

Evaluation of Low-Carbon Transport Scenarios in Mashhad Using Ecological Footprint Approach

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1. Introduction

One of the most important strategies for building low-carbon cities and increased environmental sustainability in cities is the development of low-carbon transport systems (Banister, 2008). Statistics shows that approximately 19% of energy consumption in the world and more than one fourth of carbon dioxide released in the world are due to transportation. This amount is increasing more in the transportation section compared to other parts (Knörr & Reuter, 2011, p. 4). Based on the predictions, fuel consumption in transportation sector will increase up to 50% from 2005 to 2030 and 80% by the year 2050, respectively (IEA, 2011,p.113). According to the announcement of the International Energy Agency (IEA), the transport sector will be the biggest consumer of energy by the year of 2020

Iran also has a significant share in this sector. The total carbon dioxide emission was 560.3 million mt in 2012 in Iran and increased as much as 179% from 1990 to 2008 and its growing trend has intensified up to the year of 2012. The transport sector, compared to the others in Iran, is responsible for 23% and 96% of CO₂ and greenhouse gasses emissions, respectively, of which 95% is due to ground transport (²ITF, 2010:88). No doubt the need for low-carbon transportation planning is essential not only to improve the current situation but also on a long-term vision. In recent years, numerous scientific studies have been conducted with different methodologies, one of the most common methods of transportation planning is the scenario based planning.

The ecological footprint is the one of the best methods for environmental evaluation of cities and its combination with the strategic scenario-based methods could increase its efficiency and effectiveness in a specified time interval. In this regard, this paper also presents three scenarios until the year 2025 in order to compare the effects of each of them on the city's ecological footprint. The aim of scenario making is finding the best solutions to achieve optimal vision in low carbon transportation in Mashhad and present the scenario that has the greatest impact in reducing the ecological footprint.

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2. The Study Area

Mashhad, the second most populous city of Iran, has an area of 350 km² (35000 ha) and population of 3009295 (Mashhad's City Fact Book, 2012). Based on the study of Mehrazan Consulting Engineering, the number of pilgrims and tourists of Mashhad was estimated approximately 25 million. The number of urban travelers of Mashhad citizens per day increased from 3893632 travels in 2006 to 5876313 travels in 2011, a growth equivalent to 33.7%. In addition, the coefficient of rush hours of daily travelling doubled from 5.11% to 10.94% (Mashhad's 8th Transport Fact book, 2012) and had 19.6% increase just in the first 8 months of 2013. These numbers and figures indicate the harmful and destructive effects of city machination and irreparable damages on the urban environment and citizens' health (Transport and Traffic Organization of Mashhad Municipality, 2005).

3. Material and Methods

Ecological footprint is the method that covers the ecological concept of Carrying Capacity (Chi and Stone, 2011). In fact, "Appropriated Carrying Capacity" in other parts of the world is interpreted by "area unit" so that the greater the area, the greater burden will be placed on the environment, which in turns reduces the sustainability of other parts of the world (Chambers & Lewis, 2001).

The first stage: The carbon footprint of daily personal travel $(EF+UF)/CS \times EF$

EF: The amount of carbon emission from each vehicle- per kilometer.

UF: Energy required for manufacturing and maintenance of each vehicle- per kilometer

CS : Each ton carbon per hectare per year

The second stage: The ecological footprint $(ARI \times EF \times VRS) / TDT$

ARI: The land required for transportation or area of the road infr:

EF: The number obtained from calculation of ecological footprint for land and transportation infrastructure

VRS: The rate of car ownership by percentage

TDT: The total distance of trip (Vehicle – kilometer).

4. Results and Discussion

The first scenario: Continuation of the existing trend and common business

With the current trend the total energy consumed in transportation increases to 54 million GJ and the amount of carbon produced reaches to 773 973 tons. The ecological footprint in Mashhad by the year 2025 will increase to 0.14 hectares per person. This means that any person who lives in Mashhad needs 0.14 hectares of land to refine the all the carbon produced in transportation in one year and reduce it to zero. At present, this figure is equal to an area of about 10-times larger than the current area and by continues the current trend till the year 2025 it will increase to 16 times larger the current area of the city.

The second scenario: Replacement of Euro 2 fuel by Euro 4 for all vehicles by the year of 2025

Studies show that upgrading the fuel standard from Euro 2 to Euro 4 leads to the reduction of pollutant level from 2.7 g to 1.18 g per vehicle. Considering the traffic of

1400000 vehicles which will be manufactured in Mashhad by the year 2025, if the fuel standard level in all vehicles upgrade from Euro 2 to Euro 4, we could reduce 19824 ton pollutants. Based on this scenario, energy consumption annually will be 33 million Gj, equal to 8.25 Gj per person and ecological footprint based on each 100 Gj per hectare will be 0.08 ha. This means that Mashhad needs the area 7 times larger than the current area for purification and neutralization of carbon from the transportation sector per year.

The third scenario: Public transport fleet renewal and removal of 60% of old private vehicles by the year 2025

Our calculations show that by implementation of this scenario the ecological footprint of Mashhad transportation will have a very significant reduction equal to 0.004 hectares per person which is equivalent to 16,000 hectares backup land for carbon absorption and desorption. Now old cars in Mashhad according to fuel type (Euro 2) produce the amount of 4.248 million tons of emissions per year.

According to this scenario, the complete removal of old cars from the fleet public transport and removal of 60 percent of personal old cars will reduce 2.5488 million tons of pollutants per year. So the most influential and the most important scenario for reduction of ecological footprint in Mashhad city transportation is related to the reduction and elimination of old cars.

Key Words: Ecological footprint, Low-carbon transportation scenarios, Mashhad.

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