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Our Cities Need a Smart Mobility System

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Abstract

Smart City is a concept to cope up with the emerging problems pertaining to urbanization. This approach mainly relies on the use of technological advancement and is considered as a winning strategy against the multilayered issues in big cities. For instance, the strategies to combat crime, traffic congestion, pollution, energy conservation and waste treatment all have sought the support of artificial intelligence developed through technological advancement. The latest addition to create a smart city is the idea of having smart mobility across the area of the city. Mobility has become a problem draining the resource of all the stakeholders in the city. Smart mobility need not only an investment in high technologies but a strong political system that can ease this pressure on citizens. The aim of this paper is to analyze the Smart Mobility initiatives adopted in the mega cities across the world and to investigate about the role of Internet & Communication Technology (ICT) in supporting smart mobility actions, Furthermore, the paper will assess the impact of smart mobility actions on the quality of a common citizen's life, hence creating public value for the city as a whole. Such an approach will provide remedy for problems like congestion in several mega cities across Pakistan. Therefore, a Smart City is a complex, long-term vision of a better urban settlement, aiming at reducing its environmental footprint and at creating better quality of life for citizens.

Keywords Smart city _ Smart mobility _ Traffic Congestion _ Pakistan _Political Will _ Benefits _ ICT.

Aim of the study

Traffic management is a key responsibility of city management as part of its mandate to provide quality infrastructure to its citizens. At the core of traffic management there is problem of knowing the scale of traffic on the roads. Traffic measurement has remained a high priority topic in transportation community. In developed societies, a new way of managing traffic has emerged namely Intelligent Transportation System. The new system has few initiatives like:

1. Creating Physical Infrastructure: new roads, expanding capacity of existing roads
2. Making Policy Changes: banning traffic movement at peak hours, changing traffic direction, making road usage chargeable etc.
3. Intelligent Transportation System: migrate cities to ITS infrastructure in order to measure traffic intensity on road networks including average speed, traffic volume and to manage traffic.

Previously, most of the work carried out in this domain was focused on traffic dominated by vehicles following regular lanes of developed countries and very limited work has been done in measuring traffic for developing regions where the traffic pattern is dominated by slow-moving vehicles like Tractor-Trollies, motor-cycles and horse-driven carts coupled with road encroachment. In Pakistan, there are approximately 48 different types of vehicles. Such a diversity in the types of vehicles moving on the roads have made the traffic to flow at a very slow pace. Hence, making the movement of traffic chaotic because of the reason that no one is willing to follow lane discipline. Furthermore, the political parties have never shown a desire to correct the problem. Since the inception of local government system not even a single policy to get rid-off congestion problems in any of the city of Pakistan has been suggested so far.

There is a dine critical need to acquire sustainable traffic data at city scale at low-cost, however, no satisfactory efforts in this direction has been done so far. Once traffic information is available, a lot can be done in controlling it. Attaining sustainable traffic measurements is the major cause of concern in management of traffic across Pakistan, and if this issue is catered efficiently it will provide unlimited prospects of development and growth in the pertaining field**.**

In addition, paper will explore the possibilities to learn from the experiences and efforts of advanced cities to reduce traffic congestion. An analyzation of methods and approaches adopted by these cities to tackle traffic congestion like introducing greater efficiency in the provision of public transport and new road infrastructure would definitely open up ways to replicate many initiatives.

Despite the exasperation that is caused by the traffic congestion, surprisingly, most of the people know very little about it and have limited knowledge about what can be done to solve this issue, and much of what is stated in the media is oversimplification. We live in a society in which, for political and social reasons, we consistently label congestion a major

problem to be solved but find it unacceptable to adopt the most effective solutions. Indeed, the political debate on the issue indicates that we actually prefer the problem over the solutions. If our current path continues, in the coming years we will implement innovations to mitigate worsening traffic and expand the transportation system to accommodate growth in travel to some extent, but we will likely to part away from measures that will have the tendency to cure the problem.

However, innovation in information and communication technologies is one of the major factor that have the potential to change the course of actions. There is a wide range of applications related to information technology that are waiting to be implemented and could prove to be far more significant in our struggle to defeat traffic congestion than the building of new highways and transit routes or more government regulation. In fact, we now have the technical means to finally "solve" the congestion problem.

Introduction

Pakistan is among the countries who have experienced large scale migration towards the big cities. Since the year 1998, the population of 10 major cities of the country has increased by 74.4 per cent. Furthermore, in the past 15 years the country has witnessed the mounting traffic density on roads in cities across Pakistan has led traffic planners to widen roads, construct flyovers, and build new roads. But still there is no respite from congestion on the roads. There may be a reason behind the bad conceptualization of new flyovers and new roads, because of the fact that our roads tend to deteriorate (whether by design or as a consequence of the unique operational and environmental conditions in the country) faster than ones overseas. Furthermore, the main problem faced by traffic managers in all of the cities is the enforcement of traffic rules, and directing traffic through key junctions, in order to maximize flow. Since the cities are more likely to bear the brunt of this traffic growth, the only way to handle more people, more cars, more trips, more deliveries, and more congestion is to be smart. While the traffic system is being run on a fixed time table decided arbitrarily by traffic management, did not take into account the day to day changes in traffic pattern. Addressing these problems requires the use of advance technology and specialized software applications.

However, a significant part of the blame lies with traffic management authorities, for sloppy traffic management and lax enforcement of traffic rules. The concern to homeland security authorities is that these issues tend to have a significant impact during times of crisis, a disaster requiring evacuation of citizens or an incident requiring access by emergency response agencies. Thus, our cities need a state of the art Smart Transportation Systems based on technological advancement (computing, communications, and sensors) to optimize the movement of vehicles over transport networks. This optimization covers areas diverse such as traffic signal control, automatic number plate recognition and on-line real-time traffic messaging.

