living room of the cities places where people come together to enjoy the city and each other. Public spaces make high quality life in the city possible they form the stage and backdrop to the drama of life. Public spaces range from grand central plazas and squares, to small, local neighborhood parks. Public space is conceived as open or closed spaces which constructed for the usage of every individual without any discrimination in the society (park, garden, stop etc.) ministrations. Everybody has the responsibility to create solutions for the public. American Disabilities Act (ADA) is federal legislation passed in 1990 that prohibits discrimination against people with disabilities defines the accessibility as: Accessible road, is the road that from a node in the interior of a building to the public space does not include any obstacle and provides continuity. Requires meeting the basic needs of all people and extending opportunities for economic and social advancement. A development initiative is considered sustainable if, in addition to protecting the environment and creating opportunity, it is able to carry out activities and generate its own financial resources see **Figure 2** & **Figure 3**.



**Figure 2.** Three pillars of sustainable smart city design, source authors 2020.



**Figure 3.** Accessible public building scheme, source authors 2020.

The UN Standard Rules on Accessibility make the following recommendations regarding access to the physical environment [20]:

- States should initiate measures to remove the obstacles to participation in the physical environment. Such measures should develop standards and guidelines and consider enacting legislation to ensure accessibility to various areas in society, including housing, buildings, public transport services and other means of transportation, streets and other outdoor environments.
- States should ensure that architects, construction engineers and others who are professionally involved in the design and construction of the physical environment have access to adequate information on disability policy and measures to achieve accessibility.
- Accessibility requirements should be included in the design and construction of the physical environment from the beginning of the design process.
- Organizations of persons with disabilities should be consulted when standards and norms for accessibility are being developed. They should also be involved locally from the initial planning stage when public construction projects are being designed, thus ensuring maximum accessibility.

**Entrances and Exits:** In the buildings main entrances equal right, fair usage principles have to be considered for all the users. The entrances for the disabled people have to be designed accordingly. For the passage ways, ramps, stairs, entrance doors, information and warning boards required dimensions have to be used see **Figure 3**. In front of the entrances space for the movement of wheel chair user has to be provided. If there is carpet on the ground floor, the material has to be fixed on the ground securely. This design standard should applies to

new buildings. It should be adapted accordingly in the design of alterations or renovations to existing buildings [21].

### **Street**

Streets are the connections between spaces and places, as well as spaces themselves. They are defined by their physical dimension and character, as well as by the size, scale and character of the buildings that line them. The streets range from large avenues such as Kurfürstendamm in Berlin to small, intimate pedestrian zones. The pattern of the road network is part of what defines a city and what makes each city unique.

### **Transport**

Traffic systems connect and shape the districts and enable movement throughout the city. They include road, rail, bicycle, and pedestrian networks, and together form the total movement system of a city. The balance of these various transport systems is what helps define the quality and character of cities, and makes them either friendly or hostile to pedestrians. The best cities are the ones that elevate the experience of the pedestrian while minimizing the dominance of the private automobile. At the transition areas and at the other used ramps on the roads have to have maximum 5% slope. Vehicle Parking Areas: Vehicle parking areas have to be placed closer to the entrance and open to an accessible route. The dimensions of the disabled vehicle parking side by side with an angle are minimum 250 cm × 250 cm. thinking the movement of the wheel chair the distance left in between the two parking areas for the transition corridors has to be minimum 150 cm in width. In front of the vehicle, minimum 91.5 cm in width transition road has to be left [22]. The materials of the roads in between the buildings and the vehicle park have to be non-slippery and matte taking into consideration the weather conditions. Others are deliberate, using specifications that anticipate your paper as one part of the entire proceedings, and not as an independent document [23].

