TRANSPORTATION DEMAND MANAGEMENT MODELS FOR TRANSPORTATION SYSTEM OF PAKISTAN

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ABSTRACT: The ever-increasing transportation demands in major cities of the world caused numerous problems to transportation networks across the globe. The vital problems include fuel wastage, environmental deterioration and transport congestion. These problems can be witnessed throughout the world. Pakistan being a developing country is facing these problems and its allied implications worst. The international experience from developed countries highlighted that the transport infrastructures cannot be expanded indefinitely to accommodate the rising transport needs as expansion is always an expensive option. The alternative of expansion is Transportation Demand Management (TDM) by which available transportation infrastructure is optimized by focusing on the movement of people rather than the transportation modes. Today the TDM has been established as one of the premiere method of transport management across the globe. Most of the developing countries are following TDM to manage their transportation needs. The application of TDM is time consuming and community need to be educated about it through its application models. Once these models are accepted by the public, it will prove to be the best tool in managing the transportation system. TDM has not been adopted yet in Pakistan and there is no start up reference available in community about it. An attempt has been made through this paper to introduce the concept of TDM to community along with various organizations of Pakistan dealing in transportation management. Moreover, simplified guideline models of TDM applicability for transportation system of Pakistan have been proposed based on guidelines of TDM policy of Victoria transport system of USA. The discussed TDM strategies and their corresponding targets shows that TDM has strong potential to replace conventional transportation system management models adopted in Pakistan.

Keywords: TDM, Strategies, Transportation, Management, Pakistan.

INTRODUCTION

Transportation management can be carried out by two approaches. First approach refers to perform it through scientific explanation. The key concept behind first approach is to normalize roads and vehicles, but not the driver behavior. The research on this approach narrates that for reducing traffic and parking congestions more roads and parking facilities are required (Ferguson, 1991). The approach also suggests catering accidents and crashes due to enhancement in roads and parking facilities. In this approach, the ways to reduce fuel consumption during transport has been explained viz. alternate energy sources and by fuel energy efficiency standards. Black (1997) carried out further research on this approach and concluded that solutions to manage one transportation problem using this approach may often aggravate other tribulations i.e. increasing roadway capacity may decrease congestion but lead to increased crashes, increase fuel consumption lead to more pollution, fuel efficiency principles decrease per kilometer cost of driving but on the other hand stimulate more traffic congestion and accidental crashes, paratransit vehicles increase traffic congestion which

results in accidental crash threat and pollution. Nelson and Editor (2000) narrated deep flaws in this approach. As a consequence, they narrated that this approach cannot provide solution of all transportation management tribulations because the more a solution accomplishes its objectives; the more it aggravates other problems.

The second approach, generally termed as Transportation Demand Management (TDM) states that the majority of the transportation problems that we face today share a common cause of market twist that result in excessive automobile use (Ferguson, 2001). According to the perspective, the solution of transport tribulations necessitate planning reform that enhance transport options and market transformation which provide the users with suitable incentives to select the top choice for every individual trip. The idea behind this approach is to enhance transportation system diversity and efficiency. Transportation Demand Management (TDM) is a general term employed for the strategies which enhance the efficiency of a transportation system, rather than considering the movement of motor vehicles (Todd, 2006). Transportation Demand Management emphasizes the movement of people and goods, and thus gives precedence to more efficient means (such as public

transit, ridesharing, cycling, walking and tele-work), especially under congested circumstances. Transportation Demand Management prioritizes travel based on the value and costs of each trip. In TDM approach higher value trips & lower cost modes of travel are given precedence over lower value trips & higher cost means of travel (Ferguson*, 2001). In this way, the TDM enhances