In a survey conducted in USA, 75% respondents believe that smart city technology would have a positive impact on their lives, and 65 % were interested in living with smart technology while 50% of the participants believe that the smart technology would directly impact on daily life within coming three years[2]. So the future of mega cities is mainly depends on technological investment in future as according to a report cities around the world will invest a total of about $41 trillion over the next 20 years to

1 Gallup-Pakistan, November 2, 2016.
2 https://www.businesswire.com/news/home/20171003005446/en/Study-Finds-75-U.S.-Consumers-Smart-Cities

upgrade their infrastructure and benefit from the network of connected devices known as the Internet of Things[3].

3Smart America Challenge: https://www.cnbc.com/2016/10/25/spending-on-smart-cities-around-the-world-could-reach-41-trillion.html

The Evolution of Intelligent Traffic System

Before embarking on to find a specific traffic management plane to address the traffic congestion particularly in large cities of Pakistan, there is need to address a few questions such as: how the advanced societies have responded to the problem of congestion? how the advancement in technology has provided help to find a solution to the problem? This response is generally regarded as a smart approach to achieve smart mobility in mega-cities. For a better understanding of the issue the different concepts like smart cities, smart mobility, urbanization, traffic congestion and the cost of congestions, strategies to deal congestion problem, urban growth in Pakistan and the type of traffic management existed in Pakistan will be discussed in detail before finding an appropriate traffic management system in the country followed by a conclusion at the end aim of the study.

a) Understanding Smart Cities

In general, a Smart City is a city or region that can increase its competitiveness and quality of life of its inhabitants, efficiently using resources, and support economic sustainability by using technology. Further, it is a city that uses innovation to address the needs and desires of the community, puts the citizens first and ultimately breaks down the barriers between agencies and departments, and between people and government.

Now-a-days, smart cities are touted as the future of urban living where everything from crime prevention, waste bin collections to streetlights and transportation will be connected and intelligent. A smart city is a set of innovative technologies, to build traditional infrastructure and fuel sustainable economic growth and provide a high quality of life, with a wise management of natural resources, through "participatory governance". The municipalities of smart cities use information and communication technologies to increase operational efficiency, share information with the public and improve both the quality of government services and citizen welfare. These may include Smart government, Mobility/Wi-Fi, Smart digital citizens, Smart health, Smart farming/agriculture, Smart buildings, Smart grid/energy/utilities and last but not the least is Smart transportation. Smart city technologies bring efficiencies to urban manufacturing and urban farming, including job creation, energy efficiency, space management and fresher goods for consumers. Water meters and manhole covers are just a couple of the other city components monitored by smart sensors. Free and/or publicly available Wi-Fi is another perk smart cities often include. For Example, the city of Kansas, USA provide smart streetlights, interactive kiosks and more than 50 blocks

of free public Wi-Fi along the city's two-mile streetcar route. Available parking spaces, traffic flow and pedestrian hotspots are all publicly available through the city's data visualization app.

b) Understanding Smart Mobility

Smart Transportation is a facet that deals with creation and implementation of an intelligent traffic management system that deals with congestion detection and avoidance, emergency management, car safety and accident prevention etc. It also tries to make transportation greener by helping to reduce gas emissions, fuel or energy consumption in vehicles. Transport sector contributes approximately 27% of CO2 emission and is the fastest growing sector in terms of greenhouse emissions in developing countries[4]. Smart mobility requires the rethinking of planning and development of urban landscapes and the services utilizing them in order to avoid the inefficiencies of today's problems — like double-parked vehicles, slow moving vehicles/carts and road encroachments disrupting the flow of traffic. It means that all adjustments can be made at the speed of life on a metropolitan scale.
To have a better understanding of the concept of smart mobility or smart transportation and why it is necessary for the traffic managers and citizens, we have to explore few more topics like urbanization and congestion in detail. A due effort would be made to understand how urbanization has spread across the world since the industrial revolution and how the developed communities are dealing with the problems of urbanization like traffic congestion.

c) Urbanization

The urban population of the world has grown rapidly from 746 million in 1950 to 3.9 billion in 2014. At present 54 per cent of the world's population lives in urban areas. Projections shows that urbanization combined with the overall growth of the world's population could add another 2.5 billion people to urban populations by 2050, and approximately 90% of an increase is expected to be concentrated in Asia and Africa. Much of the expected urban growth is taking place in developing countries across the world. As a result, these countries are facing numerous challenges in meeting the needs of their growing urban populations, including housing, infrastructure, education, employment and transportation.

Till the year 1990, there were only ten "mega-cities" with around 10 million houses or more in the world, which were home to 153 million inhabitants with less than seven per cent of

4 Bridging the Gap www.transport2012.org
5 World's population increasingly urban with more than half living in urban areas 10 July 2014, New York.

the global urban population at that time. While, in 2014, there are 28 mega-cities worldwide, which were around 453 million people or about 12 percent of the world's urban dwellers. Of today's 28 mega-cities, sixteen are located in Asia. By 2030, the world is projected to have 41 mega-cities with 10 million inhabitants or more[6].

Certainly, with the trend in urbanization the world has witnessed an enormous change in living standards of the people. The rise in living standards is seen as direct outcome of the urban living. One of the major issue that is aggravating the problems in the mega cities is the growing number of cars being sold around the world[7].

Number of vehicle in 2013 and expectation till 2030 in million.

