

Walking and Sustainable Urban Transportation

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Abstract—Walking as a type of non-motorized transportation has various social, economical and environmental privileges. Also, today different aspects of sustainable development have been emphasized and promotion of sustainable transportation modes has been considered according to this approach. Therefore, the objective of this research is exploring the circumstance of relationship between walking and sustainable urban transportation. For writing this article, the most important resources related to the traits of walking have been surveyed via a documentary method and after explaining the concept of sustainable transportation and its indicators, benefiting from the viewpoints of transportation experts of Tehran, as the capital and greatest city of Iran, different modes of urban transportation have been compared in proportion to each criterion and to each other and have been analyzed according to AHP method. The results of this study indicate that walking is the most sustainable mode of inner city transportation.

Keywords—Walking, Non-motorized transportation, Sustainable transportation, AHP

I. INTRODUCTION

TODAY, the transportation has been transformed to one of the most important challenges of urbanization all over the world. Movement is the main factor of dynamics in urban life and prolonging element for all social, economical, and cultural activities in the cities; “Transportation is indeed both maker and breaker of cities.”[1]

Walking as a mode of non-motorized transportation is the oldest and yet the most natural individual transportation method which has been along with the man and since the beginning of cities creation was deemed as the first and simplest type of displacement. Various traits of walking such as low cost, creating movement, non-destruction of environment, possibility of social interaction etc. has applied this type of urban transportation as one of the most important human activities.

On the other hand, upon increasing the importance of sustainable development topic in the recent decades, promotion of urban displacement modes compatible with the environment have been emphasized more than ever. Therefore, sustainable urban transportation has been raised as the main requirement of current habitats and considered by urban experts. Also, sustainable transportation is one of the grounds of planning and design of sustainable cities which has a considerable importance in various scales of neighbourhood, district and urban and different economical, social and environmental aspects.

This paper is an attempt to survey the importance of walking in cities and indicators of sustainable transportation. It also aims at detecting the role of pedestrian movement in urban sustainable transportation.

II. TRANSPORTATION IN THE CITIES AND ITS VARIOUS MODES

Transportation as one of the main factors of development has been signified increasingly upon establishment of cities. Due to the expansion and extensive context of topics containing the concept of transportation, it is reminded as industry or a branch of engineering sciences. Some of the most important relative definitions are as follows:

- Transport or transportation is the movement of people, cattle, animals and goods from one location to another. The field can be divided into infrastructure, vehicles, and operations. Transport is important since it enables trade between peoples, which in turn establishes civilizations. [2]

- Transportation engineering means application of scientific principles and technology in planning, useful plan of performance and management of all types of transportation facilities for supplying the safe, rapid, easy, simple, economic and coordinate (with the environment) transfer of people and goods. [3]

As it is obvious the common concept in all transportation definitions is centralized on the people and goods movement. On the other hand, transportation modes have been divided into many different categories. For instance, transportation may be divided according to the cargo, passenger, geographical situation of trip (inner city and inter cities) or their targets.

Although inner city transportation had a steady and almost uniform trend before industrial revolution, but particularly after invention of steam engine suddenly an enormous mutation has been occurred in this context. Presence of motorized vehicles has altered the structure of urban spaces and created new requirements and needs. “Establishment of the first underground railway in 1836, first cable vehicles in 1837 and first monorail in 1868” [4] indicate the samples of rapid changes of transportation systems within this period.

Upon beginning 20th century, accelerated growth of automobile production caused to construction of residential areas around the cities or in other word suburban life. Therefore, cities’ borders lost their former concept and function. Gradually, upon increasing immigration of villages, the cities have been changed to very big demographic, economic and politic centres and after formation of metropolises, the necessity of more extensive deliberation for transportation of citizens, goods, equipments and systems which can deal with this subject was cleared more than ever.

