

The Role of Metro Network in Sustainable Urban Development

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Abstract

In the history of transportation, there have been intricate correlations among access, transport services and urban development. Irregular growth and expanse of the cities without considering these interrelations, causes many problems to the proper urban services. It makes planners and policymakers to survey and evaluate solutions to this dilemma, according to sustainable development sights. In these terms, generation of sustainable solutions correspond with proper transportation is inevitable. Metro network is recognized as one of the solutions, because of having many exclusive qualities and abilities to alter the population balance, access and capacity of regional developments.

This paper, first reviews the sustainable urban development strategies, then evaluates the role of metro network, as one of the pillars of nowadays urban transportation, in these strategies. It is about to answer these two questions:

- How does metro network influence the structure of urban areas?
- How can policymakers profit by these influences in developing urban sustainability?

Key words: Sustainable urban development, urban transportation, sustainable transportation, metro station

1. Introduction

Environmental problems have found special position on international debates in the second half of twentieth century. Discussion about destruction of jungles, soil erosion, demolition of coasts, global warming, Ozone depletion, acidic rains and accumulation of radioactive waste have increasing significance. Recent studies about sustainable development patterns and the methods of achieving this development have tried to express its features and the procedure of executing this concept. But the subjects related to sustainable urban development have been less considered while various cities in the world have become mass consumers of natural resources and great producers of wastage.

For many years, undesirable consequences resulting from urban life style have brought serious problems and difficulties for environment and human being. These effects not only have exposed animals and plants' lives to danger but also will bring an unfavorable future for next generations. Under these circumstances, sustainable development has been taken into consideration by many organizations, institutions and governments. It is necessary to define this concept precisely, specifying its main features, and experiences of various countries in this scope should be surveyed. One of the principal bases of sustainable development is sustainable urban development which has become a major part of urban literature and urban development investigations over the world in recent years. International assemblies have abundantly discussed and surveyed this predicament and perhaps all the countries have taken it into account in their policies.

In this direction, sustainable urban development has been studied in different viewpoints and some solutions have been presented. One of the most effective ideas in these subjects is access and transportation network is a main part of it. Besides being effective in carrying passengers and goods, these networks lead to urban development through making access. Therefore transportation network is considered as one of the most effective factors on urban development which could be directed and organized by planning these networks. Since numerous problems emerged by cities irregular growth and spread and neglecting interactions between urban planning and transport management, modern planners and policymakers studied approaches to change the condition. In this situation, the concept of "development based on public transportation" was formed and it is one of the greatest subjects of urban development nowadays.

This paper initially considers presented guidelines in the field of sustainable urban development and then by aiming organized planning studies the effect of metro network on urban development along with focusing on public transportation. It also aims to find potential abilities of this system and tries to answer two following questions:

- How does metro network influence the structure of urban areas?
- How can policymakers profit by these influences in developing urban sustainability?

2. Research Methodology

Since the current research is theoretical, its methodology is based on studying scientific texts and documents and the majority of the references are books, magazines, related research projects and scientific web pages. And according to the nature of research data, research methodology is qualitative and based on analytical process. And it tries to provide a proper base for further studies by presenting principals and concepts related to this approach.

3. Sustainable Urban Development

In 1995, about 45% of world population lived in urban regions and it is anticipated the number will rise to 60 - 65% by 2025. In 2003, 38% of Asia population (about 1/2 billion) lived in cities. By 2020, urban residents' ratio will increase up to 50% and urban population will rise to 2 billion. Along with rapid process of industrialization over the world, many countries especially developing ones are experiencing quick urban growth and immigration from rural areas to cities has begun since twentieth century. In developing countries, 50 million people have been added to urban population annually and it causes more demands for residences and urban services. The lack of coordination between offer and demand of proper residence causes developing of the cities spontaneously and unplanned and in many cases, environmental problems turn into crisis. Ahmadi, M. (1386).

The history of emphasis on the interaction between city and environment at international conferences is not prolonged. The first environmental convention was held in Europe (1957) and on its manifesto, cities have been considered. And preferences are given to safekeeping and development of environments. Beside sources are utilized in a logical and optimized way by expending safekeeping of human health. In 1990, European communities' commission set forth an article and presented the first European manifesto to access real development concerning urban environmental quality. On this manifesto, strict zoning regulations are criticized. The writers believe that current zoning should be replaced by development of various, multipurpose and compressed areas. Feizi, M. and Fazel, M. (1387).