### **Landscape**

The landscape is the green part of the city that runs through the city in the form of city parks, street trees, plants, flowers and water in many forms. The landscape defines the character and beauty of a city and creates soft, contrasting spaces and elements. Urban Design weaves these elements into a coherent, organized design structure and the Urban Design structure defines the city shape and the building shape. This means dealing with the design requirements for open spaces, recreation areas and pedestrian paths. Solutions to the main problems in designing an accessible outdoor environment are presented. It could be summarized as follows:

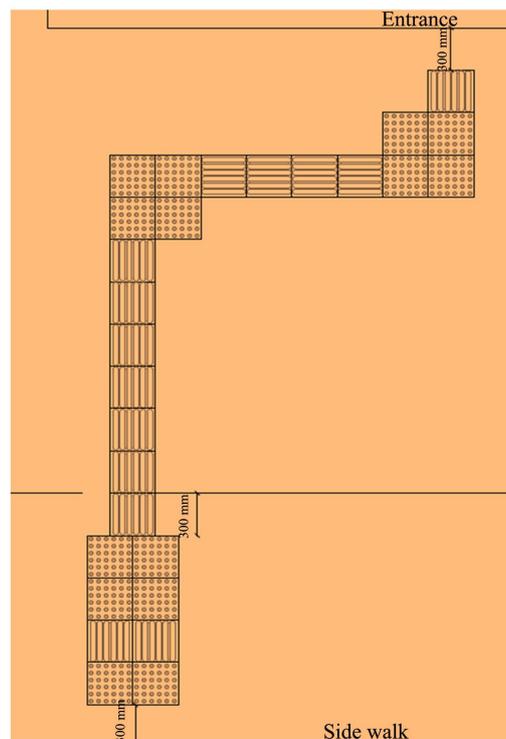
- 1) Obstructions
- 2) Signage
- 3) Street Furniture
- 4) Pathways
- 5) Curb Ramps
- 6) Pedestrian Crossing

### 7) Parking

Our goal in this research is to illuminate the light of all of these important elements that should be included in our initial design checklist. It starts with adapting the location of street furniture to allow free passage for all people without causing any danger. The design should take into account facilities that are accessible to people with disabilities. The road surface at pedestrian crossings can be raised to the same level as the pathway so that wheelchair users do not have to overcome differences in height. The time interval allowed for crossing should be programmed according to the slowest crossing persons. Pedestrian crossings should be equipped with traffic control signals.

## 4. Architectural, Design Considerations

It addresses the design requirements of vertical and horizontal access for both new and existing designs. It is the design considerations that are formulated to alert designers to the application of universal accessibility principles and requirements to buildings and facilities. A solid functional plan is single that the most important factor is in obtaining an acceptable solution to the Building Program. This can best be achieved through a careful study of the space relationships and a thorough understanding of the needs of the users as expressed in the Building Program and in subsequent meetings and discussions held between the Architect and the Building Committee, see **Figure 4**. Four levels of accessibility must be considered when designing or implementing accessible facilities or services:



**Figure 4.** Shows sketch approaching side wake to the building for an Independent wheelchair user, Source [23], reworked by authors.

- 1) How to Reach.
- 2) How to Enter.
- 3) How to Use.
- 4) How to understand instructions and information.

The Architect shall design the building with attention not only to its relationship to nearby buildings, but to the open spaces and landscaping around it. Barrier-free environments are essential for full participation and equality of disabled people [24] [25].

- 1) Ramps
- 2) Elevators
- 3) Platform Lift
- 4) Stairs
- 5) Railings and Handrails
- 6) Entrance
- 7) Vestibules
- 8) Doors
- 9) Corridors
- 10) Rest Rooms

The real aims of this research are to highlight the most important related points that give more value and guide for designers and architects.

#### **Interaction Space**

The interaction space is the space that a person needs to interact with another person, furniture, devices, machines or other elements. This space is also used by one person to change from a wheelchair to a seat or a toilet or to park a pram. The interaction space must not penetrate the accessible path. The interaction space can be frontal or lateral [24].

#### **Entrances**

The accessible path from the street or public space shall avoid stairs and ramps. Gradients up to 2% are preferred, although up to 5% are acceptable to reach the main entrance(s) at street level. If over 5% it should be designed as a ramp. All entrance doors must have a clear passage width adequate to the intended use of the building and the expected number of users. Minimum dimensions are 900 mm width × 2100 mm height. Doormats shall be levelled with the floor with a tolerance of ±2 mm [26]. The wheelchair ramp gives a wheelchair user more accessibility where a vertical distance must be traversed. Types of Wheelchair Ramps: Semi-permanent ramps rest on top of the ground or padding and are commonly used for short-term solutions. Permanent ramps Long-term solutions for disability act compliance and are usually bolted or cemented in place [24]. These are best suited for new buildings or halls. Portable ramps Made of lightweight materials and can fold for ease of transport such in berlins public transportations. It is important to find a variety that has a skid resistance surface. They are available in various metals and aluminum blends that are easy to maintain and clean. There are quite a variety of portable vehicle wheelchair ramps available. Some are just ramps while others have handrails.

