CASE STUDY

Sustainable urban development through complete streets strategies

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INTRODUCTION

There isn’t any broadly accepted definition for sustainability or sustainable development (Beatley, 1995). According to Brundtland commission, sustainable development means meeting the present needs without limiting the future generation’s needs (Bevan et al., 2007). In other words, Sustainable Development is a process of change which makes the investments, technological development and using the sources consistent not only with present needs but also with future needs (Mosaberpanah, 2013). On the other hand, one of the aspects which should be considered in sustainable development is sustainable transportation development. An efficient transportation system supports the social and economic activities and protects the environmental resources (Shen et al., 2018). Thus, sustainable transportation development needs basic changes in the procedure of problem solving by people (Litman, 1999) which means more complete direct and indirect impacts analysis (Berger et al., 1998) and considering a variety of usual solutions and involving the public in transport planning more efficiently (Litman and Burwell, 2006). One the other hand, one of the most important components of transportation planning is street networks. Street networks connect people to different places. They are about infrastructure and transportation as well as the movement of goods, people, wealth and idea (CNU, 2012). Thus, street design should consider the different users who...
drive, walk, cycle or use public transportation and increase the value of the offices, business and schools (NACTO, 2013). Nowadays, the horizontal and vertical expansion of the cities is an inevitable necessity, increasing the dependence of the citizens on motor vehicles and, consequently, making development of the transportation networks a necessity rather than an option. Cities, however, can survive and sustain only if they balance the allocation of different infrastructures and land uses. The quality of the city and urban development more than anything depends on the quality of the streets. Reducing the safety of pedestrians and increasing casualties caused by road accidents, shows that in urban planning, the streets are designed to be car-oriented and the rights of cyclists and pedestrians aren’t considered. In other words, traditional urban planning and design adapted to facilitate the movement of vehicles rather than human access; these streets are car-oriented and incomplete because not only people and their needs are not the focus of the design of these streets, but those who do not have access to personal vehicles or don’t like to use their personal vehicles are faced with the problem of mobility and access. An incomplete street doesn’t have enough accommodations for people with different abilities and involves narrow, unpaved and improper sidewalks and makes wheelchair use impossible (WSP, 2017).

One of the strategies that can provide the basis for sustainable urban development and support infrastructure that leads to social sustainability is the Complete Street Policy. This policy represents a paradigm shift in the traditional street design philosophy. Complete street planning emphasizes different functions for streets including recreation, commerce and mobility and considers different users from freight trucks to disabled pedestrians (Litman, 2012). This can have many other benefits which have attracted different cities in different countries all over the world and encouraged them to implement it. This policy considers the requirements of all the citizens without paying attention to their trip modes. In other words, it emphasizes equity. Smart Growth America defines complete streets policy as “Formalizing a community’s intent to plan, design, operate, and maintain streets so they are safe for all users of all ages and abilities” (Keippel et al., 2017). The first complete streets policy was applied in Oregon in 1971. Between 1971 and 1999, only seven other policies were applied in the United States. In 2005, the National Complete Streets Coalition was founded. It aimed to improve complete streets, a transport policy which declares that streets should be designed to provide equal accessibility to all people and different modes of transport (Vandegrift, 2018). From 2000, complete streets policy began in Earnest, until the end of 2015, 899 complete street policies had been adopted nationwide by the jurisdictions (Keippel et al., 2017). The most important elements of complete streets are bike lanes, safe crossing opportunities, curb extensions, roundabouts, sidewalks, median islands, narrower travel lanes, comfortable transportation stops, accessible pedestrian signals and special bus lanes (NCSC, 2017). In general, any type of additional road alteration or architecture which improves safety or accessibility for people can be regarded as a component of complete streets. So incomplete streets are those which are used only by motor vehicles and are not safely accessible for others (Vandegrift, 2018). Several states in US have implemented complete street policies; Such as Winter Park Health Foundation which has worked with smart growth America to examine the barriers to implement complete streets through several workshops in Central Florida; In these workshops, stakeholders from different organizations learn the best experiences including discussions about cultural and regulatory barriers and solutions to overcome these barriers (NCSC, 2017).