Country	Pax Vehicles 2013	Pax Vehicles 2030	% Change 2013-2030
USA	248.8	281.2	13.0
Germany	43.4	45.1	3.9
France	30.8	35.1	14
UK	28.7	31.9	11

This gradual increase in the number of cars sold has already put a huge strain in the infrastructure of current road networks. According to US publisher Ward's, in 2010 there were 1.015 billion motor vehicles in use across the world. This figure represents the number of cars, light, medium and heavy-duty trucks and buses, but does not include off-road vehicles or heavy construction equipment. US researchers estimate that the total number of vehicles worldwide could be double that is up to 2.5 billion by 2050[9]. Moreover, the increase in total road area is much slower as compared to the number of cars being purchased and registered. This has significantly increased the problem of traffic congestion and long waiting.

d) Traffic Congestion in Mega Cities

The roads in large cities are getting busier and more congested for the reasons explained in the preceding paragraphs. Average traffic speed has fallen, because of the increase in journey and waiting time for public transport such as buses and personal cars as well.. For example, Traffic in London is moving far more slowly than it once was. In 2012, the average speed on London's roads was 19.33 miles per hour, dropping to 8.98 in the streets of Central London in couple of years (F. O'Sullivan, 2016). High levels of

6 World's population increasingly urban with more than half living in urban areas 10 July 2014, New York.
7 http://www.statista.com/statistics/200002/international-carsales-since-1990/on 13 Jan, 2015.
8 Source: World Bank, DfT, US Census Bureau, Cebr analysis.

9 https://www.greencarreports.com

congestion aggravated a number of serious problems for the large cities across the world. Longer and more unreliable journey times affect business productivity, harming country's economy. Air pollution from congested roads has a detrimental impact on citizens' health and quality of life. Road safety has also reduced on congested roads specially the vulnerable users such as cyclists, pedestrians and motorcyclists. The causes of these trends are complex. Certainly, there are now more vehicles on the city roads. The scenario portrays a clear picture that the life has completely changed in the large cities across the mega cities as the traffic congestion has changed the amount of time, type and/or location of congestion, hence, altering the city's economy and its environment.

This increase in vehicles plying on the roads has worsened the flow of traffic and resultantly the travelling time, between home and work place has put extra burden on the economies and authorities are rigorously finding ways to deal this worsening issue. The figures shown in following table depicts a picture that the hours wasted due to traffic congestion is constantly on the rise despite all efforts to cope with the problem.

Country-level: average annual hours wasted (excluding the Planning Time Index) in congested traffic.[10]

Country	2013	2030	2013-2030 % Change
UK	40.1	44.0	10
France	43.9	46.5	6
Germany	38.2	39.0	2
USA	22.0	23.4	7
Advanced Economy Average	36.1	38.2	6

e) **Cost of Traffic Congestion**

Traffic congestion has taking a heavy toll on the economies of the developed countries. Congestion isn't just an inconvenience, it can cause health-damaging air pollution, high stress and even higher crime. The total cumulative cost of congestion in the UK is expected to be £307 billion from 2013 to 2030, out of which, total direct costs are £191 billion, and indirect costs equal £115 billion. By 2030, it is estimated that the total cost of congestion per household will be £2,057.[11] While the traffic on major San Francisco-area freeways has increased by 80% just since 2010[12]. Minnesota is experiencing similar statistics expecting

10 Source: INRIX, Cebr analysis

11 http://uk.businessinsider.com/cebr-study-on-uk-congestion-and-economic-costs-2017.

12 Bay Area's Metropolitan Transportation Commission, 2017-18.

Roadways are expected to be jammed for 30% of the time in the next 10 years. Plus, more and more major tech companies are taking their headquarters out of the suburbs and into cities to give their employees an urban lifestyle. The sudden growth of population in these cities, however, has turned the "traffic headache" into the "traffic migraine." Research from the Texas A&M Transportation Institute found that travel delays due to traffic congestion cause drivers to waste more than 3 billion gallons of fuel and sit stuck in their cars for 7 billion extra hours -- that's 42 hours per rush-hour commuter. The total nationwide price tag was estimated at $160 billion, or $960 per commuter only in USA (David Schrank, 2015). It's not only the money wasted but in reality the resources are also being wasted and emerged as a burning issue to deal with. The following two tables depicts that in single year how much resources are wasted just idling due to traffic and huge sum of money has been lost. Certainly, it has a big impact on the economy.

Fuel wasted during vehicle idling whilst driving on congested roads, millions of liters.

Country	Fuel Wasted (2013)
UK	747
France	740
Germany	1,166
USA	3,297
Advanced Economies	5,950

CITY	Fuel Wasted (2013)
London	113
Paris	83
Los Angeles	153
Stuttgart	27

India is presenting a worse picture as the anticipated average journey speed on the main highways of major cities in India are expected to reduce from about 12kmph presently to less than 6kmph by 2030.[13] The traffic trends in Pakistan are similar to that of neighboring country and it could be assumed that the congestion problem would be same in the years to come. The extra time spent or idling on the road is costing a great deal to every household. This need to be addressed as early as possible as the burden is mounting with the passage of time. The following table will help to understand the continuously rising cost to per household in the four developed countries of the world.