Deluxe versions have handrails on both sides. The old style of track wheelchair ramps is still available. These have one ramp per set of wheels for the wheel chair and are most commonly used with vehicle access. Vehicle Ramps Vans equipped with wheelchair ramps are commonly seen at senior centers and schools where they are used to transport people with disabilities to and from public events. Many dealers sell vans with these ramps already attached in fact it may be easier to purchase a new van rather than modify your old van to accommodate a wheelchair ramp. In America for loading unoccupied wheelchairs the ADA recommends a 3:12 slope. This means for every three inches of vertical rise you are required to have a least one foot of ramp. For business use, the ADA recommends a 1:12 slope which means that every one inch of vertical rise requires one for the ramp. For example, 24 inches of rise demands a 24-foot-ramp minimum. The U.K. has its own set of guidelines which are more complicated because they integrate both the metric and English terms of measurement. The reach of a wheelchair user is constrained by his seated position and the wheels of the chair and the footrest extension limit access to room corners, window opening, workbenches or switches. It is also important to consider various reaching zones for children and persons of small stature [26].

It is also important to use accessible furniture such as kitchen, table, bed, which is not only a matter of reaching but really using the equipment;

- Free space between furniture: 1.5 m to circulate.
- Free space under table, kitchen cooking table, counter, and oven:
- Height of furniture should be 0.8 m with a 0.7 m free space for legs below the surface depth 0.6 m.
- Bench/bed: height above 0.45 m Barrier-free, design for-all, life span design, and trans generational design accessibility Therefore, inclusive environments provide access for everyone, regardless of their age and abilities [27].

#### **Slope Specifications:**

Having the correct slope is crucial as an overly steep slope can render a ramp too dangerous and inaccessible for an independent wheelchair user. Preferably there should be no vertical (very steep) slope at all. The preferred slope is 5% (1 cm height: 20 cm length) and the maximum acceptable slope is 8% (1 cm height: 12 cm length) A slope of 12% is not ideal and only acceptable if it is for short distance of 50 cm [25] [28].

#### **Building Types**

It deals directly with the accessibility requirements of selected building types. Special buildings for people with disabilities, such as health and housing facilities, as well as schools, fall within the scope of this article. To define buildings and plans for access for people with disabilities, this needs to be thoroughly developed through architectural designs based on the size of the target group, a classification of the different building types.

#### **Checklist consideration**

##### **Part I: Smart city checklist consideration**

Our research tries to create a solid foundation for this content. The checklist,

which is an important tool, is displayed for those designing the smart city to evaluate the elements of a comprehensive smart city. To achieve integration and efficiency among the components of the comprehensive smart city, in order to achieve a better quality of life for all residents of the city see **Table 1** Part I.

#### **Part II: Architectural checklist consideration**

The aim of designing Checklist Application is intended to be a tool used by Architect to assess and to develop proper solutions without missing any items related to the accessibility subject see **Table 2** Part II [25].

### **4.1. Recommendations**

Smart city needs to stop thinking of compliance with accessibility as an add-on; it needs to be the baseline. Everything that the City does needs to include disability and if it doesn't, we're missing out of a huge part of the population and market share, it's leaving millions of people out of the equation. This includes the need to acknowledge the diverse range of disabilities, including those that are hidden or cognitive.

In context smart city, there is a need to view accessibility as an investment in a public good that contributes to effective, sustainable and equitable development for all and not merely an issue of cost or compliance. This will involve fundamental reconsiderations of policies that address the objective of equalization of opportunities for persons with disabilities, as a target group, and to focus on measures that contribute to accessibility to the general systems for all.

People with disabilities in smart city should be able to arrive on the premises, approach the building and enter as freely as everyone else. At least one route of travel (e.g., from a parking lot in front of the building to the entrance of an office within the building) should be safe and accessible for everyone, including people with disabilities.

Our aims by preparing this research to great clear checklists not only to understand from Architect designer, but also from others who provide services in different sectors in the smart city. Smart checklists should be a tool to examine their facilities and identify physical barriers that may prevent persons with disabilities from having equal access to their services. This could be easy to evaluate your facilities for physical accessibility?