The benefits of Complete street policy

Complete streets can create many benefits including energy efficiency and emission reductions, improved accessibility for pedestrians and cyclists, improved public health, increased affordability and livability and supporting urban redevelopment and reducing sprawl (Litman, 2012). Several studies have emphasized the advantages of complete street policies on physical activity. For example, after reducing the space devoted to motor vehicles and increasing the space for bike and pedestrian in an arterial roadway in Seattle, Washington, the number of bike users increased from 2007 to 2010 by 35%. Another study showed that adding bike lanes to a crowded street in Long Beach, California, approximately increased the rate of cycling by two times (Schlossberg et al., 2015). As mentioned above, complete streets can also make streets safer
Table 1. Indicators of Complete Streets

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Points of Interest</th>
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</table>

**Active Transportation**

- **Improving the sidewalk infrastructure**
  - Designing a comfortable environment for pedestrians
  - Providing safety for pedestrians and cyclists
  - Facilitating accessibility of pedestrians along the street (implementing center median or pedestrian refuge island and so on)
  - Creating a sense of orientation by maintaining the continuity of the pedestrian walking surfaces
  - Designing Clearways
  - Tactile walking surface indicators should enhance visibility and support accessibility
  - Push button must be provided at all pedestrian crossings
  - Facilitating the drivers’ line of sight toward pedestrians
  - Considering all the necessary amenities on the sidewalk such as seating, pedestrian-scale lighting, waste receptacles, and trees positioned adjacent to the pedestrian clearway
  - Informing pedestrians and cyclists through urban signs, city maps, booklets and so on.
  - Using ramps and sound signals and etc. for people with physical disabilities
  - Creating a friendly atmosphere on the sidewalks
  - Using public arts to decorate the sidewalks

- **Considering cycling facilities**
  - Designing the bikeways based on street content
  - Pavement markings and signage should be used to provide cyclists with intuitive guidance for their correct path
  - Considering safe and convenient bikeways for cyclists
  - Providing separation between motor vehicles and pedestrians and cyclists by appropriate designing
  - Considering the minimum standard width for bike lanes
  - bikeway’s orientation signage and pavement markings should be clear and consistent
  - Encouraging residents to use public transport, bicycles and walk.
  - Considering a bike box to increase the visibility of cyclists and facilitates bicycle turns

- **Improving public transportation**
  - The movement of transit vehicles should be prioritized on all transit routes
  - Implementing stop designs that mitigate cyclist-bus conflict
  - Creating safe routes to facilitate the movement of public transit
  - Planning for multi-modal travel
  - Encouraging residents to use public transport, bicycles and walk.
  - Using methods for reducing the speed of passing cars
  - Implementing road diet
  - Considering raised intersections and crossings
  - Using speed cushions
  - Minimum use of mandatory restrictions if necessary...

- **Traffic Calming**
  - Categorizing the land uses (organizing and enforcing them)
  - Using methods for reducing the speed of passing cars
  - Implementing road diet
  - Considering raised intersections and crossings
  - Using speed cushions

- **Motor Vehicles**
  - Selecting an appropriate design speed
  - Considering induced demand when determining the capacity of street
  - Observing the minimum standard width for motor vehicle lanes
  - Use of traffic controllers such as: traffic lights, roundabout and etc.
  - Considering on-street parking that alternates between two sides of the street
  - The importance of driver’s line of sight in parking and lanes design
  - Angle parking is not recommended in any context due to the limited sightlines
  - Turning Parking spaces into public spaces

- **Environmental infrastructure and climatic and mental comfort**
  - Implementing Green Infrastructure to manage storm runoff, improving Air Quality and mitigating urban heat islands and etc.
  - Considering multiple canopies on the route on warm months of the year
  - Using bio filtration planters, and rain gardens
  - Choosing the “right tree, right place” and considering the best practices.
  - Using trees to define neighborhood identity and create a sense of place
  - Considering surface materials that are light in color and reflect a greater proportion of sunlight
  - Providing drainage in all the gardens