13 http://www.hindustantimes.com/opinion/how-smart-solutions-can-ease-traffic-jams-in-our-cities/story-1NM5NIpVJK6QxC4whkKuMP.html

Country-level: average direct and indirect costs of congestion per individual car commuting household.[14]

Country	Sector	2013	2020	2025	2030	2013-30 % Change
UK	Direct Costs (Value of fuel & Time wasted)	1,519	1,788	2,007	2,251	48
	Indirect costs (increased cost of doing business)	711	807	883	966	36
	Total	**2,230**	**2,596**	**2,891**	**3,217**	**44**
France	Direct Costs (Value of fuel & Time wasted)	1,711	1883	2,012	2,148	26
	Indirect costs (increased cost of doing business)	870	921	965	1,015	17
	Total	**2,580**	**2,804**	**2,977**	**3,163**	**23**
Germany	Direct Costs (Value of fuel & Time wasted)	1,588	1,755	1,920	2,110	33
	Indirect costs (increased cost of doing business)	599	656	729	817	36
	Total	**2,187**	**2,412**	**2,649**	**2,927**	**34**
USA	Direct Costs (Value of fuel & Time wasted)	1,179	1,368	1,500	1,617	37
	Indirect costs (increased cost of doing business)	557	617	655	684	23
	Total	**1,736**	**1,985**	**2,155**	**2,301**	**33**

f) Pakistan' Urban Growth & the Problem of Congestion

Our country is no exception and are facing more or less the same situation as other countries around the world. The problem of urbanization in Pakistan and the quality of life is under pressure with the advancement in living standards in mega cities of Pakistan. Pakistan's urban population expanded sevenfold during 1950–2011, while the total population of Pakistan increased by over fourfold. The unprecedented social changes in this part of the world have led to rapid urbanization and the emergence of mega cities. During 1990–2003, Pakistan sustained its historical lead as the second-most urbanized nation in South Asia with city dwellers making up 36% of its population.

14 Source: INRIX, Cebr analysis

Interestingly, the migration towards the big cities have accelerated the recent times than ever, as the population of 10 major cities of the country has increased by 74.4 per cent since 1998. The total population of the 10 cities of Pakistan surged to 40,956,232 individuals as per the 2017 census from 23,475,067 registered during the 1998 census.[15]

Rank	City	Population (Census-1998)	Population (Census-2017)	Growth %
1.	Karachi	9,339,023	14,910,352	59.65%
2.	Lahore	5,143,495	11,126,285	116%
3.	Faisalabad	2,008,861	3,203,846	59.4%
4.	Rawalpindi	1,409,768	2,098,231	48.8%
5.	Gujranwala	1,132,509	2,027,001	78%
6.	Peshawar	982,816	1,970,042	100%
7.	Multan	1,197,384	1,871,843	56%
8.	Hyderabad	1,166,894	1,732,693	48.4%
9.	Islamabad	529,180	1,014,825	91.7%
10.	Quetta	565,137	1,001,205	71.1%

This influx of people towards large cities has brought many other problems as the infrastructure here in Pakistan never has the capability to cater such huge burden. The roads were never designed to accommodate this unprecedented traffic flow and the scarcity of funds multiplied the problems instead of presenting any solutions. The cities not only have to accommodate population but more vehicles were moving on the road as the economic activity brought sudden change in living standards. This has resulted in more vehicles on the road as the country has seen a sudden rise in living standards. Furthermore, the past 15 years has seen a 268% increase in the total number of registered motor vehicles 439% increase in motor cycles in the country. While the public transport increased by 167% in the same period and the Cargo Transport increased by 73%. Ironically, the length of roads across the country remains 263, 356 km and has received an increase of only 5% in 15 years[16].

It is pertinent to mention that in the past 16 years there has been a 25% decrease in the railway locomotives, 37% decrease in the freight wagons while the railway routes remain constant and there is a 43% decrease in the number of passengers[17]. This has developed a tendency among people to use roads which resulted in huge congestions and delays in the traffic.

15 https://en.wikipedia.org/wiki/2017_Census_of_Pakistan

16 Pakistan Economic Survey 2015-2016.

17 Gallup-Pakistan, November 2, 2016.

Present State of Traffic Management & Congestion in Pakistan

In recent years, the mega-cities in Pakistan have found themselves at the brink of massive traffic explosion, hence, curtailing their ability to manage traffic. The conventional traffic management has been casted as a mismatch situation between supply and demand because of many reasons including unplanned cities, poor road discipline, lack of alternate traffic means, outdated traffic management system, budget constraints and most importantly lack of political will.

(i) Unplanned cities: Roads tend to be narrow and poorly built, and there are a lot of architectural flaws as we lacked a culture of involving all stakeholders in decision making. As cities grow in an ad-hoc manner without consultation of traffic managers, no provision is made towards scaling road capacities, eventually resulting into several bottleneck roads, which remain congested for extended periods of time.

(ii) Poor discipline: Drivers often are not trained sufficiently to follow lane discipline. The impact of poor lane discipline, especially at traffic junctions, deteriorates the already overcrowded junction situation. Furthermore, drivers frequently cross the pedestrian crossing even the red lights and block the intersection, causing further traffic congestion. These problems are compounded by the fact that traffic law enforcement is poor, thereby providing no incentive for drivers to follow the rules.

(iii) Alternate traffic means: Our country has been miserably failed to provide alternative means of transport or unable to build mass transit system and resultantly the cities have witnessed a surge in the number of vehicles across the country. The problem is further compounded by the social stigma, where people view operating a private vehicle as a sign of prosperity, while public transport is viewed as being used by the lower echelons of society.

(iv) Archaic management: Traffic junctions never been redesigned are seen largely independent of any traffic management strategy, only optimizing the respective junction traffic flow, in the direction of maximum traffic build up.

(v) Tighter budgets: A significant amount of investment is required to set up a traffic management infrastructure which can scale with the increasing traffic. Such an infrastructure not only involves measuring and analyzing real-time traffic data but also focuses towards enhancing congestion detection, solving real time congestion and forecasting congestion scenarios. Pakistan's society ravaged by corruption and inefficient bureaucracy, have to face multiple hurdles before the money actually progresses towards such large initiatives.