overall efficiency management of transportation system (Flint, 2008). If TDM is efficiently applied, it has lot of benefits over the conventional transportation management systems (Todd, 2005). The trends and benefits using the TDM system are shown in Figures 1 (a) & (b).
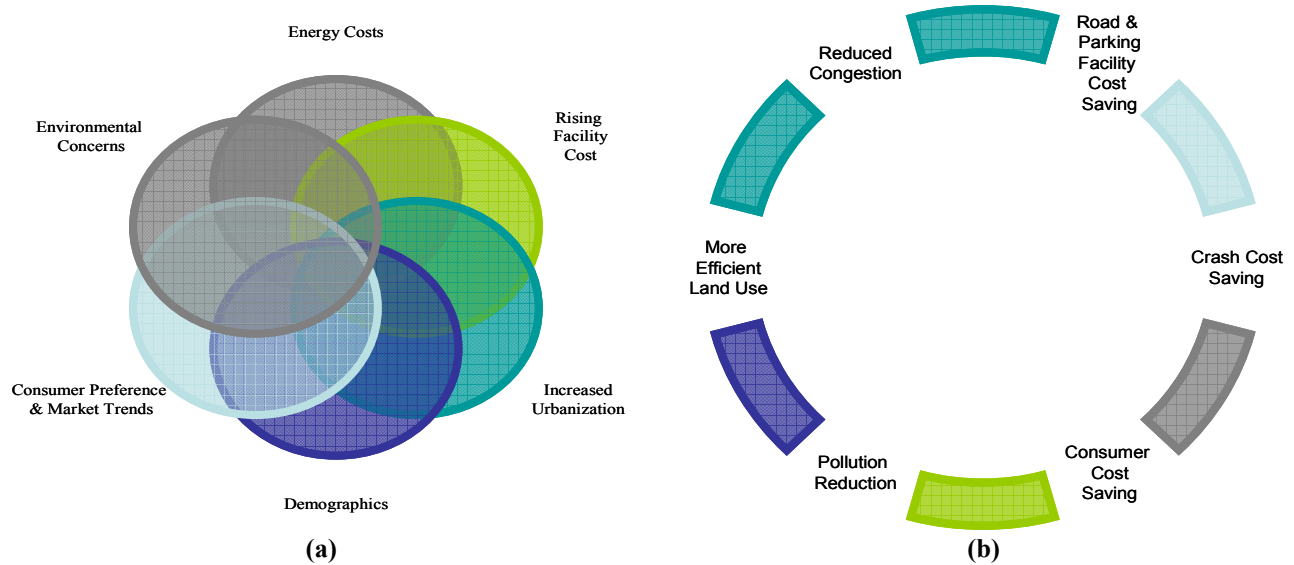

(a)   **(b)**

Fig-1: Transportation demand management (a) Trends (b) Benefits

TDM is the set of strategies that consequence in organized employment of transportation resources for its management (Khan, 2007). The conceptual distribution of the TDM strategies is shown in Figure 2.
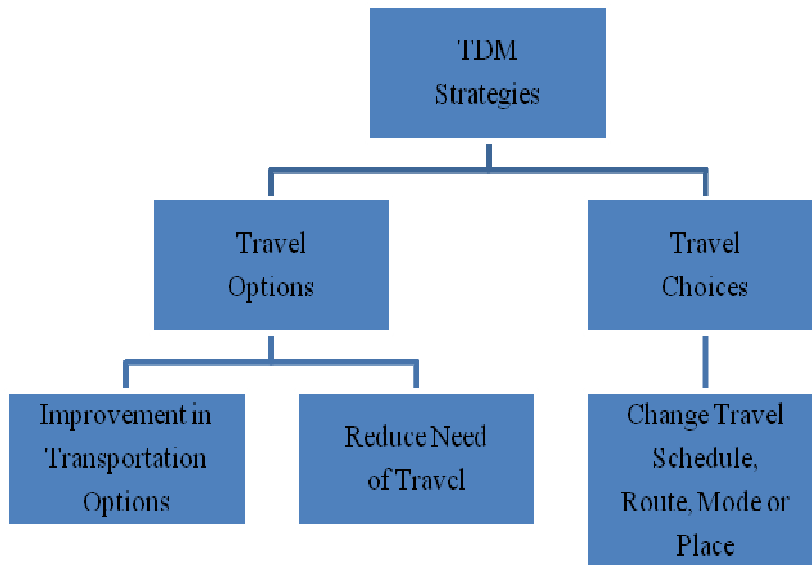

Fig-2: Conceptual TDM strategies (Khan, 2007)

The strategies for the application of TDM can be classified in two major branches. First branch is referring to achieve the travel options through management of transportation options and reduction in need of travel.