- **Utilities and urban furniture**
  - Facilitating access to underground utilities
  - Above ground utilities should be designed with consideration of the surrounding streetscape using public arts and etc.
  - The standard position for water mains is 4.9m from the property line
  - Considering runoff valves for water disposal
  - Maintenance holes should be positioned outside the wheel path of vehicles and bicycles
  - LED fixtures are used for all new installations to maximize energy efficiency
  - Gas mains are typically positioned 1.2 m from the property line
for pedestrians, transit users, cyclists and drivers and provide economic benefits like increased retail activity and higher property values (Carlson et al., 2017). It also makes streets livelier. Lively streets inspire more walking and enhance city livability (Jensen et al., 2017).

Complete streets can act as a public health intervention too. A study in US examined the impact of complete streets with a light rail expansion, more bike lanes and wider sidewalks on transit-related walking and non-transit walking. The results showed that people who lived near complete streets had more transit-related walking and non-transit walking than other people who lived in the other parts (Brown et al., 2016). Table 1, shows the indicators which are used to examine Jomhuri street in this study.

In Iran, the increase of car ownership has made many problems such as air pollution and decrease of pedestrian safety for different cities such as Shiraz. In this research, Jomhuri Street in Shiraz, has been examined according to complete streets criteria and several strategies have been proposed to improve this street to a complete street.

**MATERIALS AND METHODS**

**Case study**

Jomhuri street, which extends from the beginning of Eram Square to Abu Al-Kalam Square, is one of the main arteries of the Shiraz city and due to high traffic accidents on this street every year, many citizens die. This street has various potentials, such as proximity to the mountains and its beauty which attracts the...
pedestrians, the proper street width to suggest a special bus line, the suitable width of sidewalks and mostly residential areas around the street, so it can act as a complete street. Fig. 1, Shows the location of Jomhuri street in shiraz city.

In order to determine the current status of Jomhuri street, a cross section and a plan of the current status of the street is represented in Fig. 2.

**SWOT Analysis**

SWOT analysis is a technique which helps in representing the strategic direction for an action. In fact, it is an analysis tool for strategic management which was first proposed by ken Andrew (Khalifpoor et al., 2012) and helps to propose strategic actions for organizations by considering internal and external aspects. Internal Elements define the strengths and weaknesses and External Elements determine the opportunities and Threats (Mobarki, 2014). Strengths are characteristics that have benefits whereas weaknesses have disadvantages for the system, opportunities can have benefits while threats can cause trouble for the system (Gurel and Tat, 2017).
Table 2. Jomhuri Street Analysis Based on Complete Street Design criteria