Another writer supposes that sustainable urban development lies in efficient land use and encouraging reusing buildings. He also believes that size, compression and place of human residences which is suitable for sustainability, will be varying according to development of technology in the field of energy, production, building and transportation.

Ambiguity in the meaning of sustainability has also caused some sort of uncertainty to define sustainable urban development. City is a complicated system and the larger it is, the more unpredictable development proceeding would be. A city or an urban zone has a specified capacity if which overloads, the quality of life will decrease. An urban zone or region by which development should be adapted, is greatly measurable through approaches such as carrying capacity approach. Carrying capacity approach means studying interactions between physical environment and demand pressures among all parts of activity. By considering limited capacity of cities ecological context, sustainable urban development would be possible according to environmental and local specifications and observing basic principles of sustainable development. Leghaei, H. and Mohammzadeh titkanloo, H. (1385).

Since 1994 in Europe, an international urban environment institution has commenced to prepare urban sustainability indexes for Europe Environment Agency. These indexes are measured in three main dimensions:

- Flows of sources (raw materials, goods, food, energy and water) and the pollution related to them.
- Land use, traffic and transportation patterns and their effects on cityscapes.
- Urban environment quality (water, air, safety, residence and green field land).

Regarding to the concepts, manifestoes and point of views mentioned above the goal of process of sustainable urban development is to create or strengthen sustainability features in

economic, social- cultural life and environment. According to authorized principles of 21 agendum and Rio manifesto and authors opinions, the following considerations in table 1 are proposed for sustainable urban development.

1.environmental considerations:	<ul style="list-style-type: none"> -Linear process of materials and inputs entering urban areas should be a closed system as far as possible (recycle of materials and reuse). -Serious studies and evaluation of environmental impacts of urban development plans. -Designating carrying capacity of environment. -Decreasing pollution of air, sound, wastage and sewage. -Increasing urban environment health. -Protecting cities to prevent accidents' impacts and minimizing damages.
2.cultural and social considerations:	<ul style="list-style-type: none"> -Giving priority to human and his needs. -Confronting population explosion and decreasing growth rate down to zero. -Accentuating identity and specific cultural features of every city. -Decreasing poverty and difference among social classes. -Changing the behaviors in order to decrease levels of consumption patterns. -Encouraging people to cooperate in instruction and promote the culture of being environmentally friendly. -Fair distribution of facilities among urban regions.
3.Economic considerations:	<ul style="list-style-type: none"> -Recognizing and defining unsustainable technologies, products and materials. -Preventing irregular immigration. -Changing models of production, distribution and consumption of materials. -Obtaining economic growth of city. -Supplying required goods in cities to reduce distances and decrease energy consumption. -Diminishing per capita costs of urban services to raise economic efficiency of city management.

Table 1: general considerations in planning sustainable urban development

Leghaei, H. & Mohammzadeh titkanloo, H. (1385).

4. Role of Transportation in Sustainable Urban Development

Being the main pillar of economic growth and urban social development, transportation allows doing different activities. Besides providing access, Goods and Information flows are available through it.

On the other hand, transportation consumes more than 20% of energy sources and is responsible for the main part of air pollution over the world. As far as we see, people are dependant to use personal vehicles more than ever. It is predicted that by 2025, energy

consumption in transportation sector and producing of greenhouse gases will doubly increase compared to 2000. Environmental impacts and damages to human health have seriously created difficulties due to vehicular transportation rapid growth and its weak legitimacy process. About 750,000 people, whose majorities come on foot, are annually killed by accidents resulting from motorized vehicles. In addition, in developing countries about 500,000 people annually meet with premature death resulting from air pollution made by transportation. Shahidi, M. H. (1384).

A sustainable transportation system requires activities such as control of air pollution, traffic or fuel consumption. Sustainable management of urban transportation attempts to decrease environmental impacts, increase transportation system efficiency and improve social life condition. Its aim is to increase efficiency and carrying goods, services and people with minimum access problems. This issue could not be achieved without reorganizing strategies, policies and plans.

Numerous definitions have been presented for sustainability in transportation. Canada transportation institution has mentioned that goal of developing sustainable transportation system is to ensure considering economic, social and environmental factors in policy making related to transportation activities.

