Investigating the Role of Urban Railway in Ecological and Economic Perspectives of Transportation in Mashhad

Mohammad Ajza Shokouhi
Associate prof. of Geography and Urban planning, Ferdowsi University of Mashhad, Mashhad, Iran

Ezzatollah Mafi
Associate prof. of Geography and Urban planning, Azad University of Shirvan, Shirvan, Iran

Fahimeh Ebadinia[1]
Ph.D. student in Geography and Urban Planning, Ferdowsi University of Mashhad, Mashhad, Iran

1. INTRODUCTION

A sustainable transportation system must contribute to life improvement and fulfillment of human mobility needs with emphasis on conservation of natural resources for next generations through replacement of renewable resources, conservation of biodiversity, carbon emission reduction, and support of economic knowledge in the field of transportation .Today, transportation sector has given rise to a myriad of environmental, economic, social and health damages. It is predicted that the annual production of carbon dioxide gas will rise to 85 gigatonne by 2050 from 42 gigatonne in the early 21th century. Urban transportation is regarded as the main cause of this problem. Although cities only cover 0.4% of land area in the world, they are responsible for the production of 80% of harmful gases and pollutants. Therefore, greater attention should be paid to cleaner transportation vehicles such as railway to achieve sustainable development. Since railway lines are geographically fixed, they can serve as permanent transportation vehicles, which can be used conveniently by passengers. Among all transportation systems, rail transport offers the highest efficiency in terms of energy consumption and poses the least damage to the environment, which explains the term green industry often attributed to this system. Carbon emission rate of electric high-speed trains is approximately one third of cars and one fourth of airplanes. Moreover, the area of land occupied by rail transport is equal to 0.2 to 0.3 of road transport with the same capacity, which is a decisive factor in issues related to development. In addition, its pollutant effect is 1.1 compared to other forms of transport. By creating new lines and connecting densely populated areas, rail transportation industry must provide equal conditions for convenient and quick travel of all people in the city. Therefore, rail transport plays an important role in environment conservation and livability of different areas of the city for all people.

2. METHODOLOGY

To calculate the ecological footprint in transportation, a collection of different activities affecting environment is considered, which includes: carbon dioxide, nitrogen oxides and methane produced from fossil fuels, and carbon released from the maintenance of vehicles, roads and transportation infrastructures (Barrett and et al, 2001).

Eq. 1. $aai = c_i / p_i$

(aa): The area land required for per capita funding of each consumable item*(i).*

c_i : Average annual consumption of an item.

P_i : Annual production efficiency.

Eq. 2. $ef = \sum aa_i$

(ef): Per capita footprint of people which is obtained from calculating the total consumption of a person relative to the ecological land required for its supply.

Eq. 3. $EF_p = N(ef)$

(EF_p): Ecological footprint of population, which is obtained from multiplying per capita

---

*. Corresponding Author: ebadinia @ um.ac.ir

footprint of people *(ef)* by the entire study population *(N)*.

3. DISCUSSION

The basic scenario: following the current trend and conventional business transactions

Overall, transportation utilizes 87785616 m^2 of the total land uses of Mashhad city, having a per capita of 0.0029 ha. Currently, Mashhad with a consumption of over 35 million gigajoules of energy per year produces 497554 tons of carbon. According to the table below, the share of gasoline among all other forms of energy is more than 24 million GJ, which solely accounts for 69% of total energy consumption.

According to the previous calculations of the authors, energy consumption in transportation section is 11.17 GJ for each citizen of Mashhad, with per capital ecological footprint of 0.11 ha per person for each 100 GJ per hectare. Given the current trends and annual increase of 40000 vehicles in city, there will be over 1400000 cars in the city by the year 2025, which would increase fuel consumption in transportation section up to 54 million GJ and carbon production up to 773973 tons.

It is estimated that Mashhad population will reach over 4 million people by the year 2025, thereby increasing the ecological footprint of Mashhad city transportation to 0.14 ha per person in 2025.