It helps us to give answers of: services and activities are accessible?

It helps us to give guidelines for design related issues.

Evaluate new and old buildings if meets accessibility requirements or can be altered to meet them?

You can use this checklist to assess where you are and identify the areas where you need to improve.

We encourage all to use this checklist as a way to strengthen their own knowledge and ensure that the final proposal is truly inclusive. This checklist is intended as a guide for better Change to guide planning and programming to ensure that their final application incorporates disability inclusionary practice.

**Table 1.** Smart city requirement.

SL	Checklist Items:	Yes	No
<b>1: Public spaces and built environment</b>			
1.1	Are there accessible and barrier free routes?		
1.2	Are there Accessible public toilets?		
1.3	Are there Accessible parks?		
1.4	Are there Accessible buildings?		
1.5	Are there Presence of disabled people in public?		
1.6	Considered Inclusive urban planning strategies?		
1.7	Is there action plans for addressing presence of disabled people in public?		
1.8	Are there inclusive projects of built environment take into account disabled people?		
<b>2: Public services and community supply</b>			
2.1	Is there accessible emergency number?		
2.2	Are staff training of public servants across all services for help disabled people?		
2.3	Are accessible public services institutions by disabled people (post offices, banks, hospitals, medical centers, local authority offices, employment offices etc.)?		
2.4	Are there sign language service provision if needed?		
2.5	Are there accessible water supply?		
2.6	Are there Accessible energy?		
<b>3: Transportation and urban mobility</b>			
3.1	Are there accessible means of transportation (bus, train, tram, metro, taxi, city center vehicles, and special bicycles)?		
3.2	Are there accessible information and communication about transportation?		
3.3	Are there accessible stations and platforms?		
3.4	Are there accessible ticket machines and other equipment?		
3.5	Are there accessible ticket offices?		
3.6	Are there available parking for disabled people?		
3.7	Are there accessible parking machines for disabled people?		
3.8	Are there accessible petrol station for disabled people?		
3.9	Are there accessible websites for disabled people?		
3.10	Are there Funding schemes for transportation service providers for disabled people?		
3.11	Are there accessible information and navigation apps?		
3.12	Are there Tactile guiding systems?		
3.13	Are there accessible helpline for disabled passengers?		
<b>4: Policy and governance</b>			
4.1	Are there accessible voting procedures for disabled people?		
4.2	Are there accessible voting locations for disabled people?		

**Continued**

- 4.3 Are there disabled representatives in governance bodies?
- 4.4 Are there number of bodies with disabled representatives?
- 4.5 Are there participation of disabled people in strategic planning and design?
- 4.6 Are there participatory governance programs?
- 4.7 Are there sufficient number of participatory projects for disabled people?
- 4.8 Are there number of disabled citizens participated?

**5: Legislation and standardization**

- 5.1 Are there available disability legislation?
- 5.2 Are there accessible disability legislation?
- 5.3 Are there participation in legislation design?
- 5.4 Are there enforcement of disability legislation?
- 5.5 Are there available disability inclusive standards?
- 5.6 Are there awareness, acceptance and enforcement of standards?
- 5.7 Are there presence and incorporation of disability inclusion principles in overall legislation?

**6: Media, Information and Communication**

- 6.1 Are there inclusive, non-discriminating media contents?
- 6.2 Are there awareness-raising campaigns, projects, articles about inclusion and disability?
- 6.3 Are there available audio descriptions of TV and other visual media?
- 6.4 Is it possible adapted for visually impaired people?
- 6.5 Are there available sign language interpretation and large captions?
- 6.6 Are there Accessible media websites?
- 6.7 Are there staff trainings and staff trained to assist disabled people?

**7: Education, training and childcare**

- 7.1 Are there available education, training and childcare programs, facilities, opportunities?
- 7.2 Are there available funding scheme?
- 7.3 Are there number of disabled people in mainstream vs. special education?
- 7.4 Are there available assistance services (e.g., pedagogues, personal assistance, educated teachers etc.)?
- 7.5 Are there available adapted literature and educational content (audio, sign language, easy to read versions)?
- 7.6 Are there accessible playgrounds for children?