As mentioned, improper urban development is one of the basic reasons of most transportation problems in the world. Rapid, unplanned and uncoordinated growth of cities causes population dispersion and more people move from downtowns to suburbs. Population dispersion results in decreasing access to public transportation. Meanwhile high costs of executing new public transportation systems hinder public transportation development to meet new needs. Nowadays in some countries including third world, transportation development is mistakenly interpreted to activities such building bridges, widening roads and creating rapid transportation systems. This system is mainly centralized on transfer vehicles instead of people which practically raise air pollution and traffic density. When transportation infrastructures are inefficient, then costs of maintaining and developing infrastructures, fuel and external transportation costs just force large financial problems on national economy without having an effective role in transportation problems in long term. In industrialized countries presentation of logistics plans as different and inherent aspects of a sustainable transportation system are being formed with following specifications:

- Minimum need to commute and coordinated by needs of all social classes.
- Utilizing transportation methods with the least environmental impact and minimum using human and financial resources.

5. Guidelines in Developing Sustainable Urban Transportation

5-1. Management of Transportation Demand

Response to progressive needs of commuting in cities is practically feasible via two ways:

- Increasing capacity of transportation infrastructures.
- Management of transportation demand.

To some extent increasing capacity of infrastructures, is sensible and logical but enhancement of capacity accompanying with raise of demand is impractical and costly.

Management strategies should be practical, inexpensive and in accordance with people's need.

Management of transportation demand is considered as the best approach and the most economical factor. In this case, various advantages such as decreasing traffic density, using personal vehicles, parking and roads, declining accidents and consumers costs, decreasing air pollution by using replaced transportation via non-motorized transportation, parking management strategies and efficient planning of land use are obtainable. For instance, non-motorized transportation in the cities in developing countries influences urban structure and is influenced by it. This sort of transportation could remain as an attractive option provided that there is urban high compression proportionate to multi-purpose land use development pattern.

5-2. Territory Logistics and Intelligent City Growth

Territory logistics techniques are requisite for coordination between trip rate and ability of improving transportation facilities. Intelligent growth is a concept which means management of urban growth through confronting suburbs living and its aim is to achieve a strategy concerning land use that increases population compression in residential regions and makes transporting easier. "Access via nearness" as one of the main policies in sustainable urbanism means solving transportation problems through getting people more close to places they should commute every day. It is mainly done with fundamental changes in existing condition of functions. By encouraging development of regions with mixed used functions, creating local centers and urban villages which have residences, workplaces, shops and recreation facilities close to each other may achieve the above goal. It is not by chance that developments with small scale and mixed used functions leading to more interesting and lively places. "Inversing transportation hierarchy" is the result of this policy which means accentuating pedestrians. Travel on foot is the most efficient sort of transportation concerning energy consumption and also brings about human presence in urban areas and make them livelier.

5-3. Non-Motorized Transportation

By various reasons, walking and cycling are ideal methods for intra city travels because it does not produce sound or air pollution and required energy is directly supplied by its own. Besides, this method is completely economical and having a cost much less than public transportation.

Usual assessments regarding sustainable development prefer non-motorized transportation to use personal vehicle. This sort of transportation has numerous advantages but unfortunately like many strategies and methods of achieving to sustainable development, these benefits may hardly be evaluated, so consequently they are ignored and not considered enough. For example, it is difficult to determine the number of non-motorized travels in a region and is not often recorded in studies and traffic enumeration. Nowadays the importance of walking and cycling in some countries like developed ones and few Asian countries are known and have a top rank on urban transportation development plans.

However, using public transportation, development and implementation of transportation efficient systems in sustainable urban transportation planning are unavoidable. Optimum using of these systems, stops irregular process of using personal vehicles and decrease energy consumption and greenhouse gasses production. Naturally, there is no independent

and exclusive option for public transportation in a city. Every city should be planned according to its related problems. Kennedy, C. et al (2004).

5-4. Public Transportation

Development plan based on public transportation is a form of land development which is influenced by public transportation systems and has created a good relationship between land use and transportation. It presents a more efficient image of land use. This approach basically aims to pace in the direction of declining number and length of trips, through establishing attractive and crowded functions around public transportation corridors or passing corridors of public transportation through more crowded regions with more trip attractions to prepare suitable transportation and functionality proportionate to land. Therefore, in order to make a suitable relationship between functionality and transportation, services and functions are mainly concentrated around public transportation corridors and compression increases naturally.

Compression and establishing crowded functions around public transportation corridors prepare especial facilities. It has much positive effects in the process of urbanism and transportation. This concentration through supplying travel destination at public transportation stations omits two branches of intra city trips of every passenger and economizing amount of city travels. Thus, placing crowded functions around stations rises using public transportation system and increases its efficiency. Tsekeris, T. and Tsekeris, C. (2009).