(vi) Lack of political will: The political parties have never given any importance to the issues of the people residing in mega cities. They are not prepared to delegate their powers to the district governments or the local Governments the third tier of a federation. On the contrary, in developed democracies local governments are responsible for municipal services. Furthermore, in many

cities, there is a lack of adequate funds, infrastructure and insufficient qualified and trained administration as well as staff.

We have to adopt new trends in traffic management like consideration of importance of traffic to citizen's daily lives and have to understand the importance of traffic information as a value-added service by businesses like tv/radio stations and mobile phone operators as citizens are willing to pay directly or indirectly towards the cost incurred on this facility. We have to move towards an intelligent transportation system based on IT infrastructure to measure and manage traffic according to the city's dynamics along with modernization of roads matching the fast-paced traffic of new era.

Discussion

Traffic congestion is a vexing problem experienced by residents of all urban areas. Despite efforts and spending billions of dollar worth of public spending to alleviate congestion, the problem appears to be getting worse. If we dig into the history, we find Caesars in ancient Rome who was of the view that the rise in goods carts on narrow city streets made them impassable and unsafe for pedestrians. Resultantly, he introduced law that enforced selling of goods at night, but, this policy was soon overturned because citizens complained that their sleep was interrupted by the sounds of vehicles traversing the pavement and of animals straining under their loads. Again, Charles II of England issued a famous proclamation in 1660 to ban standing carriages, wagons, and horses from the streets of Westminster and London because they were excessive and were creating a public nuisance (A. E. Weinstein, 2002). He ordered that they be required to wait for their passengers off the main thoroughfares to enable the traffic to flow more freely on the boulevards.

The earlier innovation that addressed the problem of congestion in mega cities has improved public transportation, from carts being pulled by horses and ultimately to the vehicles powered by steam and electricity engines. Affordable and reliable public transportation meant that people may live farther from where they worked and travel much more. At the first national Conference on Planning and the Problems of Congestion held at Washington D.C, in 1909, speakers urged on the suburbanization of the population. The flat subway fare (meaning that the fare was the same for a 20-mile journey as for a 1-mile trip) was adopted to encourage lower-income people to move out of the city center and new immigrants to locate in outlying neighborhoods (M. C. Sies & C Silver 1996).

The most rapid growth rates in automobile ownership after the World War II resulted in congested streets. Innovations devised during this period by engineers, politicians, and bureaucrats included the widening of roads and the rationalization of street

networks by, for example, straightening streets and making them more continuous with one another. Busy intersections gradually came to be managed by signs and mechanical signals that were eventually replaced by electric signals that later were coordinated with one another into systems that accommodated higher traffic volumes.

In the recent past, the costs of new highway capacity have become political liabilities that exceed its benefits. Community disruption, land taking, decentralization of population, production of air pollution, and dependence of the automobile and highway system on petroleum energy sources all limit the likelihood that government policy will emphasize continued expansion of roadway networks. It is now common to say that we cannot build our way out of congestion, because new roads induce new traffic. Between 1980 and 1999, travelling on U.S. roadways grew by 76 percent, while lane miles increased by only 3 percent. In a study of 68 urban areas published in 2001, the Texas Transportation Institute reported that the percentage of daily travel taking place during congested periods increased from 32 percent in 1982 to 45 percent in 1999 while motorists faced seven hours per day of congested roadways in 1999 compared with five hours in 1982, as the road delays increased by 8.5% between 1993 and 1997 only (Governor's Business Council, 2003).

Changing people's behavior is hard and some cities are using financial nudges to try to control traffic and encourage people to use other modes of transport. A number of strategies including levying congestion charge have been tried to solve the issue of traffic congestion. A few of those were clearly inclined and directed to use advance technologies to fight this problem.

(i) In 2003, London was one of the first cities in the world to introduce a congestion charge. It remains in operation Monday to Friday 07:00-18:00 within a specified area of central London. The tariff was fixed per day and enforcement was primarily based on automatic number plate recognition. Revenue from the Congestion Charge is spent on further improvements to transport across London. The results showed that traffic entering the original charging zone has remained stable at 27% lower than pre-charging conditions, meaning that nearly 80,000 less cars enter the original charging zone each day[18].

(ii) The City of Stockholm also has a congestion tax -- the amounts charged fluctuate, and are highest during the periods and in the places where the traffic is heaviest. They also introduced optimized traffic lights and projects to increase off-peak deliveries of goods. The congestion taxation has had a

[18] https://tfl.gov.uk/modes/driving/congestion-charge.

strong and continued effect on reducing traffic volume in rush hours by approximately 20 % (Jonas Eliasson, 2014).

(iii) In Pittsburgh, Professor Stephen Smith at Carnegie Mellon University USA developed a strategy to keep the traffic moving on the streets based on "Decentralized" approach a smart traffic lights system enabled to reduce travel times by 25 %, the number of stoppages by 30 % and idle time by 40 % in 2015. By 2017, 150 more smart intersections were added in Pittsburg to maintain the flow of traffic in a smart way[19].

(iv) Dubai Road Transport Authority (RTA) has announced the transition of all its applicable services to smart apps[20], resultantly, RTA offers 173 services with the help of nine mobile apps with a tap on the smart phones. These apps include Smart Drive, Wojhati, Smart Salik, Smart Parking, Smart Taxi, Drivers & Vehicles, Public Transport, Corporate Services and RTA Dubai. Besides, RTA has developed a plan to cover 900 km of bikeways connecting mass transit system.