**8: Work, career and employment**

- 8.1 Are there available programs for disability employment development?
  - 8.2 Are there funding opportunities for disabled people?
  - 8.3 Are there accessible, inclusive employers?
  - 8.4 Are there accessible job posts?
  - 8.5 Are there accessible employers?
-

**Continued**

- 
- 8.6 Are there accessible employment offices?
  - 8.7 Are there accessible employment services and information?
  - 8.8 Can we find out number of disabled employees vs. unemployed and vs. non-disabled?
  - 8.9 Can we find out success rate in job interviews?
  - 8.10 Are there working climate and Staff training support?

**9: Housing**

- 9.1 Are there available funding programs and schemes?
- 9.2 Are there development plans for accessible housing?
- 9.3 Are there No. of disabled people in accessible housing units (in terms of application, actual accommodation)?
- 9.4 Are there funding programs for private owners to support inclusive and equal access to housing?

**10: Health Care and Social Security**

- 10.1 Are there available programs and schemes?
- 10.2 Are there financial accessibility?
- 10.3 Are there accessible infrastructure?
- 10.4 Are there information-communication accessibility of services?
- 10.5 Are there sufficient number of accessible hospitals, medical and rehabilitation centers?
- 10.6 Are there success rates of rehabilitation programs?
- 10.7 Are there number of disability specific schemes?
- 10.8 Are there staff training?
- 10.9 Are there number of available sign language interpreters?

**11: Assistive Technology and Independent Living**

- 11.1 Are there available programs and schemes to support access to assistive technology?
- 11.2 Are there aids and support independent living?
- 11.3 Are there financial access and aids?
- 11.4 Are there legislation on assistive technology?

**12: Family life**

- 12.1 Are there awareness raising activities?
- 12.2 Are there support services?
- 12.3 Are there number of disabled people with their own family?
- 12.4 Are there number of disabled people in their own household?
- 12.5 Are there number of disabled people with children?

**13: Economy and business**

- 13.1 Are there funding programs for disabled business owners?
  - 13.2 Are there available business climate for disabled people?
-

**Continued**

- 13.3 Are there access to incubators business for disabled people?
- 13.4 Are there access to business offices for disabled people?
- 13.5 Are there accessible market for disabled people?
- 13.6 Are there accessible services and products for disabled people?
- 13.7 Are there economic stability of disabled people/Financial safety/poverty index among disabled people?

**14: Recreation, sports and leisure**

- 14.1 Are there accessible recreation for disabled people?
- 14.2 Are there accessible leisure and sports facilities for disabled people?
- 14.3 Are there accessible Leisure and recreational parks with adapted equipment for disabled people?
- 14.4 Are there available and accessible funding for sports of disabled people?
- 14.5 Are there available funding for talented disabled children?
- 14.6 Are there accessible events disabled people?

**15: Safety, quality of life and independent living**

- 15.1 Are there ensuring physical and psychological safety among persons with disabilities?
- 15.2 Are there domestic and non-domestic violence rates?
- 15.3 Are there Safe public spaces persons with disabilities?
- 15.4 Are there safe transportation persons with disabilities?
- 15.5 Are there satisfaction levels with the quality of life among persons with disabilities?

**Table 2.** Building or compound surroundings and outdoor areas. (Architectural checklist).

SL	Checklist Items:	Yes	No
1	External Space (outdoor areas)		
1.1	Accessible path free of obstacles > 1200 mm		
1.2	Signage at all non-accessible entrances should clearly indicate location of accessible entrance		
1.3	Designated accessible parking spaces located closest to accessible entrance		
1.4	Barrier-free unobstructed path of travel (minimum width of 1200 mm) from parking area to building entrance (clear of snow, garbage cans, sign posts and other obstacles; pathway well lit) not behind vehicles		
1.5	Curb ramp to sidewalk located between parking spaces		
1.6	Access aisle painted on pavement between parking spaces		
1.7	Accessible parking symbol painted on pavement at the entrance of each stall		
<b>Part 2: Access to Buildings Entrances</b>			
2.1	Is the main entrance easily seen?		
2.2	Signage at all non-accessible entrances should clearly indicate location of accessible entrance		
2.3	Doorway clearance is 800 mm when the door is in the open 90 degree position (920 mm preferred)		