Second branch is referring to manage choice of travel with consideration on travel schedule, route, mode or place.

Pakistan now a days is facing major transportation problems like increasing fuel demands, road accidental crashes, congestion, environmental issues, lack of parking facilities etc. (Imran and Low, 2005). The adopted conventional urban transportation managing systems in Pakistan are based on evaluation practices that concentrate on individual problems. According to these systems (first approach discussed above), the comprehensive management is necessary for individual solution of the transportation problems. The conventional urban transportation managing systems support the idea of technical solutions, which are effective at reducing one or two transportation problems, but they often intensify others due to rebound effects (Hameed and Nadeem, 2006). For example, in order to reduce the traffic congestion on a particular road, a favorable option may be to increase its capacity but this may result in an increase in the traffic congestion downstream of the road and may also generate parking problems, accidental crashes and environmental issues. Reduction in vehicle operating costs by introducing fuel efficiency standards or cheaper alternative fuels i.e CNG, LPG also encourage more vehicles to come on the roads which results once again in traffic congestion, crashes and parking issues (Khan, 2007). Hence, presently adopted transportation management practices are insufficient to resolve transportation problems of Pakistan.

The modern research has confirmed that the best method to enhance the quality of the transportation system in developing countries is simply by employing management strategies that result in efficient utilization of existing transport resources (Sohail *et al.* 2006). When all impacts are considered, TDM strategies often provide the optimum solution to the problems faced by the transport system in developing countries (Rassafi and Vaziri, 2005). TDM suggests that the transportation improvements at any scale require new modes of travels i.e. railroads, automobiles, canals, steamships, and air travel. However, there is no assurance that these improvements will immediately solve existing transportation tribulations or it will do it certain time frame (Qureshi and Huapo, 2007). The transportation industry is the backbone of Pakistan's economy, therefore, problems associated with this industry need to be resolved. Pakistan has developed extensive urban transportation network systems in all its major cities particularly in the last decade. These transportation network systems are grown-up and becoming intricate day by day. In the past, these systems permitted transporters to move to the non-required destinations with relative expediency, safety and affordability. However, now days the main transportation problems faced particularly by the urban transportation system of

Pakistan is overcrowding of vehicles on roads and parking areas, insufficient scope of movement for non-drivers, and different costs (economic, social and environmental) related with high levels of vehicular travel (Khan, 2007). Pakistan consumes 17 million tons of petroleum products, with about 7.8 million tons for transport sector only with an annual growth of about 6%. Pakistan has to spend US$ 2.5 billion a year on import of crude oil and other petroleum products (Qureshi and Huapo, 2007). The solution of these transportation system problems in Pakistan is required to be addressed and examined on urgent basis to avoid lot of future impairments. An attempt has been made through this research to provide solution of various challenges faced by transportation industry of Pakistan through transportation demand management. The main objectives of this research were to introduce transportation demand management to community and transport management agencies in Pakistan as an alternative to the practice of expanding roads or transportation facilities.

MATERIALS AND METHODS

The objectives of research were achieved by adopting comprehensive literature review regarding TDM [Ferguson (1991), Black (1997), Ferguson (2001), Ferguson* (2001), Flint (2008), Khan (2007), Todd (2006), Todd (2005), Qureshi and Huapo (2007), Sohail *et al.* (2006), Rassafi and Vaziri (2005), Imran and Low (2005)] for the selection of a state of art application of TDM based on its international success as a role model. TDM strategies were formulated based on database obtained from the role model. Analysis was carried out to propose application suitability of this model for management of transportation system of Pakistan in order to address the solutions of transportation problems successfully.