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But from the 1970s, upon appearing the negative outcomes of increasing use of personal automobiles, many efforts have been done for limitation of this use and extension of the other modes of transportation particularly public transportation and pedestrian movement. Also, since about two decades ago, the topic of travel demand management (TDM) has been raised seriously. Means that instead of centralizing on responding the travel execution, a kind of prevention has been applied and the necessity of doing urban travels has been reduced with a range of activities. These measures are very varied and include issues such as: diverse pricing of personal transportation, flexibility of daily work beginning and finishing hours, development of communications and promotion of tele working, establishment of relative centres and expansion of tele education. Furthermore, within two recent decades upon development of information and communication technology (ICT), new challenges and predictions in relation to the increase or decrease of transportation demand rate have been raised which was along with different and sometimes conflicting opinions. Considering the characteristics of various cities, each one of road, air, rail or even marine transportation may be used. Generally, different modes of transportation in the cities are divided in three groups of personal transportation, paratransit (semi-public transportation) and public transportation. In personal transportation, various means are served for displacement of a person and movement path is determined according to his will. Walking is the simplest way of movement and is the only mode of transportation that is independent of any tool or device: "Pedestrian movement is the most natural, ancient and necessary form of human disposition in the environment." [5] Automobile is the most common personal transportation mode in the recent period. Although, using the personal vehicle comparing to the other displacement modes has more speed and individual comfort, but dependence and merely relying on the personal vehicle create many losses for the society in macro level. So, today the necessity of balanced planning for determination of automobile role in the urban movement system is emphasized more than ever.

One of the other means for personal displacement is bicycle and due to its special characteristics in proportion to the other transportation modes has more mobility. The bicycle even comparing to the public transportation is advantaged due to "non-variation of habitats structure and alternating with walking (and consequently body energy saving intensively)." [6] Moreover, at present, using motorized bicycles, rockers and electric powered bikes (noiseless and without pollution) are growing in many pioneer cities considering the increasing traffic of the streets. Of course, for using them in special bike lines, necessary observations shall be applied.

Transportation with small wheels including the various types such as "skaters, skateboards, walkers, scooters, electric powered bikes, wheelchairs, segways" [7] is deemed as personal transportation. Transportation with small wheels due the effects of environmental conservation is increasing in many pioneer cities in the recent years and through appropriate designing of special lines, the citizens may be persuaded to use such vehicles.

Generally, walking, bicycling and using various means with small wheels are altogether referred to as "non-motorized transportation" which is carried out with three major purposes including; recreation, accessing the goods and activities or a combination of both mentioned types. One of the other methods raised recently for individual transportation is personal rapid transit (PRT). This system is based on using small transportation means that usually move in a separate fixed course upper than the ground. The whole system is controlled by computer and information technology and it takes up the passengers in specified stations and takes them down in the desired stations upon the request of the users. "At general, net length of this system and its capacity is not so much." [8]

Paratransit includes systems such as taxi, minibuss, van and personal vehicles (with high occupancy). These systems have higher level than personal transportation as respect to the displacing capacity but as respect to the schedule and moving course are more flexible than public transportation.

Public transportation systems comparing to the personal transportation and paratransit could displace more passengers. "Public transportation contains all transport systems including two features: the passengers not to travel in their own private car and they travel in group and not exclusively. Public transportation is usually referred to as rail and bus systems. But in a more comprehensive definition, passenger airplane and passenger ship are deemed as public transits." [9] Inner city public transportation has been divided in various categories but according to the most common definitions: "generally three types of public transportation in the cities are used separately or in combination with the other vehicles including buses and electric buses, light railways (tramway) and urban railway." [8]

In consideration to the foregoing, urban transportation may be divided generally in three modes of personal transportation (walking, bicycling and private vehicle), paratransit (car pooling, minibuss and van) and public transportation (bus, light rail transit and metro). Also, each one of the transportation systems in the cities shall be chosen considering the different traffic, social, economic, physical and cultural conditions and studies.