**Continued**

- 
- 2.4 The primary entrance is accessible (automatic sliding doors are optimal; power doors with large paddle/pushplate is the next best alternative)
- 2.5 Color contrast to identify doorway threshold, frame or entrance. Corridors should be 1100 mm (recommend 1800 mm)
- Signage**
- 2.6 Facilities and services for persons with disabilities identified with appropriate symbols (e.g. availability of assistive listening devices)
- 2.7 Signage available in symbol form for those with visual processing difficulties or who are unable to read
- 2.8 Signage includes braille as well as large print, high colour contrast tactile lettering that is a mix of caps and lower case letters and be processed to prevent glare.
- 2.9 General and way-finding signage consistent in design and easily identifiable
- 2.10 Signage font in Sans Serif (e.g., Verdana, Arial) for reading ease. Signage should be 1350 mm high from floor level and not located on a door (should be 150 mm from the door frame). If tactile signage is installed it should be 1200 mm from floor level (building directories should be tactile)
- stairs**
- 2.11 Slip-resistant, tactile finish or strips contrasting in color and texture on all landings, treads edges, and the beginning and end of a ramp
- 2.12 Tactile strips in contrasting color on all stair nosing. Step demarcation in yellow on sides and back of escalator steps
- 2.13 Steps for stairs have a rise between 125 mm and 180 mm and a run of not less than 280 mm (should not be open between steps)
- 2.14 Avoid single isolated steps
- Elevators**
- 2.15 Need for an elevator in the school and health centers, offices and high levelled homes.
- 2.16 The elevator should have at least a 150 cm wide and 150 cm long clear landing in front of its entrance and a door which provide a clear opening width of at least 80 cm
- 2.17 the height of the elevator's buttons should be same of the attached figure
- 2.18 Entrance and internal doors width > 900 mm
- 2.19 The height of door handles should be between 85 cm and 110 cm
- 2.20 Doors have clear colour contrast from door surroundings
- 2.21 Location of elevators clearly identified at main entrance
- 2.22 Braille and tactile numbers placed on both sides of door jams at appropriate height to identify floor level
- 2.23 Elevator buttons and emergency controls incorporate large print tactile numbers and Braille mounted in a raised fashion (not flush or recessed)
- 2.24 Visual indicator in elevators to indicate "help on the way" for use in an emergency
- Ramps**
- 2.25 Strong color contrast and tactile surfacing on all ramp landings and a 15 mm wide strip in contrasting color and texture at the top of ramp to warn users of a change in elevations
-

**Continued**

- 2.26 Ramps that allow persons using wheelchairs to move independently shall not exceed a slope of 8% (1:12).
- 2.27 Landings designed to accommodate larger chairs and scooters (able to open door without backing onto ramp). Landings must be min 1200 mm long.

**Handrails**

- 2.28 Handrails provided at two heights with unobscured view between. Handrail height should be 900 mm and another at a height of 700 mm
- 2.29 Two continuous handrails on both sides of steps, one at 90 cm and one at 70 cm are required
- 2.30 Handrails extend horizontally beyond last stair and terminate to wall or ground

**Toilets**

- 2.31 The toilets location should be visible sign indicating in accessible format (e.g. Braille, Contrasting colors)
- 2.32 Each toilet for persons with wheelchair should have an unobstructed turning space of at least 150 cm × 150 cm to enable a person using a wheelchair to manoeuvre
- 2.33 the total dimension of the toilet is at least 175 cm × 200 cm
- 2.34 The minimum number of students' toilet cubicles that should be provided for the use of girls and boys in a 25 classrooms double shift boys and girls school is 25 toilet cubicles
- 2.35 the door handles should be positioned at a height of between 85 cm and 110 cm
- 2.36 The toilet seat a height should be between 46 - 48 cm
- 2.37 Handrails should be fixed on the wall next to the toilet seat at the exact height.
- 2.38 water taps should be easy to reach and use for children with different disabilities
- 2.39 toilet paper reachable without leaning too far off toilet

**Interior Building Elements**

- 3.1 Space for persons using wheelchairs to sit/park in all public seating areas, including companion seating (without blocking walk through areas)
- 3.2 Level wheelchair seating area (in theatres, lecture halls, sports arenas etc.), to also include companion seating and unobstructed views
- 3.3 Glass doors or partitions include a contrasting strip of color across at eye-level
- 3.4 All alarm systems to include an audible and visual signal (e.g., flashing light)

**Furniture**

- 4.1 Furniture should only be placed outside the main path of travel (inside or outside) and is detectable by someone who uses a cane
- 4.2 There should be good color contrast between street furniture and background surfaces (generally, grey colors should be avoided as they blend into the general background)
- 4.3 Variety of benches should be provided (some including a back and an arm rest)

## 4.2. Conclusions

The smart city has an opportunity, as well as a responsibility, to incorporate groups that have been failed by the traditional urban planning.