The ideal scenario: higher share of Mashhad rail transport in daily trips from 3.7 % in 2013 to 20% in 2025

It is predicated that each of the four lines of urban railways would come into operation in a five-year period. It is estimated that the complete operation of urban railways will increase the share of rail transport in carrying passengers from 3.7% to 20% by the year 2025. Therefore, one million and eighty-eight thousands passengers will be transferred by rail network in each day. It not only causes 10% reduction in traffic, but also significantly reduces the fuel consumption. Assuming that rail network of Mashhad would come into full operation by the year 2025, the amount of gasoline saved per day will reach 674560

liters, which is equal to annual saving of 246214 thousand liters or 7859460 GJ as well as an annual reduction of 111604 tons in carbon production. It also means a reduction of 23827 thousand liters of diesel fuels consumption per year. As a result, the consumption of gasoline and diesel in the transport sector fall by 20 percent. Given the annual consumption of 52 million GJ energy in transportation section by the year 2025, the completion of the rail network will reduce this figure to 44 million GJ with an ecological footprint of 0.13 ha per person, which is equal to the current figure.

In addition to the economic benefits, the completion of Mashhad railway network will have the following outcomes: In terms of reduction in fuel consumption:

Total gasoline saving in 2025= $674560 \times 365 \times 0.33 = 82 \times 10^6$ \$

Total diesel saving in 2025= $65280 \times 365 \times 0.15 = 35 \times 10^6$ \$

Cost of wasted time:

Cost of wasted time = $365 \times (1088000 \times 20\%) \times 42\% \times 1.6 = 53 \times 10^6$ \$

Total saving in the treatment costs of disease caused by air pollution:

Saving in treatment costs of disease caused by air pollution= $800000 \times 10 \times 20\% = 1.6 \times 10^6$ \$

Total saving in depreciation and spare parts of vehicles

Saving in total annual depreciation costs of vehicles in 2025= $1400000 \times 6600 \times 10\% \times 20\% = 185 \times 10^6$ \$

Total saving in total annual costs of vehicles spare parts in 2025= $1400000 \times 6600 \times 5\% \times 20\% = 93 \times 10^6$ \$

Total saving in developing costs of Mashhad city street network

Total saving in developing costs of street network = $600000 \times 7.4 = 4.4 \times 10^6$ \$

4. CONCLUSION

Given its importance, the rail transportation requires further attention. In long term, rail transport will be the most important and effective strategy of sustainable transportation, especially in metropolitans. In Mashhad metropolis, which in addition to its 3-million populations plays host to huge number of

religious tourists and pilgrims, rail transport is the key to sustainability and one of the requirements of urban planning. The ideal scenario proposed in this research is optimistic in that it assumes that by the year 2025, four railways and one monorail line will be operating in full capacity. This assumption, however, has only been made in 2025 outlook, and it seems impossible to be realized in the next 10 years, especially given the slow progress of rail network completion. The findings of this research suggest that achieving ideal conditions in rail transport of Mashhad city, despite the increase in population and vehicles, can hamper the ecological footprint increase. Currently, over 35 million GJ of energy is consumed to satisfy the need for fuel in transportation sector in Mashhad city, which produces 497,554 tons of carbon. It is estimated that by the completion of the railway network and its full operation, the consumption of gasoline and diesel in the transport sector will decline by 20 percent. Given the annual consumption of 52 million GJ of energy in the transport sector in 1404, this amount will decrease to 44 million GJ after the completion of the rail network, with the ecological footprint being 0/11 ha per person. A comparison of the current scenario and the ideal scenario reveals that the completion and operation of the railway network also produce positive effects in terms of financial saving. Thus, the saving derived from reduced gasoline consumption would justify the construction costs of Mashhad Urban Railway Corporation Company. In general, the total economic saving is estimated to reach 454 million dollars.