RESULTS AND DISCUSSION

Based on extensive literature review during research the transportation demand management (TDM) models of Victoria Transport Policy, Victoria, USA has been selected as reference state of art application of TDM to propose suitable TDM models for transportation system of Pakistan. Figure 3 shows extract of initial strategies to apply TDM for transportation system of Pakistan.

Table 1 narrates the ranks of various strategies to achieve TDM objectives in Pakistan. Table 2 presents impact evaluation of TDM program in comparison with conventional transportation system of expansion in Pakistan.
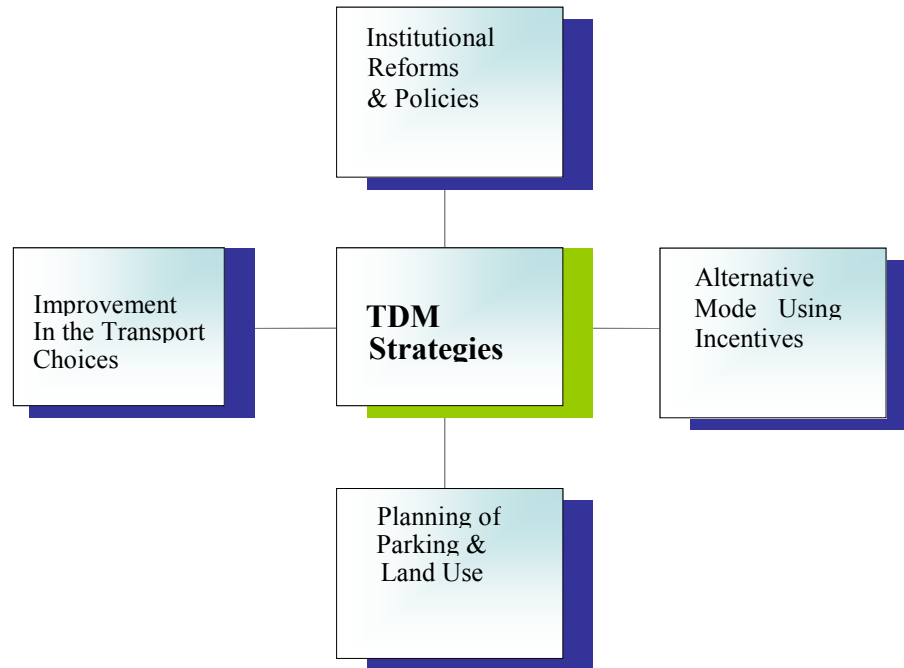
Fig-3: TDM implementation strategies

Table-1. Ranks of TDM strategies to achieve transportation management objectives

Rank	Strategies	Objectives
1	Reduction in Congestion	Plans for reducing traffic congestion.
2	Conservation of Energy and Reduction in Emission	Plans for decreasing vehicle energy utilization and addressing pollution issues.
3	Public Health and Physical Fitness	Plans that increase physical activity with an aim to improve public health and fitness.
4	Improving the Participation of Equity	Plans that help to achieve objectives of equity.
5	Life Style	Plans that transform a community into a favorable place to live, work and explore.
6	Planning for Parking	Plans for the solution of parking problems.
7	TDM of Community in Rural Areas	Plans that can assist in improving transportation in suburban and rural areas.
8	Loss Prevention and Safety	Plans that improve traffic safety and ensure public well-being.
9	Affordability of Transportation	Plans that increase the affordability of transportation.