Inclusive design is not just about designing for people with disabilities. It's about keeping the diversity and uniqueness of each individual in mind as you create all your communications materials. It's about knowing your users, understanding what their accessibility challenges are, and adjusting your design approach to ensure that each and every one of them can successfully engage with your platform.

Urban planners must work collaboratively with all sections of the population to build truly inclusive smart cities for the future. A checklist role helps to determine how well you're aligned with the principles of Universal Design for disability persons, achieving the goals of the smart city in achieving universal access for all.

## Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

## References

- [1] Aastal, A. (2019) Enhancing Sustainable Urban Development through Smart City Using (GIS & BIM): Case Study of Hamad City Khan Younis. Master Thesis, Islamic University Gaza, Gaza.
- [2] World Health Organization, World Report on Disability (WHO 20154). [https://www.who.int/disabilities/world\\_report/2011/report/en](https://www.who.int/disabilities/world_report/2011/report/en)
- [3] Agarwal, A. and March, A. (2016.) Disability Considerations for Infrastructure Programmes. [https://assets.publishing.service.gov.uk/media/57a08954ed915d3cfd0001c4/EoD\\_HDYr3\\_21\\_40\\_March\\_2016\\_Disability\\_Infrastructure.pdf](https://assets.publishing.service.gov.uk/media/57a08954ed915d3cfd0001c4/EoD_HDYr3_21_40_March_2016_Disability_Infrastructure.pdf)
- [4] Department of Economic and Social Affairs United Nation (2003) Accessibility for the Disabled—A Design Manual for a Barrier Free Environment.
- [5] Giffinger, R., Fertner, C., Kramar, H., Kalasek, R., Milanović, N. and Meijers, E. (2007) Smart Cities—Ranking of European Medium-Sized Cities. Vienna University of Technology. [https://www.researchgate.net/publication/261367640\\_Smart\\_cities\\_-\\_Ranking\\_of\\_European\\_medium-sized\\_cities](https://www.researchgate.net/publication/261367640_Smart_cities_-_Ranking_of_European_medium-sized_cities)
- [6] Chourabi, H., Nam, T., Walker, S., Mellouli, S., Nahon, K., Pardo, T. and Scholl, H. (2012) Understanding Smart Cities: An Integrative Framework. 2012 45th Hawaii International Conference on System Sciences, Maui, 4-7 January 2012, 2289-2297. <https://doi.org/10.1109/HICSS.2012.615>
- [7] (2014) IBM's Smarter Cities Challenge: A 5-Year Evaluation.
- [8] Alastal, A., Salha, R. and El-Hallaq, M. (2019) The Reality of Gaza Strip Cities towards the Smart City's Concept. A Case Study: Khan Younis City. *Current Urban Studies*, 7, 143-155. <https://doi.org/10.4236/cus.2019.71006> <https://www.scirp.org/Journal/PaperInformation.aspx?PaperID=91553>