The existence of concentration releases lands around public transportation corridors, regulates coordination of functions, provides opportunity to create urban green areas and prepares possibility of creating urban footpaths around public transportation corridors. These interactive influences of public transportation system and urban context create capabilities which could be considered as opportunity to develop urban context provided correct planning and guidance. (Table 2)

6. The Role of Metro Network in Development with Centrality of Public Transportation

Urban development approach with centrality of public transportation includes all transportation options. Although metro network is the most costly public transportation system but it has maximum capacity of carrying passenger. Besides its high capacity, efficient use of land, high speed, safety, convenience, proper cost and accordance with environment are of the advantages of this system. Entering metro in public transportation system according to its especial features comparing to other transportation vehicles, has made main changes in operation of traffic and transportation in cities. Consequently it influences on equilibrium of population absorption and capacity of regions development. What is important is to know rate and method of influencing this network on urban development.

Metro is a railing transportation system that in its exclusive path (generally underground) moves by using power force from third rail or elevated cable. This system with maximum 90km and average 27 to 40 km per hour has capability of carrying 80,000 people per hour. The history of metro presence in transportation is relatively long and it refers to launching London metro (1836). Tsekeris, T. and Tsekeris, C. (2009).

Metro network connects urban different places to each other however it is independent of divisions of the city since moves underground. Thus, its effect on development appears in the points it joins to ground level as stations. Since metro stations are supposed as the cores of transportation system where passengers getting on and off, is important to attract passengers considering transportation planning. On the other hand, they are themselves places which could develop in two ways. One is to develop station itself and activities concentrated locally. The other is their effect on near lands.

Supposing metro stations as places, opens a new horizons for urban planning. In this view, railing transportation station is a place where different activities are happened and makes value added in its area of influence.

1.Environmental indexes:	Air pollution:	<ul style="list-style-type: none"> -Consumption of non-restorable resources. -Controlling consumption of oil resources and products. -Preventing destruction of environment through construction developments. -Decreasing consumption of construction materials and resources.
	Consumption of non-restorable resources:	<ul style="list-style-type: none"> -Controlling consumption of oil resources and products. -Preventing destruction of environment through construction developments. -Decreasing consumption of construction materials and resources.
2. Social indexes:	Health:	<ul style="list-style-type: none"> -Protecting people against harmful suspended particles, nitrogen and carbon oxides. -Protecting people against sound pollution. -Decreasing mortalities and injuries resulting from traffic.
	Opportunities:	<ul style="list-style-type: none"> -Decreasing inequality resulting from setting people exposure to pollution. -Declining total lost times in traffic. -Increasing the level of access to public transportation and acceleration of transferring people. -Raising access to downtown and services. -Increasing liveliness of downtown.
3.Economical	Benefits and	<ul style="list-style-type: none"> -Increasing benefits of transportation users. -Raising economic advantages in transportation

indexes:	general indexes:	sources. -Total incomes of transportation system in terms of vehicle sort. -Advantages resulting from per capital.
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Table 2: evaluation of general indexes of sustainable urban transportation

Therefore station may completely influences around areas and modifies the composition of settled functions. Such modifications may have a great effect on accelerating the process of sustainable urban development. Influencing factors on development of every station are different regarding location and environmental conditions. Therefore, in every station, impressionability of region development and influencing on development capacity may be different. Even in the case of stations which are arranged along the metro line. Rezazadeh, R. and Raadmand, M. (1384).

6-1. Factors of Development of Metro Stations

In order to know facilities of development of stations, one should consider specified features. Effective factors on development of metro station as a place are included:

6-1-1. Number of Passengers

Total number of passengers using a station has an important role in the capacity of development of that station and influencing on the kind of services which should be presented. The more the number of station passenger, the larger is the capacity of its development. Following factors are effective on attracting passengers and the quality of services for metro system:

- Way of distributing lines and stations in the city.
- Quality of rival transportation systems such as highways, pedestrian access systems and bicycles.
- The rate of personal vehicles possession.
- Public transportation system as bus, minibus and taxi.
- Way of distributing functions and activities in the city.
- The quality of connectivity of stations with other transportation systems.

6-1-2. Localization and Roles of Stations

Station role is mainly related to its localization and kind of source and destination and in other words, travel goals. At stations which travel goals are merely business, stoppage at the station is short. So placing some kind of activities is accompanied with success. While at the stations which travel goals is basically recreation or education, placing some other group of activities would be suitable. Based on this, travel goal and length of stoppages in the place specify station situation. The more stoppage is at the place of station, the larger possibility of development of station would be.