Table-2. Impact evaluation of TDM program

Objective	Conventional Transport System Program		TDM Program
	Widen Highway	**Energy Efficiency Standards**	
Reduction in Congestion	✔	✗	✔
Saving of Road & Parking	✗	✗	✔
User Savings (vehicle costs)	✗	✗	✔
Transport Mode Choice	✗	✔ ✗	✔
Safety on Road	✗	✗	✔
Environmental Conservation	✗	✗	✔
Efficient Use of Land	✗	✔	✔

TDM models were developed based on the extensive data analysis of transportation system of Lahore city reported in Integrated Master Plan of Lahore – 2021 (NESPAK and LDA, 2004). Tables 3 (a), (b), (c) & (d) proposes TDM models along with its

application effects for transportation system of Pakistan. Various ranks were also proposed in the models to set the priorities of various TDM strategies.

Table-3(a). TDM strategy model (policy and institutional reforms and application effects) to achieve transportation management implementation

Rank	Policy and Institutional Reforms	Application Effects
1	Management of Transportation Assets	Policies and plans to conserve precious transportation assets.
2	Reduced- Driving Plan	Reduce the number of vehicles at particular places and times.
3	Organizational Management	Devise methods for better management at organizational level.
4	Social Reforms	Policies to make Transport pricing more efficient.
5	In-Context Design	Representation of community values by employing flexible design requirements.
6	Risk Management	Develop planning strategies to deal with any uncertainties arising in the future.
7	Cost Efficient Planning	Creating a framework for transportation planning which is impartial and cost effective.
8	Management and Operations	More efficient use of transport system by introducing management and operations programs.
9	Prioritizing Transportation	Formulating principles which prioritize transport activities and investments.
11	Regulatory Reform	Policy reforms to encourage healthy competition, novelty, variety and productivity in transportation services.

Table-3(b).TDM strategy model (improved transport options and application effects) to achieve transportation management implementation

Rank	Improved Transport Options	Application Effects
1	Improved Security	Policies for increasing security at individual level.
2	Flexible Working Environment	Compressed work week (CWW), Telework, Flextime and staggered shifts.
3	Bus Rapid Transit	Introduce Bus Rapid Transit system that considerably improves cost effectiveness and service quality.
4	Improved Cycling	Policies for enhancing travel via bicycle.
5	Bicycle and Transit Integration	Methods for integration of cycling and public transit services.
6	Car sharing	Introducing automobile rental services so that private ownership can be reduced.
7	Assured Ride Back Home	An incentive for customers who use alternative modes, in form of an occasional subsidized ride back home.
8	Personal Input	Actions taken by individuals to support TDM goals.
9	Light Rail Transit	To relieve load on busy urban roads, Light Rail Transit systems are designed as a suitable local service.
10	Non-motorized Planning	Planning which takes into account the movement of pedestrians, bicyclists etc.
11	Management of Non-motorized Facilities	Strategies employed for management and maintenance of non-motorized facilities such as paths, walkways and sidewalks.
12	Park & Ride	Provision of convenient and ample parking at transit and rideshare stations.
13	Improvements for Pedestrians	Methods for improvement in walking conditions.
14	Sharing of Ride	Encouragement of vanpooling and carpooling.
15	Shuttle Services	Provision of shuttle buses, and free transit zones.
16	Small Wheeled Transport	Management of scooters, handcarts and service wagons.
17	Improvement of Taxi Services	Plans and practices for the improvement of taxi services.
18	Tele-work	Use of telecommunications as an alternate to physical travel (Telecommuting, Distance-Learning, Tele-shopping, etc.).
19	Traffic Calming	Design of roadways that decrease traffic speeds and volumes on the road.
20	Improvement of Transit Services	Strategies and plans for the improvement of public transit services.
21	Design for All	Transportation systems where all users (including disables) are accommodated.