<table>
<thead>
<tr>
<th>Indicators</th>
<th>Strength</th>
<th>Weakness</th>
<th>Opportunity</th>
<th>Threat</th>
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<tbody>
<tr>
<td><strong>Active Transportation</strong></td>
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<tr>
<td>Improving the sidewalk infrastructure</td>
<td>1. The sidewalks are separated from the roadways.</td>
<td>1. Lack of traffic signs and street names.</td>
<td>1. Preparation of all the streets and intersections for disabled and blind people.</td>
<td>1. Blocking the sidewalks by building materials due to the tendency to extensive construction adjacent to the street.</td>
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<td></td>
<td>2. Use of natural landscape on the sidewalks of this street to attract pedestrians</td>
<td>2. Not suitable paths and intersections for disabled and blind people.</td>
<td>2. The organization of the transportation system in the study area mainly relies on walking, cycling and public transport.</td>
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<td>3. The presence of light-colored pavements in some parts of the street.</td>
<td>3. Lack of road safety due to the high speed of vehicles.</td>
<td>3. Increasing tendency to use the green infrastructure in Jomhuri street</td>
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<td>4. Using the sidewalks by the residents for walking during the day.</td>
<td>4. Discontinuity of the existing sidewalks.</td>
<td>4. No attractive public transportation station’s design in the street</td>
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<td>5. Different types of pavement in sidewalks causes visual pollution</td>
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<td><strong>Considering Cycling facilities</strong></td>
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<td></td>
<td>1. Respecting the rights of cyclists along the street by residents and divers</td>
<td>1. The lack of bike lanes and weaknesses in the pedestrian movement system.</td>
<td>1. The organization of the transportation system in the study area mainly relies on walking, cycling and public transport.</td>
<td>1. The tendency of the residents to use active transportation in the parks around the area</td>
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<tr>
<td><strong>Improving public transportation</strong></td>
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<td></td>
<td>1. Bus routes as the main means of public transportation.</td>
<td>1. Low quality of the existing transportation system.</td>
<td>1. The organization of the transportation system in the study area mainly relies on walking, cycling and public transport.</td>
<td>1. The residents tend to use their cars to move in the street.</td>
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<td>2. The presence of enough bus stops along the street</td>
<td>2. Disorganized public transportation stations.</td>
<td>2. The possibility of developing a public transport system due to the wide area of the existing network (construction of subway lines)</td>
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<td>3. No dedicated public transportation routes according to street’s width</td>
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<td>4. No attractive public transportation station’s design in the street</td>
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<tr>
<td><strong>Traffic Calming</strong></td>
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<td></td>
<td>1. The existence of speed control cameras at some parts of the street.</td>
<td>1. No functional speed controllers according to the content of the street and an increase in conflicts between pedestrians and motor vehicles caused to fatal accidents</td>
<td>1. Making streets intersections intelligent. 2. Increasing tendency for planting trees as passive traffic calming method</td>
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<td></td>
<td>2. Using speed cushions to reduce vehicle’s speed</td>
<td>2. The steep slope of the street in jam square.</td>
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<td>3. Narrow lanes due to their color disappearance and lack of visibility for drivers</td>
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<td><strong>Motor Vehicles</strong></td>
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<td></td>
<td>1. A wide network of streets with relatively low traffic and smooth vehicle flow at relatively high speeds.</td>
<td>1. Lack of considering a suitable design speed in this street</td>
<td>1. Increasing number of street signage along the Jomhuri street</td>
<td>1. Increasing of the through traffic in the study area, especially with the construction of Kuhsar Mehid Highway.</td>
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<td>2. Considering potential demands in order to design the street</td>
<td>2. Prioritizing motor vehicle on top of any other mode of transportation in this street</td>
<td>2. Tendency to reduce the number of U-turns in street and relocating them in order to reduce conflicts</td>
<td>2. The risk of crossing the street due to the high speed traffic.</td>
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<td>3. Considering on-street parking along the whole street.</td>
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<td>3. Using too much mandatory limitations to control the traffic speed</td>
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<td>4. The dedication of motor lanes with the width of more than 3.5m</td>
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<tr>
<td><strong>Environmental infrastructure and climatic and mental comfort</strong></td>
<td>1. Using street trees along the Jomhuri street</td>
<td>1. Lack of places for pedestrians to sit and rest</td>
<td>1. Increasing tendency to plant trees along the street</td>
<td>1. Tendency to use dark-colored pavements in front of new residential buildings.</td>
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<td>2. Using the canopy in some parts of sidewalks to create climatic and mental comfort for pedestrians</td>
<td>2. Lack of refuges with standard width</td>
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<td>2. Turning the lost spaces to private vehicle’s parking with no other use</td>
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<td>3. No appropriate sightlines for drivers due to wrong tree planting</td>
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<td>4. Lack of human-scale light poles in sidewalks</td>
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<tr>
<td><strong>Utilities and urban furniture</strong></td>
<td>1. Appropriate street lighting in some parts.</td>
<td>1. Using non-efficient lights in the sidewalks.</td>
<td>1. Increasing tendency to use non-harmonized frontage lighting along the Jomhuri street</td>
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<td>2. Electricity utilities collision with street trees in some parts</td>
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<td>3. Wrong use of sanitary sewer valves in roadway</td>
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<td>4. Lack of considering aesthetic aspects of designing utilities</td>
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<td>5. Lack of adequate urban furniture such as: seating, trash...</td>
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<td>6. Lack of human-scale light poles in sidewalks</td>
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Space Syntax