6-1-3. Patterns of People Behavior

Surveying patterns of people behavior is effective in services and goods which may be presented at stations. Behavior pattern is the alternation of using metro such as daily, weekly, etc. Using metro may reinforce the habit of providing some daily needs from metro stations and presenting these services results in development of station place.

6-1-4. Variety of Users

Category of metro network users is effective in the sort of presented services at the stations. One of the specifications of metro stations is variety of users so that almost all social classes use metro network for a reason. Thus, social class of users on every station depending on the situation of the place determines presented services.

6-1-5. Selected Vehicles

Complete travel from source to destination is always accomplished through combination of different vehicles. The most important factors in the points of changing vehicles are convenience and facility. Metro stations are places which concerning usage of selected vehicle to move between travel goals and themselves require providing facilities and capabilities. Sorts of vehicles used by passengers including personal vehicle, taxi, bus, minibus, service, bicycle and walking require facilities at the stations.

Surveying the number of passengers who use personal vehicles to arrive there is necessary not only for evaluation of number of demanded parking but also for finding proper places suitable for services. Correct prediction of kinds of travels to metro stations is determinant to organize these travels. According to it, one may benefit from proper plans to develop immediate lands of metro stations.

As mention earlier, a station can modify completely influence area and change composition of settled functions. One of the first actions to rearrange areas around of stations is to know and determine influence area of them. Actually the main intention is to determine regions in which a station has influence on functions, prices and other indexes. What mainly specifies rate of limitation and development is the location of the station in city.

Generally, one may acknowledge that stations with suitable access to local routes networks and facilities of pedestrian access have influence area about 400m, stations with proper access to system of accumulative routes and desired access of pedestrian and bicycle have influence area about 600m, stations with suitable access to system of arterial routes and proper access of pedestrian and bicycle, personal vehicles and public transportation system having influence area about 800m and stations with adequate access to freeways and highways and proper access of pedestrian, bicycle, personal vehicles and public transportation system possessing influence area more than 1000m. Rezazadeh, R. and Raadmand, M. (1384).

6-2. Factors of Development of Lands around Metro Stations

Most of the studies show that conditions and features of zones near stations have essential role in the capacity of land development of influence areas:

6-2-1. Existence of Undeveloped and Developable Lands

One of the most important factors on development which influences on place and severity of development attraction is existence of undeveloped and developable lands or lands that development has been performed but destruction and reconstruction is economical. It is observed in some cases that development near stations has been delayed due to shortage of developable lands. For example, development around metro stations in Toronto because of being developed at the time of constructing stations was postponed. This situation continued up to the time that development pressure increased value of lands around stations so that destruction and reconstructing buildings for suitable functions became economical. In some instances such as San Francisco Bart system, availability of developable lands has been the most important factor of development attraction. So that stations having developable land, have been attracted to development more than other stations. Zariony, M. R. (1371).

Besides availability of expandable lands, size of divisions is also effecting on attraction capability of development. Instead, the smaller are divisions, the more is their problems and risks through acquisition, accumulating and development.

6-2-2. Development Process

It should be regarded that occurrence of development requires existence of development process, so that in the cases which stations have been settled in developing regions, they have escalated development process. But in some cases in which stations have an economic downturn, there is no development and finally development of metro networks has just slowed progress of economic downturn. Therefore, in surveying capacities of development resulting from constructing metro stations, existent process of region should be considered too.

6-2-3. Localization of Stations

Another effective factor on development of stations is role and location of station in city. Depending on the location, Stations influence different extents of near lands and have various effects on developing them.

7. Conclusion

Development with centrality of metro is a kind of urban sustainable development in cities or reconstructing existing cities with sustainable approach which by settlement and function centralization at metro stations and near lands which decreases using personal vehicles and increases using metro. In central core of this region, there is a metro station which has been surrounded by compressed collection of functions. Collection of metro stations, lands and buildings around finally create complexes in city. It is because of lowering urban travels rate and making lively places which may play a determinant role in developing and reforming city structure. It is obtainable by centralizing and using correct composition of functions. It is worthy of note that sort of activities and proposed functions at every station is determined regarding station role in city spatial planning. Thus, by correct understanding of situation of every station, one may make a logical, intelligent and acceptable interaction between station and its influence area and benefit from it as an effective strategy in progress of sustainable urban development.

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