Table-3(c).TDM strategy model (incentive to use alternative modes & reduce driving and application effects) to achieve transportation management implementation

Rank	Incentives to use Alternative Modes and Reduce Driving	Application Effects
1	Encouragement of Bicyclists and Pedestrians	Plans and strategies for encouraging non-motorized transportation.
2	Financial Incentives to Commuter	Travel allowance, parking cash out, transit and rideshare benefits.
3	Variable Pricing	In order to decrease peak-period vehicle trips, variable road pricing is devised.
4	Pricing Based on Distance Travelled	Different fees and taxes based on the distance travelled by the vehicles.
5	Fuel Taxes	Increase in fuel taxes to accomplish TDM goals.
6	Priority to HOV (High Occupant Vehicle)	Plans and methods that give high priority to transit and rideshare vehicles, over other traffic.
7	Parking Charges	Parking is directly charged.
8	Pay As You Drive Vehicle Insurance	Insurance premiums are set according to the distance covered.
9	Road Pricing	Toll taxes, value pricing, congestion pricing.
10	Reallocation of Road Space	Roadway space reallocated to favor efficient modes.
11	Speed Restrictions	Methods to decrease traffic speeds.
12	Reclaiming of Streets	Plans and policies to encourage civic collaboration on locality streets.
13	Encouragement of Transit Use	Plans and policies to encourage public transit services.
14	Restrictions on Vehicle Use	Policies to restrict vehicles from coming on particular roads at specific times.

Table-3(d). TDM strategy model (parking & land use management and application effects) to achieve transportation management implementation

Rank	Parking and Land Use Management	Application Effects
1	Parking for Bicycles	Bicycle stands, lockers and facilities for changing.
2	Car Free Areas	Planning special regions for minimal vehicular use at specified times.
3	Commercial Centers	Creating vivacious business areas, downtowns and city centers.
4	Interconnectivity	Constructing more linked roadway, passageway and pathway networks.
5	Efficient Land Use	Common destinations are located close together in order to improve the accessibility.
6	Easy Access	Development that provides easy and economic accessibility.
7	Improved Urban Areas	Urban area design which is accessible and suitable for living.
8	Cost Benefit Analysis	The costs and benefits of parking facilities are calculated and analyzed to set the parking price.
9	Parking Management	Policies and plans for more efficient and well-organized use of parking areas.
10	Parking Charges	Parking is directly charged.
11	Solutions for Parking	Comprehensive guide of solutions to various parking tribulations.
12	Evaluation of Parking	Strategies for assessing parking tribulations and their solutions.
13	Shared Parking	Different commuters use the same parking facility.
14	Improvements to Urban Streets	Different ways to improve urban streetscapes.
15	Transit Oriented Development (TOD)	Transit stations are used as a promoter for improving the comfort level of a community.

Motor Vehicles are brilliant servants but awful masters. It is the duty of the transportation planners to avoid motor vehicles from damaging our communities or burdening our lives. Automobiles are here to solve the problem of traversing long distances safely, efficiently and comfortably, but we should not let them become a problem.

In Pakistan, the majority of the urban community relies on automobile travel. This is partially because of the public policies which encourage automobile use beyond what should be in a neutral transport system. The current transport planning and investment practices in Pakistan are designed simply to favor the use of cars, which results in overcrowding and traffic congestion on almost all important roads. This congestion leads to increase in pollution, more crashes and allied problems. The problems directly faced by users are increased fuel consumption, wastage of time and frustration. The present policy is to keep on expanding the capacity of road and parking facilities, which is not the best option as it is wastage of resources and finances.

These solutions may decrease or eliminate one problem but intensify others.

The TDM strategies presented in Figure 3 depends on following factors; Rising costs of transport facilities (rehabilitation, up-gradation and maintenance), rapid urbanization, demographic trends, escalating cost of energy, lack of using multiple modes of transport and environmental concerns.