Significance of the study/proposed model

Administration and Municipalities of mega-cities in Pakistan are facing a challenging task, on one hand to harmonize a sustainable urban development and on the other to make old infrastructure compatible to new advancement and civic requirements by taking into account the need of both creating job opportunities and preserving the environment, offering to people the best living conditions. Moreover, cities are looking for competitive advantage in attracting and retaining the best, more educated and skilled human resources for innovative and performing companies, and high touristic fluxes. However, a poorly managed traffic system has adversely impacted the quality and standards of life in large cities.

While, contrary to this smart mobility strategies adopted in the advanced countries have proven a success story to counter traffic congestion in mega cities. This model could be presented as one of the main options to seek more sustainable transport system in under developed country like Pakistan. But, unfortunately this issue is not on the agenda of political parties and the local governments are clearly held responsible for this criminal neglect. As smart mobility is a set of coordinated actions adopted to improve the efficiency, effectiveness and the environmental sustainability of cities. Therefore, the issue of mobility is growing and continuously worsening due to other related problems and are in need to be addressed particularly by the city governments.

19 https://spectrum.ieee.org/cars-that-think/robotics/artificial-intelligence/pittsburgh-smart-traffic-signals-will-make-driving-less-boring

20 http://gulfnews.com/news/uae/transport/rta-completes-transition-to-smart-government-1.1501523

Political leadership in Pakistan either failed to understand or deliberately neglecting the issue of mobility. They must acknowledge that mobility is one of the most important facilities to support the functioning of the urban area. While disruption in flow of traffic or traffic congestion is responsible for many severe negative impacts and problems for the quality of life in cities including pollution, street congestion, long time to cross the city and therefore, have an adverse impact on the balance between work and life balance, high cost of public local transport services and much more. Smart Mobility is considered one of the most promising solutions as it could produce high benefits for the quality of life of almost all the city stakeholders. Smart Mobility is not a unique initiative, but a complex set of projects and actions, different in goals, contents and technology intensity. Especially Information & Communication Technology could be the pivot of a Smart Mobility initiative. Smart Mobility has two meanings in respect of the use of ICT:

1. the first one refers to an efficient and effective mobility system and is independent from the role played by ICT but it is rather connected to the use of appropriate technologies;
2. while the second one relates to a mobility system characterized by a consistent and systematic use of ICT, (Staricco, 2013).

The Smart Mobility sector presents a remarkable breadth of contents and implications because a large number of variables are connected to it. It is possible to identify several studies focused on individual applications, while it is more difficult to find studies that provide an holistic and interrelated vision of these actions. Due to the complexity of the urban mobility scenario, the aim of this paper, which operates a multiple level classification of a large number of Smart Mobility initiatives due to a deep literature review, is an effort to provide an overview of this area through the proposal of an arrangement considering three aspects:

(a) Innovative transport solutions. Smart Mobility variables responsible for moving the smart initiatives;
(b) Use and intensity of ICT in Smart Mobility initiatives;
(c) Goals and benefits of Smart Mobility actions on smart goals.

The suggested arrangement is based on a literature review regarding policies and technologies for urban mobility and smart mobility, especially in the cities of the developed countries. An attempt will be made to explore the interrelations between initiatives, aims and enabling technologies. This paper would specifically make the case that increasing road capacity is not the only way to mitigate traffic problems. By smart flow-control techniques in present infrastructure, it is possible to increase the operational capacity of the existent road system.

Proposed Traffic Mobility Model

(a) Innovative Transport Solutions

This step includes all the initiatives carried out by the companies or individuals supplying the local public transport services in the city with an aim to positively change the quality of public transport under different points of view, ranging from a change in the transport vehicles for instance (EUR-5[21]), such hybrid cars and car-sharing and fuels or interventions will improve the quality of public service like availability of wi-fi etc. Hybrid vehicles would allow a pronounced reduction of pollutant emissions without requiring the development of new technologies, while car-sharing allows reduction of urban congestion, reduction of pollution emissions, reduction in employment of public space and, in general, a new push towards the use of public transport. While the SMS-based solutions do not require large investments but it needs citizens involvement and readiness in terms of technological literacy and their willingness to use this system. For this reason, ICT when introduced into an environment ready to accept it, is able to determine a significant step forward for the creation of a modern and sustainable urban transport system.

Pakistan seems to be ripe to adopt ICT based strategies as the internet users have crossed 39 million mark a growth rate 47% recorded in one year from 2014-2015, while there are 139.2 million mobile phone users in the country expected to add another 17 million by 2020. By the end of 2016 the people possessed 40 million smart phones[22]. There are many other initiatives that need a political will and are relatively cheaper than building infrastructure like flyovers and expressways.

(i) Radio Frequency Identification Device developed by NADRA[23] is a contact lens chip containing vehicles & owner's details is fixed on vehicles windshields. This chip is readable with the help of cameras, RFID antennas, static scanners as the vehicles cross the places fully equipped with technology. The system is operational on limited basis in the country.

(ii) Transmission of complete date including timestamp, vehicle information is transmitted in real-time to the central control room that allows authorities to monitor vehicles. This system would allow authorities to collect traffic data and flow of vehicles at traffic signals helping them to monitor speed limit, traffic violations, eradicate vehicle theft and smuggling, catch suspects and improve vehicle tax collection.

(iii) The system could also be adopted at secured premises/ building entry/exit points to restrict access of vehicles at designated gates, levels and points. The system is useful in monitoring activity at entry/exit points and generates reports

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21 EUR: Vehicles with direct injection engines are subject to a limit of 0.005g/km emission.