- [9] [https://www.nccd.edu.au/sites/default/files/2019-02/categories\\_of\\_disability\\_transcript\\_0.pdf](https://www.nccd.edu.au/sites/default/files/2019-02/categories_of_disability_transcript_0.pdf)
- [10] Bianquin, N. and Bulgarelli, D. (2016) Conceptual Review of Disabilities. In: *Play Development in Children with Disabilities*, De Gruyter, Berlin, 22.  
[https://www.researchgate.net/publication/316306819\\_4\\_Conceptual\\_Review\\_of\\_Disabilities](https://www.researchgate.net/publication/316306819_4_Conceptual_Review_of_Disabilities)
- [11] Jonell, A. and Meritähähti, A. (2017) Creating a Smart City for People with Disabilities: A Qualitative Study on How to Make Smart Mobility Solutions Following an Inclusive Design Approach. Master's Thesis in Interaction Design & Technologies, Department of Applied Information Technology Chalmers University of Technology, Gothenburg.  
<https://odr.chalmers.se/bitstream/20.500.12380/250864/1/250864.pdf>
- [12] Bowman, E. (2017) Smart Cities Work for People with Disabilities, Share America.  
<https://share.america.gov/smart-cities-work-for-people-with-disabilities>
- [13] G3ict and World Enabled. A Global Strategy for Digital Inclusion.  
[https://smartcities4all.org/wp-content/uploads/2018/08/SC4A\\_Vision-Six\\_Strategies\\_XT.pdf](https://smartcities4all.org/wp-content/uploads/2018/08/SC4A_Vision-Six_Strategies_XT.pdf)
- [14] Neto, J. (2018) Inclusive Smart Cities: Theory and Tools to Improve the Experience of People with Disabilities in Urban Spaces. PhD Thesis, Electronic Systems Engineering Department, University of Sao Paulo, Sao Paulo.  
[https://www.researchgate.net/publication/330511428\\_Inclusive\\_Smart\\_Cities\\_theory\\_and\\_tools\\_to\\_improve\\_the\\_experience\\_of\\_people\\_with\\_disabilities\\_in\\_urban\\_spaces](https://www.researchgate.net/publication/330511428_Inclusive_Smart_Cities_theory_and_tools_to_improve_the_experience_of_people_with_disabilities_in_urban_spaces)
- [15] Da Silva, W.M., Alvaro, A., Tomas, G.H.R.P., Afonso, R.A., Dias, K.L. and Garcia, V.C. (2013) Smart Cities Software Architectures: A Survey. In: *Proceedings of the 28th Annual ACM Symposium on Applied Computing*, ACM, New York, 16.  
<https://doi.org/10.1145/2480362.2480688>
- [16] Kazičková, T. (2018) IT Services of the Smart City. Master Thesis, Faculty of Informatics, Masaryk University, Brno Czech.  
[https://is.muni.cz/th/kigls/DP\\_KAZICKOVA-20170521-2245.pdf](https://is.muni.cz/th/kigls/DP_KAZICKOVA-20170521-2245.pdf)
- [17] Mainka, A., Hartmann, S., Stock, W.G., *et al.* (2015) Open Innovation in Smart Cities: Civic Participation and Co-Creation of Public Services. *Proceedings of the Association for Information Science and Technology*, **53**, 1-5.  
<https://doi.org/10.1002/pr2.2016.14505301006>
- [18] Gürallar, N. (2009) Kamusal Alan, Mimarlık 350 Dergisi, Kasım-Aralık.
- [19] Aruri, N. (2013) Ramallah: From “Sumud” Resilience to Corporate Identity. *Planum, The Journal of Urbanism* 1-13.
- [20] Arvanitis, A.V. (2004) People with a Disability in Modern Society. Biopolitics International Organization, Athens.
- [21] Koca, D. and Yılmaz, M. (2017) Engelliler İçin Mekan Düzenlemelerinde Kapsayıcı Tasarım, Yok yayını, Ankara.
- [22] ClimaSouth Technical Paper N. 2 (2016) The Economics of Climate Change in the Palestine.
- [23] Dubai Universal Design Code (2017) British Standard 8300, Design of Buildings and Their Approaches to Meet the Needs of Disabled People: Code of Practice, 2009. 27.  
<https://www.dha.gov.ae/Documents/HRD/RegulationsandStandards/Polocies/Duba%20Universal%20Design%20Code%20Final%20Feb%202017.pdf>

- [24] Disability Standards for Accessible Public Transport (Australia) 2002.  
<https://www.legislation.gov.au/Details/F2011C00213>
- [25] Badawy, U.I., Jawabrah, M.Q. and Jarada, E.A. (2020) Adaptation of Accessibility for People with Disabilities in Private and Public Buildings Using Appropriate Design Checklist. *International Journal for Modern Trends in Science and Technology*, **6**, 125-137. <https://doi.org/10.46501/IJMTST060627>
- [26] (2002) Guidelines for Buildings and Facilities, Appendix A to Part 1191—Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities.
- [27] Centre for Inclusive Design and Environmental Access (2010) International Best Practices in Universal Design.  
[http://gaates.org/wp-content/uploads/2014/pdf/BP\\_english.pdf](http://gaates.org/wp-content/uploads/2014/pdf/BP_english.pdf)
- [28] Design Resources: Architectural Way Finding. Centre for Inclusive Design and Environmental Access. <http://architecturalwayfinding.pdf/>