References

1. Abbas poor, M. (2010). Environmental impact assessment of railway transport projects. *Journal of Human and Environment*, *15*, 17-36. [In Persian]
2. Barret, J., Scott, A., & Vallack, H. (2001). *The ecological footprint of passenger transport in merseyside.* New York: Stockholm Environment Institute.
3. Brown, L. (2012). S*aving environment* (Plan B4.0) (H. Taravati, Trans.). Mashhad: SID publication. [In Persian]
4. Brown, D., O'Regan, B., & Moles, R. (2008). Use of ecological footprinting to explore alternative transport policy scenarios in an Irish city-region. *Transport Research Journal*, *13*, 315-322.
5. Buchanan, C. D., et al., (1963) Traffic in Town.The spacially shortened edition of the Buchanan Report Harmonddsworth: Penguin.
6. Caves, R. (Ed.). (2004). "*Principles of intelligent urbanism","* *Encyclopedia of the City".* Londo Routledge.
7. Chambers, N., & Kevin, L. (2001). *Ecological Footprint Analysis: Towards a sustainability indicator for business*. London: Spon Press.
8. Chi, G., & Stone, B. (2005). Sustainable Transport Planning: Estimating the ecological footprint of vehicle travel in future years. *Journal of Urban Planning and Development, 131*(3), 170-180.
9. Department of Transportation and Traffic of Mashhad municipality. (2005). *The second transportation statistics book of Mashhad*. P. 36.
10. Department of Transportation and Traffic of Mashhad municipality. (2012). *The eighth transportation statistics book of Mashhad*.
11. Eco Transit. (2011). Ecological Transport Information Tools for Worldwide Transport, Berlin - Hannover -Heidelberg, July 31th.
12. Energy balance sheet (2010). Department of Energy, Deputy of Power and Energy. Office of Electricity and Energy Macro Planning, Office of Political Divisions, Khorasan Razavi Governorship. [In Persian]
13. Forouzandeh, K. (2006). *A comparative analysis of the environmental pollution caused by fuelconsumption in road and railway transportations of Iran*. Research Center, Department of Economic Studies. [In Persian]

14. Gudmundsson, H., & Hojer, M. (1996). Sustainable development principles and their implications for transport. *Ecological Economics, 19,* 269-282.
15. Hosseinzade, D., & Sasanpour, F. (2012). The role of ecological footprint in the sustainability of Tehran metropolis. *Geography Research Quarterly*, *82*, 83-101. [In Persian]
16. International Energy Agency. (2011). Transport Energy and CO2- Moving toward sustainability.
17. Jeon, C. M., & Amekudzi, A. (2005). Addressing sustainability in transportation systems: Definitions, indicators and metrics. *ASCE Journal of Infrastructure Systems. American Society of Civil Engineers, 11*(10), 31-50.
18. Mazrati, M., & Partoue, B. (2005). Prediction of fuel consumption of Tehran and the role of metro in reducing its consumption. *Journal of Energy Economy Studies*, *22*(4). [In Persian]
19. Moutin, C. (2005). *Green dimensions of urban design* (Kaveh Mehrabani, Trans.). Tehran: Urban Analysis and Planning Publication (affiliated to Tehran municipality). [In Persian]
20. Organization for Economic Cooperation and Development. (2004). Environmentally Sustainable Transport, OECD, Paris.
21. Rahnama, M. R., & Ebadinai, F. (in press). Analysis of the sustainability of urban transport in Mashhad using ecological footprints. *Geography and Environmental Hazards.* [In Persian]
22. Rezvani, M. R., Salmani, M., Ghanbari Nasab, A., & Baghiani, H. R. (2010). Ecological footprints, a new approach to assessment of environmental impact (concepts, application and assessment). *Geography and Development*, *20*, 154-166. [In Persian]
23. Sasanpour, F. (2011). *Principles of sustainable development with emphasis on Tehran metropolis*. Tehran: Centre for Studies and Planning of Tehran. [In Persian]
24. Statistics book of Mashhad (2012). Municipality of Mashhad: Vice president of planning and development.
25. Transport and Energy Information of the Country. (2009). The company for optimization of fuel consumption. SID, Shahid Beheshti Branch. Institute of Applied Sciences.
26. Wackernagele, M., (2003). Towards a sustainable London: Reducing the Capital Ecological Footprint, WSP Environmental Ltd natural strategies LIS, London: Spon Press.
27. Wackenagel M., & Rees, W. (1996). Our Ecological Footprint, educating human impact on the earth Gabriola Iisland, BC: New Society Publishers.