Space syntax is a technique that measures the relative accessibility of different spaces in a structure. In this method, first the convex spaces are identified and shown by axial lines. These lines represent the important sight lines for humans (Thomson, 2003). This technique is one of the important techniques for analyzing space configuration and works on the applied knowledge and consequently promotes the general knowledge (Bahrainy and Taghabon, 2015). As Hillier states, space syntax requires four elements in analyses. Firstly, space syntax works with a succinct urban space definition. Secondly, it suggests a group of methods for analyzing cities as spaces shaped by the buildings. Thirdly, it includes a variety of methods for examining the relation between space networks and functional patterns like land use, movement and etc. Fourthly space syntax develops a group of theories about the relationship between urban space networks and the factors shaping them (Hillier et al. 2007). Space syntax uses some criteria such as integration, depth and connectivity to analyze the configuration of the space. Depth shows the least number of intermediate spaces that should be passed to go from one space to the other one. Connectivity shows the number of spaces or lines that are connected to any line or space directly or indirectly and Integration shows the average depth of an element to other elements. The spaces can be ranked from the most segregated to the most integrated ones (Klarqvist, 1993). In this research, space syntax technique is used to examine the spatial configuration of Jomhuri street and the streets adjacent to it.

RESULTS AND DISCUSSION

As mentioned above, in this research SWOT analysis is used to examine Jomhuri street based on complete street criteria. These criteria include Sidewalk infrastructure improvement, Traffic calming, providing active transportation routes, improving public transportation and Providing comfort and safety for the pedestrians. The results of the SWOT analysis are shown in Table 2 and Figs. 3 to 8.

Additionally, the space syntax analysis results are

![Fig 4. Considering Cycling facilities](image1)

![Fig 5. Improving public transportation](image2)
Sustainability and Complete Streets

Fig. 6. Traffic Calming

Fig. 7. Environmental infrastructure and climatic and mental comfort

Fig. 8. Utilities and urban furniture
shown in Fig. 9. In Space Syntax analysis, the axial maps are displayed with a range of colors from cold to hot ones. The cold colors show a low amount of the index while the hot ones show higher amounts of the index. As displayed in the maps, this area has a connected network of streets which increases the accessibility for the users and Jomhuri street has a relatively high integration which can help this street act as a complete street.

CONCLUSION

In Table 3, strategies and policies for designing Jomhuri street as a complete street are proposed. As shown in the table, strategies like using ramps for the disabled pedestrians, maintaining the continuity of the sidewalks, using techniques to decrease the width of the street, considering suitable furniture along the street can help us to improve Jomhuri street to a complete street. Therefore, in formulating the appropriate strategies and policies for Jomhuri street, the attempt is to help sustainable urban development through the creation of a safe spaces to facilitate the movement of all users in this street.

In the proposed model of Jomhuri Street as a complete street, the design of the street is intended to establish a good and effective communication.
Table 3: Strategies and Policies Proposed for Jomhuri Street