Figure 4 shows a comparison of yearly increasing cost of the transportation system in Pakistan based on statistics presented in Master Plan of Lahore 2021. Based on international success experience of TDM, if TDM will be implemented in Pakistan it can reduce the increase in cost factor less than one in study period described in Figure 4. Those can show the economic benefits associated to policy makers of the community in implementation of TDM.
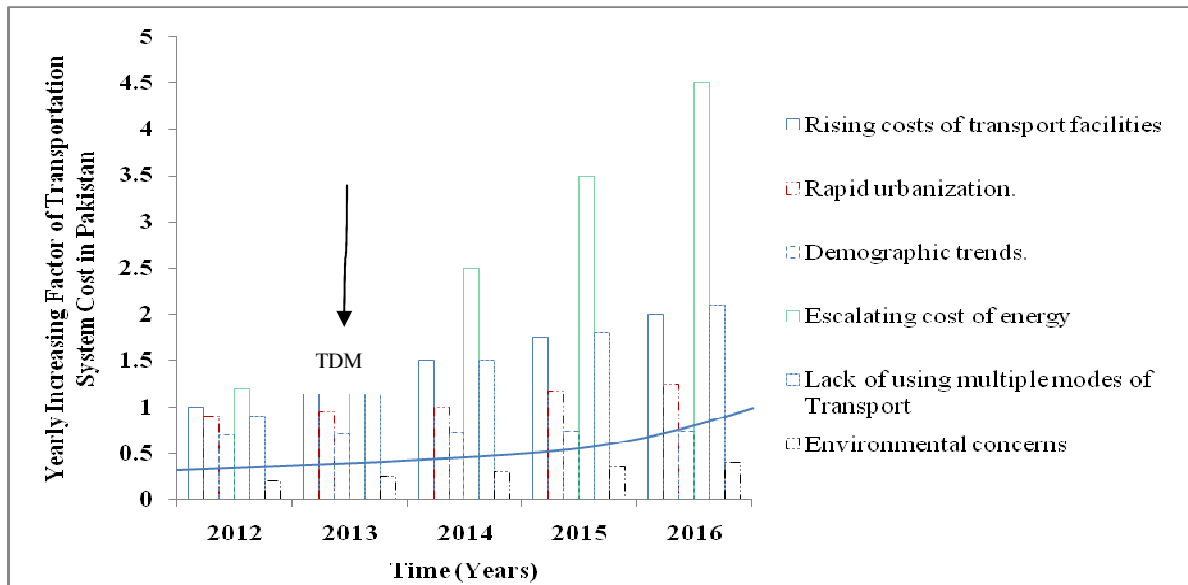

Fig-4: Comparison of factors contributing in yearly increase transportation system cost in Pakistan

Transportation Demand Management (TDM) objectives described in Table 1 are the set of policies which address the above mentioned problems and propose an efficient, cost effective and sustainable solution. As TDM is a shift of travel attitudes so there is no wastage of resources required for expanding roads. In Pakistan, the use of alternate options of travel is not popular as depicted in comparison presented in Table 2. Implementing strategies which encourage the general public to utilize other modes by providing incentives may be the key solution for most of the transport problems that we are facing today. Instead of increasing the capacity of the roads, it is better to decrease the traffic volume on them.

Currently in Pakistan, automobile use is very common and it will be difficult to change the travel patterns but it is not impossible. By properly educating the public and providing them with positive incentives will surely do the magic. After all we have many success stories where public changed their attitudes according to the new policies like reduction in smoking, recycling and use of seat belts. Therefore, TDM will likely solve most of the transport problems of Pakistan and will assist in the economic development of the country for that purpose the models are presented in Tables 3.

The TDM strategies applications require problem formulation, conduct of analysis and implementation. There are several TDM strategies with a range of application impacts on the urban transportation system of Pakistan. Out of which, there are certain strategies which are for increasing the modes and options of transport available to users of transport facilities. Some strategies offer incentives to revise trip setting up, route, means or target. Some others lessen the requirement for physically moving from one place to another by introducing efficient land use patterns or by employing various transportation alternatives. Although the individual effect of a particular TDM strategy may not be much but the cumulative effect of a comprehensive TDM program can be noteworthy. The models of TDM strategies along its implementation application effects to the urban transport system of Pakistan is shown in Table 3(a), (b), (c), (d).

Individual TDM strategy models discussed tend to provide modest but multiple benefits. A comprehensive TDM program that comprises of various TDM strategies (Table 3(a), (b), (c), (d)) will usually help to achieve most objectives of urban transportation system improvement in Pakistan. If all costs and benefits associated with a suitable TDM program are calculated

and analyzed, it can act as the cost effective solution to the various problems faced today by the transportation system of Pakistan as highlighted in Figure 4.