22 http://www.pas.org.pk/digital-in-2017-global-overview/

23 National Database & Registration Authority of Pakistan.

of visitors and staff vehicles. This could be a valuable tool where security is a priority and passage of vehicles must be regulated by time. Furthermore, the system can be deployed at toll plazas on motorways and/or highways for electronic collection of toll from vehicles bearing the e-Tag. The system is easily configurable and modifiable and generates reports on financials and traffic turnover.

(iv) Adaptive Traffic Signals: Traffic signals are getting smarter through V2I (Vehicles to Infrastructure) technology. The cities of Columbus and Ohio, is using data collection from government fleet vehicles as part of other smart city pilot programs to improve the timing of traffic signals. By getting a better idea of traffic flow and how long a vehicle idles at stop lights, the city can better modify traffic signal timing with the changes in traffic throughout the day[24].

(v) V2I Smart Corridors**:** Adaptive traffic signals are one part of smart corridors. Smart corridors can address traffic congested roads as well as hazardous areas, such as one major highway in Wyoming, USA used heavily for freight transportation in addition to regular passenger cars. Using V2I technology, the state is implementing a pilot project that will send safety-related weather and accident alerts to drivers volunteering for the program. Officials expect a significant effect on safety and even the economy since the state will likely spend less energy on accident clean-up and highway closures to deal with tractor-trailer blow-overs. In Atlanta, a 2.3-mile smart corridor that just opened in September 2017 is expected to reduce travel times on the route by 25%[25].

(vi) Tracking Pedestrian Traffic**:** Addressing traffic congestion is also about understanding pedestrian traffic. In Las Vegas, for example, the city is using V2I[26] technology to not only track how many vehicles go through a given intersection at different times but how many pedestrians are crossing streets. So, the city can reroute vehicle traffic at times of high pedestrian traffic, and so on. The city can also get alerts when a pedestrian is in a roadway when the light is about to change so they can delay the light if needed, increasing the safety of people on the streets as well.

(b) Infrastructure and Policies Supporting Smart Mobility

These initiative based on actions including infrastructure and policies supporting the initiatives of Smart Mobility.

(i) The creation of bus/motor cycle lanes or interventions aiming at changing mobility as the creation of restricted traffic zones. The expansion or creation of bus/motor cycle lanes is an intervention that is closely linked to the use of

24 https://www.geotab.com/blog/reduce-traffic-congestion/

25 https://www.geotab.com/blog/reduce-traffic-congestion/

26 Vehicle to Infrastructure Technology

the public transport/motor cycle as a mean of public/private transport and could have positive impacts on the spread of sharing ride. This initiative led to a modal shift from car to bike from 2 to 10 % in cities like Paris, Montreal and Lyon. The traffic closure in certain urban areas for time zones or periods of the day in order to reduce pollution and congestion represents another interesting solution adopted by municipalities.

(ii) The next initiative is a series of integrated policies implemented to change the mobility system, in particular by the public decision maker, for example, incentives for the use of less polluting fuels, tax incentives or measures such as higher taxation on polluting fuels. Especially banning the public services vehicles older than five years. Other interventions that may alter the urban mobility may be the redesign of the city and its spaces including creating one way zones, installation of message signs for the commuters, integrated traffic lights system, reduction in the number of intersection and U-turns for a better flow of traffic. Many streets within city centers could be turned into auto-free zones. The shifting of wholesale market, workshops, light industrial units and warehouses from the city to suburban areas etc.

(iii) e-Government Portal: Information & Communication Technology has provided enormous opportunities to improve the quality and delivery of public services in mega cities. The local governments have to recognize this potential of ICT to ease up the pressure and keep people off the roads. E-government, also known as Electronic Government or Digital Government, is a process of providing services to government customers, employees and other governmental agencies electronically. E-government uses a wide range of networks and mobile computing to transform the government's operations for better efficiency and to facilitate its customers. Government-to-Citizen (G2C) includes information spreading to the public, basic citizen services such as license renewals, ordering of birth/death/marriage certificates and filing of income taxes, as well as citizen assistance for such basic services as health care, education, hospital information, libraries etc.

(c) Intelligent Transport Systems

Intelligent Transport Systems (ITS) are advanced applications to collect, store and process data, information and knowledge aiming at planning, implementing and evaluating integrated initiatives and policies of Smart Mobility. They are a large and heterogeneous set of applications, including:

(i) Demand control systems for access to reserved areas (congestion pricing, electronic tolling, with GPS, pay as you drive);
(ii) Integrated Parking Guidance Systems;
(iii) Variable Message Signs (VMS);
(iv) Urban Traffic Control (UTC);
(v) Video surveillance systems for area and environment security;

(vi) Integrated systems for mobility management;
(vii) Traffic data collection systems;

The data collected in the EU countries, USA and Japan show that the introduction of Intelligent Transport System (ITS) technologies has significantly contributed to improve the efficiency, safety, environmental impact and overall productivity of the transportation system. These applications, as pointed out by the European Commission, are an attractive solution to many of the problems of the transport sector especially in the road sector it is possible to record reductions in journey times (15–20 %), in energy consumption (12 %) and in emissions of pollutants (10 %), as well as increases in network capacity (5–10 %) and decreases in the number of accidents (10–15 %) (R. P. Dameri, 2017).

This aspect is perhaps the most advanced frontier in terms of Smart Mobility solutions. It is a series of possible actions that can be implemented only under certain conditions. In the first instance, the use of ICT is adopted in an integrated manner and not only to cover a few projects. The adoption of these solutions requires a holistic view, the presence of previous policies and an integrated vision across different dimensions of urban living.