III. WALKING IN THE CITY AND ITS ADVANTAGES

Walking has different meanings in different aspects. In the dictionary of urbanism, walking and pedestrian have been described as follows: "The degree to which account is taken of the interests of people on foot is fundamental in determining the effect of planning policy and practice. The Los Angeles planner quoted by Rebecca Solnit (2001) represents one extreme. The pedestrian, he or she said, remains the largest single obstacle to free traffic movement." [10]

What is understood from this definition is first undeniable effect of the pedestrians in the cities on the urban planning and second taking to account the pedestrian movement in contrast with riding movement. Walking is among the few human activities that has kept its primary form despite the development of different kinds of technological, communications and transportation tools. In the meantime, all city-travels via any vehicle whatsoever begin with and end

with walking. Meanwhile, walking is accepted as the best type of human interaction with the urban environment: "What makes pedestrians distinctive is that they are open and slow. These qualities enable walkers to truly experience and interact with their urban environment. It is walking that knits the structures, spaces and people of a city together." [11]

The walking is superior to riding movement either physically due to the much more flexibility and coordination with the path or mentally due to providing the contemplation and communication with the space. John Boucher Founder of International Conference of Walking in 21st Century describes the pedestrian movement as follows: "walking is a practice without requiring the practice place, a prescription excluding drugs, weight control without diet and is an elixir that is found by no alchemist. And more valuable point is that walking makes no pollution, consumes fewer natural resources and is efficient intensively. The walking is easy and requires no special equipments, is self-sufficient and safe naturally. Walking is natural like as breathing." [12]

The extent of the cities and interval between its various centres in the old the cities was so that the citizens went on foot from one place to another place and whereas the only mean for displacing the people or goods was livestock, Because of their speed and moving mode, necessarily no need was felt for differentiating the pedestrian and riding roads and spaces from each other. Such movement pattern in the city not only made an interactional, emotional and tasting bond between city and citizens but characterize the urban roads and passages as social and cultural features. Before industrial revolution, the cities' structure and figure in all over the world generally followed the geographical conditions and streams and path ways. And urban structures followed human scale and possibilities of human and somehow livestock pedestrian movement. Therefore, the urban paths and spaces formed in compliance with the human sizes and social and mental requirements of the citizens.

But pursuant to the expansion of entering the vehicles into the cities and widening the streets for convenience of motorized vehicles movement, various former functions of urban spaces were allocated only to the transit of goods and passengers which has been followed so far. Therefore, the thousand-year priority right of pedestrians for using the public urban passages and realms was ignored generally and the pedestrians exiled to the independent islands and the vehicles dominated the urban spaces.

The walking is a part of natural behaviour of the man that is old as human being history. In the walking, contrary to common perception, not only the movement organs of human are activated but neural and mental system becomes active together. Thus, providing the conditions for movement of pedestrian through the city conveniently and enjoys from his around events and occurrences seems to be necessary both for fulfilling the human intrinsic requirements and for upgrading the quality of public urban spaces. This topic at present and at the beginning of third millennium has been signified considerably because the vehicles have dominated the cities and machine life and consequently the citizens' separateness from their natural needs increase day to day.

The people walk in the cities with different purposes. "In an urban setting, a pedestrian journey is rarely single purpose: on the way to somewhere else, we stop to buy a newspaper, talk to a friend, enjoy a view or watch the world go by. Bill Hillier terms the potential for such optional activities the by-product of movement that is, the potential for other (optional) activities in addition to the basic activity of travelling from origin to destination." [13] There are two clear purposes for walking through the city: first, transportation for accessing to a particular destination and second for entertaining in order to watching interesting views or sporting. These two purposes may be combined with each other. On the other hand, the advantages of walking comparing to the other modes of transportation are as follows: [14]

- Not using the nonrenewable energy resources;
- Not disordering and polluting the urban environment;
- Low cost for supplying appropriate walking network comparing to other transportation means;
- Pedestrian pathways are urban natural spaces and generally don't occupy separate location;
- The walking is reliable and people can handle their works on time;
- Considering the walking acts towards fair distribution of accessing the urban facilities;
- The walking helps the health and cheerfulness of people;
- The walking creates dynamism and movement in urban spaces.