The application of TDM models described in Tables 3 to manage Pakistan's transportation system can impart several advantages including but not limited to reduction in congestion, decrease in pollution, saving of costs related to roadways and parking facilities, saving of user costs, reduction in road crashes and improved land use. The overall merits associated with the application of proposed TDM models of Tables 3 in Pakistan transportation system can be narrated as following:

Flexibility: *Transportation Demand Management can offer flexible solutions to manage the urban transport system of Pakistan. TDM provides a wide range of solutions to address the transportation problems and has the ability to modify the solutions according to varying conditions (Table 3a). As TDM is a group of strategies so it can be implemented quickly (Tables 3). It can be employed to address the problems of the entire urban area or can be implemented to solve the local issues like coping with the problem of congestion in case of emergencies or special events. It may assist in further development of regions where road and parking capacities have already achieved their maximum limits, and can effectively protect sensitive environments.*

User Benefits: *Transportation Demand Management can give support directly to users. Most TDM strategies increase the modes of transportation available to the users so that the most favorable and cost effective option may be chosen (Table 3b). Moreover, TDM provides incentives to the users for reducing driving or shifting to rideshare. The motorists who change their driving patterns according to the management program are given direct benefits in form of saving in the cost of fuel, toll tax and parking charges. In addition to the direct benefits to the users, there are indirect benefits which are the basic aims of TDM. These consist of reduction in congestion, decreased pollution, crash reduction and an improvement in the general health of the public. Some people are uncertain about the feasibility of TDM strategies, because it necessitates the users to alter their travel habits and support policy (pricing reforms) changes (Tables 3). Both are difficult to implement. Travel patterns can be affected by providing incentives to the users. Policy reforms on the other hand, require the users to be educated first so that they will be comfortable with the change and willing to accept it.*

Equity: *Transportation Demand Management can assist to achieve the equity objectives of managing urban transportation system (Table 3c) through enhancing horizontal equity (impartiality) by introducing unbiased planning, investment methods, setting the transportation prices more precisely to reflect costs, assisting lower income people by improving low-priced options for transportation, and by improving the transportation system by increasing transport alternatives or decreasing the vehicle's external costs.*

Economic Benefits: *In Pakistan, most of the policies regarding the maintenance of transportation network as well as its enhancement are made with little or no consideration to their long term impact on travel and land use patterns. As a result, the direct and indirect costs incurred by the users are increased. Furthermore, the government has to bear the burden of expanding the capacity of the road and parking facilities in order to accommodate the increasing traffic volumes. TDM can be an effective tool in decreasing these unwanted costs (Table 3d). Transportation Demand Management tends to decrease the direct costs by encouraging healthy competition, increasing the number of transport choices available to the users and setting the prices according to the costs. The indirect costs are reduced by strategies to reduce traffic congestion, decrease pollution and reduce road crashes. Hence, TDM can efficiently support the economic development of Pakistan by controlling the expenditures in the transport industry and managing it in a better way.*

Sustainable Transportation: *Transportation Demand Management can help to create a more sustainable transportation (Tables 3). TDM addresses the basic sustainability objectives, including protection of environment, equity, conservation of resources, efficient land use, and involvement of public. Transportation Demand Management is a preventive solution to transport problems. It is better and more cost effective to prevent the problems than to treat them. Likewise if the transport problems are prevented by implementing TDM then it will lead to a better and sustainable transportation system.*

Conclusions: The problems faced by the urban transport system of Pakistan can be addressed comprehensively by TDM. TDM can be successfully used as an alternate of conventional transportation system expansion models currently adopted in Pakistan to meet the challenges of the transportation demands of Pakistan.

TDM models proposed are based on the application success of TDM research in the world. However, database used was of Lahore city, hence, applications of these models are more specific for Pakistan.

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