<table>
<thead>
<tr>
<th>Goal</th>
<th>Strategy</th>
<th>Policy</th>
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<tbody>
<tr>
<td>Improving the sidewalk infrastructure</td>
<td>• Improving the separation between sidewalks and roadways</td>
<td>• Considering height differences between sidewalks and roadways from the beginning of Abrishami street to Abu al-Kalam square to increase pedestrian safety. Using green-edge for a more complete separation of the sidewalk and the roadway</td>
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<td></td>
<td>• Designing the sidewalks for disabled pedestrians</td>
<td>• Using electric stairs and ramps for the pedestrian overpass located at the beginning of Narvan street.</td>
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<td></td>
<td>• Maintaining the continuity of the sidewalks along the street</td>
<td>• Using signs and adequate viewpoints in pedestrian facilities along the street.</td>
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<td></td>
<td>• Using techniques for increasing the residents’ tendency to walk along the street</td>
<td>• Using green infrastructure in sidewalks to create mental comfort for pedestrians. Using historical height differences between the sidewalk and the roadway from the beginning of Abrishami street to Abu al-Kalam square to increase pedestrian safety. Using attractive colors for pedestrian bridges. Using unique pavements along the street in order to help pedestrians to orientate</td>
</tr>
<tr>
<td>Considering Cycling facilities</td>
<td>• Assigning a section of the street to bike lane</td>
<td>• Considering bike lane from Jame Jam square to Abu al-Kalam square. Using bike stations at the beginning of Narvan and Abrishami streets. Using different signs and pavement for showing the bike lane. Using green infrastructure to separate bikeways from the roadways to increase safety.</td>
</tr>
<tr>
<td>Traffic calming</td>
<td>• More intelligent speed controllers on the street</td>
<td>• Considering speed control cameras at the beginning of Jame Jam square to control the driver’s speed at the slope of the street. Increasing the surveillance over the U-turn. Using raised crossings for pedestrians in the steep slope of Jame Jam square.</td>
</tr>
<tr>
<td></td>
<td>• Techniques for reducing the street width</td>
<td>• Planting trees to reduce the street width. Using on-street parking that alternates between two sides of the street. Using road diet in the steep slope of Jame Jam square.</td>
</tr>
<tr>
<td>Improving public transportation</td>
<td>• Quantitative and qualitative upgrade of the public transportation in the area</td>
<td>• Making the interior space of bus number 74 appropriate for everyone. Making the height of the bus stairs suitable for getting on and off and using ramps for the buses. Considering a card reader for the back door of the bus. Setting up bus timetables to reduce the waiting time for passengers at the bus stops. Construction of bus stations with convenient facilities around the pedestrian area.</td>
</tr>
<tr>
<td></td>
<td>• Improving the quality of bus stations in this street</td>
<td>• Relocating the bus stations in this street Considering sunlight to design the bus stations.</td>
</tr>
<tr>
<td>Improving the movement of motor vehicles</td>
<td>• Improving the traffic speed with consideration of all users’ right</td>
<td>• Improving the visibility of pedestrian crossings and roadway lanes in front of the police station of Jomhuri street Considering suitable design speed and informing the drivers through signages Considering a road diet to control the traffic speed in front of the Karim Khan restaurant.</td>
</tr>
<tr>
<td></td>
<td>• Using right trees and right pavement in Jomhuri street</td>
<td>• Using right trees according to the weather of Shiraz along the street. Using rain gardens to separate bikeways from roadways and to support green space capitalization. Using light-colored pavement in all sidewalks along the street.</td>
</tr>
<tr>
<td>Using green infrastructure along the street to support climatic and mental comfort of residents</td>
<td>• Creating friendly spaces in the street</td>
<td>• Creating wider sidewalks from the beginning of Abrishami square to Abu al-Kalam square to increase safety. Turning lost spaces next to Abrishami square into urban spaces. Using road diet to create stop points and places for residents.</td>
</tr>
<tr>
<td></td>
<td>• Improving safety and visibility of the pedestrians</td>
<td>• Increasing the visibility of the pedestrians by the drivers from Jame Jam Square to Narvan Street due to the Great slope of Jomhuri street.</td>
</tr>
<tr>
<td>Providing adequate urban furniture along the street and creating security</td>
<td>• Providing adequate urban furniture along the street</td>
<td>• Using furniture like: seating, trash bins along the street in all sidewalks.</td>
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<td>• Creating suitable light during the night</td>
<td>• Improving the light of sidewalks form the beginning of Abrishami street to Abu al-Kalam square. Using human scale light poles along the sidewalks.</td>
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in a way that all modes of transportation, such as walking, cycling, public transport and personal vehicles will be able to provide safe movement for all groups of society regardless of their age and ability in a coherent and sustainable manner. In Fig. 10, the designed plan and cross section of Jomhuri street is represented. The bikeway is considered next to the sidewalks with the width of 2meter, also dedicated bus lanes are designed next to bikeways alongside the street to provide equal accessibility for all modes of transportation. Other designed features are: ramp used in pedestrian crossings for disabled people, refuges and road diets to create a friendly space for users, separating bikeways with rain gardens and refuges and road diets to create a friendly space for pedestrians and cyclists.

CONFLICT OF INTEREST

The author declares that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancy have been completely observed by the authors.

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