The walking due to giving the opportunity of discovering the new spaces and stimulation of curiosity may have a great effect on creation of calmness and mental health for man. Meanwhile, it is emphasized that the other types of transportation even bicycling although lead the man towards the special destinations but only walking has a closed and alive relationship with public spaces and through creating the sense of place cause to the real recognition and perception of urban places.

Generally, the characteristics and main requirements of pedestrians may be divided in two physical (related to the physical topics and quantitative aspects of the human) and mental (deal with qualitative ad perceptual aspects) groups. Also, pedestrians have different behavioral characteristics in terms of different age ranges which should be considered by urban planners. The planning and design instruction of Florida has been divided the pedestrians in 7 age ranges according to their characteristics including: infants and toddlers (ages 0 to 4), young children (ages 5 to 12), preteens (ages 13 to 14), high School aged (ages 15 to 18), adults (19 to 40), middle-aged adults (41 to 65), senior adults (65+) and for instance has mentioned to some issues such as: "impulsive and unpredictable, limited in their peripheral vision, limited in training/lacking in experience, thrilled or excited by close calls, short and hard to see by drivers, susceptible to darting or dashing out into the intersection, likely to copy the behavior of older people" [15] as young children walking traits. Thus, pedestrians are necessary for the life of a big city and the rate of citizens' walking in addition to all existing privileges, is

considered today as one of the most important factors of quality of life in a city. As Sir Colin Buchanan: "The condition in which a person can walk freely in an urban environment and looks around, is considered as the most important sign of its civilization quality." [16] Finally, the walking as a mode of transportation which is independent and the other types such as public transportation relying on it should be considered by urban planners and designers more than ever at the beginning of third millennium.

IV. THE CONCEPT OF SUSTAINABLE TRANSPORTATION AND ITS INDICATORS

It has been presented different definitions for the term of sustainable development. One of the most perfect and reliable terms of which have been expressed by United Nations in 1987 is: "Development which meets the needs of present without compromising the ability of future generation to meet their own needs." [17]

Whereas the transportation is one of the most important elements of urban structure formation, the sustainability of transportation has a great role in sustainable urban development. Various definitions have been raised for sustainable transportation each one has emphasized on this subject from a different aspect. Some of the most important definitions are as follows:

- Sustainable transportation is policies and infrastructures for economic development, conservation of environment and social equality with the objective of optimizing the transportation system for achieving the economical, social and environmental purposes without endangering the future generations. [18]

- Sustainable transportation is the most effective and easiest way for displacing the people and vehicles with the least rate of energy consumption (fuel and human efforts) with most acceptable cost, minimum traffic and the minimum environmental disadvantages such as air and noise pollution. [19]

- A type of transportation including three approaches; any measures taken towards reduction and omission of inner city travels, moving towards non-motorized transportation modes such as walking and bicycling instead of using motorized transportation system and approaching the modern transportation systems in the energy sector is referred to as sustainable transportation. [20]

- Sustainable transportation includes the cases that may meet the essential displacing needs of all people and to be continued in a foreseeable future without harming the human health or reduction of basic local or earth resources. [21]

Considering the above definitions and the main concept of sustainable development, the sustainable transportation may be deemed generally as a type of transportation that meets the present needs and demands of human societies to the displacement without wasting the capabilities of future generations for obviating their needs. Therefore, any type of transportation or any policing in the transport affairs compatible with the environment and considers the minimum

consumption of non-renewable energy resources, economical, social and physical issues of the cities is deemed towards sustainable transportation.