(d) Smart Mobility Actions and Smart Goals

It is a systematization of a large number of initiatives discussed in the literature, with an emphasis on ICT, but not strictly and necessarily tied to ICT. Although the new frontier of innovation is certainly linked to the adoption of mobility solutions for ITS, we can say it is possible to adopt solutions and changes in the system of mobility without the need for large investments or sophisticated technologies. We can therefore argue that ICT is a pivotal, but not necessary technology to start the implementation of Smart Mobility initiatives. However, Its importance increases when the complexity and the maturity of Smart Mobility projects become higher. In ITS or other integrated Smart Mobility policies, ICT plays a crucial and fundamental role.

In this case it is possible to say that the ICT, if properly directed, would seem to have a greater positive benefit than other initiatives a society has to improve in order to enhance its quality of life. The concept of well-being is wide but it is possible to individuate some common targets like the safeguarding of the environment is strictly related to the reduction of PM10[27] concentrations in the air and green-house gas emission. Also, personal safety and a good balance between work and life time are shared goals between well-being and Smart Mobility. Therefore, it is possible to argue that Smart Mobility directly impacts the quality of life of people living in cities.

[27] Particulate Matter with a diameter of 10 micrometer or smaller.

Conclusion & Way forward

Smart city initiatives must include its residents, businesspeople and visitors. City leadership must not only raise awareness of the benefits of the smart city technologies being implemented, but also promote the use of open, democratized data to its citizens. If people know what they are participating in and the benefits it can bring, they are more likely to engage. Fostering collaboration between the public and private sector and city residents is key to creating a smart citizen who will be engaged and empowered and positively contribute to the city and community

Congestion is, in principle, a mostly solvable problem, even if no fast-growing city has fully solved it. But, there are many ways tried to solve the congestions successfully. The first step in mitigating traffic congestion is to estimate the amount of traffic on the link at any given point of time. A common method is to place sensors on the road and count the number of times they are actuated by the passing wheels of a vehicle.

Once, the actual number of vehicles are measured the most common-sense solution to reduce traffic congestions are to improve capacity and connectivity of the existing infrastructure. Capacity can be expanded by adding lanes to existing roads, and sometimes problem is not the width of the road but where it goes. So, by reducing the indirectness of the network through selected connections can reduce traffic congestion. But, the problem with these two solutions are first, one they are very expensive and second, it would be used up very quickly by the new travelers.

The next most obvious solution is to have a better control on the existing infrastructure in effective manner. Coordinating traffic lights on a city road grid can make sure more vehicles hit green lights. Furthermore, it is estimated that half of all delay is due to non-recurring congestion, most notable crashes. This could be managed by better designed roads. Accidents can also be reduced with better-trained drivers and making license more difficult for them to acquire. Crashes have to be cleared quickly by improving emergency response and it could reduce the amount of subsequent delay.

Maintaining roads is important but closing entire road for construction is not the strategy. Doing all work at night or weekends is another strategy. The point is, the cost of the delay vs. the cost of construction need to be properly weighed. Consideration of a competing mode is a theoretical solution to many problems like building a rapid transit line or running an express bus or even building bus lanes and motor cycle lanes etc.

Redefining of the gauge of road lanes could be another possible option and it could double the capacity on the existing roads. We are also wasting surface by storing parked cars. A lane or turn-lane or bike lane or a bus-lane could be added in the space to

increase the throughput. The adjacent property owners are often under the mistaken impression that their customers have a right to park for free on the public street in front of their business/house. Where there is no congestion this is not a problem but on the roads with traffic congestion this artificial right is costly for the other member of the society.

If schools, colleges and universities are near to the people where they study or work, they will not have to travel as far, and hence, there will be less traffic on the road (assuming they still traveled by car) or not at all (if they walked). From a public policy perspective, restricting students to have admission in schools and colleges where they live, and by increasing the local balance between students and educational institutions can reduce travel. In practice this is difficult, as there is no mechanism to require students to enroll in institutions near their residence.

We will not have congestion if people skip their intentions to travel at the sametime. We could stagger work hours, so not everyone arrived at work/schools/colleges/universities at the same time. Car sharing and carpooling has been around since the dawn of cars. It is easiest when there are two people going from the same place to the same destination at the same time. All this sameness though requires coordination to arrange, or sophisticated matching to discover. High Occupancy Vehicles (HOV) lanes or restrictions in some cities encourage people to pick-up strangers to fill up the extra seats to save time. This policy could easily be adopted in school pick and drop services. No vehicle with less than four passengers be allowed to reduce traffic burden in front of schools.

The effective use of ICT would enable majority of the drivers especially those who are inefficient routers. The people can find shortest path to their destination to reduce the length of their trip by using real-time traveler information rather than using their own intuition or incomplete mental map in this way they can contribute by reducing congestion for others. Smart city projects should include plans to make the data transparent and available to citizens through an open data portal or mobile app. This enables residents to engage with the data and understand what it is used for. Through a smart city app, residents may also be able to complete personal chores, such as viewing their home's energy consumption, paying bills and finding efficient public transportation.

Using history as a guide, we have the technical means at hand with which to finally solve the congestion problem. Thus, the most significant determinants of the future use of IT for traffic control will be political rather than technical. Based on the history reviewed here, I believe that in approaching the future, the goal of policymakers should not to eliminate traffic congestion but rather to try to strike a new balance between

growth, congestion, and the political acceptability of the measures by which we can eliminate that congestion.

It is pertinent to note that traffic congestions cannot be solved through introduction of technology alone. Getting the system to work through the control room rather than manually by policemen at traffic junctions requires a change in mindset which can be achieved through regular trainings.

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