On the other hand, sustainable transportation doesn't mean as elimination of automobile. But if this topic is taken into account and targeting the non-motorized displacing modes such as walking and bicycling will automatically reduce the traffic volume and consequently fewer use of personal vehicles. Furthermore, according to the applied researches, it has been specified that avoiding from using automobile and approaching the clean transport is not adequate solely for creation of sustainable urban development: "using public transportation, bicycling and walking is not sufficient for sustainable urban development; and along with them, restricting plans such as urban development control, traffic limitation for car riding, parking control, speed control and increasing the fuel price are necessary as well. [22]

Reviewing the sustainable transportation indicators mentioned by the associations and different reputable societies such as sustainable transportation center of America, world business council for sustainable movement, environmental mechanism and transportation of European union and the sustainable movement of European commission indicates that they may be classified generally according to the existing common points to three main aspects including: social, economical and environmental issues. Also, considering the studies applied by the world literature and taking the native conditions into account and observing the maximum abbreviations may compile 9 indicators for sustainable transportation and measures for analyzing each of them. These factors have been provided in table1.

TABLE I
PROPOSED INDICATORS AND MEASURES FOR SUSTAINABLE TRANSPORTATION

Aspect	Indicators	Relative measure
Social	Social safety and security	Car accidents and death caused by driving and crime rate
	Individual and social health	Body fitness and assisting the improvement of physical and mental conditions
	Accessibility	Accessibility of children, women and affordable for all
	Vitality and general desirability	Mean value of peoples' satisfaction with transportation systems
Economical	Transportation costs (users/load)	Lateral costs, fuel costs, transportation costs
	The land allocated for the infrastructures	Transportation and parking spaces
Environmental	Air pollution- noise pollution	Gases exiting from vehicles (Co2, Co, No)
	Environmental interventions rate	Conservation of natural settlements and environmental elements
	Use of renewable resources	Use rate of fossil and non-fossil energies

V. THE EFFECT OF WALKING ON THE TRANSPORTATION SUSTAINABILITY IN THE CITIES

For evaluation of various modes of inner city transportation according to the introduced sustainable transportation indicators, analytic hierarchy process (AHP) and Expert Choice software have been used. Therefore, all modes of inner city transportation have been divided in three main groups (personal transportation, paratransit and public transportation) and for observing the abbreviations and achieving the maximum applied results divided in 9 modes (walking, bicycling, personal vehicle, van, minibus, trip taxi, car pooling, bus systems, light rail systems and metro) and were analyzed and compared in relation with each other and each one of the factors. Whereas towards the maximum validity of research findings via AHP method, it is necessary to the experts and scholars to give score, out of a 10-member group including masters of transportation and traffic deputy of Tehran who in addition to necessary specialty had relative executive records, were requested to act for evaluation of 9-item sustainable transportation factors to each other. In figure 1, the result of comparison and final ranking of all transportation modes in relation to the 9-item indicators of sustainable transportation aiding Expert Choice software has been exhibited. The inconsistency ratio is equaled to 0.07 and is acceptable. (less than 0.1) The results indicate that among all transportation modes, the walking has gained the highest rank and bicycling and metro are placed in the next positions. Paratransit (minibus-van) has obtained the lowest rank.

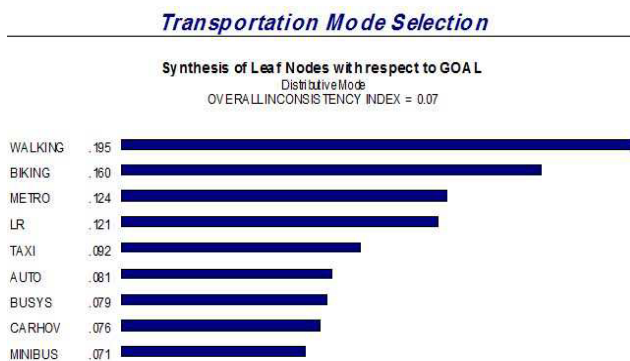


Fig. 1 Comparison and ranking of all transportation modes in relation to the 9-item sustainable transportation indicators

Displacement in the cities is not solely a purpose. The people move for accessing the other people or things. But in the car-oriented cities, the activities incline to the promotion. This will force the people to more and more trips for the same level of previous access. The healthiest and most sustainable modes of transport are walking: "The healthiest and most sustainable modes of transport are walking and cycling. Even car drivers become pedestrians to complete a trip, and effective public transport depends on people being able to walk comfortably to stations and stops." [23]

One of the essential points in sustainable transport is focusing on the access instead of movement. In other words, whatever the possibility of arriving the destination with less trips and less movements are provided, the transport mode will be more sustainable.

In the pedestrian-oriented the cities against the car-oriented the cities that the purpose of them is facilitating the vehicle movement even for further movements, arriving the people to the destination is the main emphasis and consequently the activities instead of promotion incline to the compression.

Verifying these that walking is interfered in achieving all of principles indicated for sustainable transportation directly or indirectly: pedestrian movement provides direct access to the destination, is the best mode of displacing as regard to causing equality and social justice between all the persons in the society, causes to the health and is the safest and cleanest transportation mode, through simulating the curiosity and involving all visual senses causes the public participation and through integrated planning and complete linking the urban pedestrian networks may take actions for rehabilitating some land uses and preventing destruction of natural resources.

Today and specially at the beginning of third millennium, disappointment of people from machine-oriented life and the consequences thereof in the world has distinguished the requirement to the pedestrian transportation and car-free zones. For instance, in Barcelona of Spain, wide streets have been constructed with the priority of pedestrians in proportion to the cars. In Paris, for zones which have been located on the cars traffic road and have been exhausted, improvement plan has been executed. Thus, "it is forecasted that until the end of 21st century, upon limiting the energy sources, the plan of constructing car-free the cities will be transformed to a worldwide subject and leads the cities towards constructing pedestrian neighborhoods." [24]

Considering the foregoing may conclude that the pedestrian movement comparing to the other transportation modes in the cities from among all indicators, is the most sustainable mode and includes all conditions of sustainable transportation measures. Therefore, paying further attention to the expansion of infrastructures of pedestrian movement and upraising their efficiency will be an essential step for achieving the sustainable transportation.

VI. CONCLUSION

Transportation in macro scale means the displacement of individuals and goods based on the physical, geographical characteristics and transfer volume of passenger or load could be classified to different categories. But particularly in the cities the most common transportation subsets are road and rail transit each one including diverse systems and modes. The studies on inner city transportation history indicate a constant and almost uniform trend before industrial revolution and creation of sudden and extensive changes after this period. Urban transportation has been divided in three personal transportation, paratransit and public transportation.

The walking as the most common mode of non-motorized and personal transportation comparing to the other modes of inner city transportation has frequent features and advantages such as non urban environment pollution, justice for accessing to the urban facilities, increase of individual and social health and cheerfulness, stimulation of urban spaces, creation of social interaction etc. Therefore, at the beginning of third millennium, the walking as the healthiest, most economic and dynamic displacement mode in the cities has been considered

seriously by the relative authorities and thus various strategies and inventions for development of such transportation mode are in progress.

Sustainable development which means supplying the current human needs considering the requirements of future races and contains multi dimension concepts including social, economical and physical aspects has changed today into dominant discourse in all activities and scientific levels.

Meanwhile, particularly within two last decades, sustainable transportation has been emphasized as one of the main principles of sustainable urban development intensively. The applied studies on several countries indicated that the indicators of sustainable transportation may be classified in three social, economical and environmental groups. In consideration of native conditions and maximum distinctions and minimum interventions, these indicators including 9 issues were suggested. Meanwhile, comparing all modes of inner city transportation according to the opinions of transportation and traffic experts in Tehran showed that non-motorized transportation and particularly walking is the most sustainable mode of displacement in the cities.

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