

PROPOSED CONGESTION CHARGING PROGRAM FOR PUNE CORE AREA**D S Aswar¹, S D Khandekar², S D Ambadkar³**¹ Assistant Professor, Sinhgad College of Engineering Pune, Maharashtra, India.² Professor, Sinhgad College of Engineering Pune, Maharashtra, India.³ Assistant Professor G. H. Raison University, Amravati 444701, Maharashtra, India.**Abstract**

Pune city has a very high density of private vehicles. Core (Peths) Pune has limited road capacity and high travel demand creating a traffic congestion problem. This reduce the use of public transport leading to traffic problems. To address all cascading traffic issues, a study for congestion charging as a possible solution for the Pune city core area has been proposed. The study encompasses discussion on the important congestion charging issues like cost efficiency, user's privacy, equity, political risks, awareness, land use effects, impact on business, utilization of revenue etc. which needs to address for effective implementation of the scheme. Also, traffic spillover impact and its mitigation measures for roads adjoining to selected cordon areas are suggested. Suitable measures for the mitigation of program implementation risks are also suggested. The traffic volume survey and user questionnaire survey were carried out for the proposed congestion pricing zone. The traffic volume studies at suitable survey stations for the cordon area was carried out with real-time video recordings. The traffic data was analyzed to get the classified traffic volume and congestion peak hours. Both the classified traffic volume data and user survey data were analyzed to check the feasibility of the congestion charging for the core area of the city. The sample questionnaire survey results indicate the users' willingness and feasibility of the congestion charging program for the Pune Core area. The evaluation of questionnaire survey result also emphasizes the need for an integrated approach for effective implementation of congestion charging program.

Keywords: congestion charging, cordon area, risks mitigation, traffic volume survey, questionnaire survey.

1. INTRODUCTION

Congestion charging is a traffic management measure for reducing traffic congestion. It's a type of road pricing with higher fees during peak times of congestion as a way to reduce traffic volumes to optimal levels. [1]. The objective is to charge vehicles at places and at times where and when they caused congestion. A congestion pricing rate may be adjusted for reducing usage.[2]. The congestion charging scheme aims to deter personal vehicle usage, reduce congestion, and support investment in public transport. Congestion charging is charging the vehicles for using the road as a commodity which is causing the problem of congestion. The main objective is to reduce the traffic volume, increase the capacity of the roads, motivate public transport, reduce air and sound pollution, and improve the liveability in these areas. India's urban pollution is already about 40% above the permissible limits across the major cities. In the country, the estimated traffic congestion cost is over \$20 bn across the metro cities. Traffic index- peak hour congestion i.e. percentage of additional time to travel in peak hours in four metro cities is about 150%. [3] Union government has expressed concern over the rising vehicle population and its consequences like congestion, lowering GDP by about 3.5%, increasing accidents and air pollution. Considering all these traffic problems, the government has suggested exploring congestion charging (CC) to decongest central areas and improve the mobility of people at large, by limiting the excessive use of private vehicles on limited available urban road space [4].

2. LITERATURE REVIEW

There are several specific ways to implement congestion charging which can be adapted to suit the specific location and charging objectives. The congestion charging applicable may be classified into different types such as Cordon ring, Corridor, Network etc. [5, 6]. The congestion charges need to be planned carefully to deter traffic congestion but at the same time not to lead the system under-utilized leading to a financial loss. Though the congestion charging program has fairly low operating costs a high initial investment is required for the implementation of the system [7]. Revenues from the charges must be sufficient to fund the scheme itself, as well as associated public transportation improvements. Congestion charging for selected locations has an impact on several aspects of area use, users' preferences, traffic conditions etc. The charging can affect either positively or otherwise. The impacts need to be understood and mitigated for successful implementation. [8]. Congestion charging schemes will inevitably have impacts upon the geographical areas and economic sectors that they interface with. There are objections to the loss to local property prices and businesses. [9].

However, on contrary, congestion pricing increases overall commercial activities by allowing high-value activities over others, thus with an overall advantage. [2]. The traffic spillover in congestion charging areas due to diverted traffic may increase congestion on adjoining free roads. However, the traffic spillover case studies have indicated that the traffic spillover effect due to diversion is limited and may be managed with variable pricing by expanding the priced area to outer zones with lower rates compared to higher rates of the centre zones [10]. One of the major reasons for initial opposition is the political risk. The lack of political support is the major challenge to implementing congestion charging. [7, 11]. Congestion pricing can generate substantial revenues. The revenue from congestion charging should be utilized for public facilities and welfare only. Net revenues after deducting the operating expenses can be used for the costs of expanded roadway facilities, public transit, toll discounts or credits for low-income groups or to reduce other taxes such as fuel taxes, vehicle registration fees or sales taxes [12]. When an automated system is used for congestion charging, it can allow the video surveillance and vehicles tracking system, leading to an invasion of privacy. Hensher et al. [13] suggested a three-step privacy, complexity, and equity awareness plan for promoting the public acceptance of congestion charging. Congestion charging can be successful only if people are benefited from the project. Awareness campaigns should also aim to communicate benefits, different payment options etc.

Pune is the second-largest city in Maharashtra and the 7th most populous city in India (2020). Twin city Pune and Pimpri Chinchwad are fast transforming into one urban complex. In 2018 the total number of vehicles has exceeded its population with 3.62 million vehicles and 2.70 million being two-wheelers [14]. Pune city is facing growing vehicular traffic due to an unmitigated increase in the number of personal vehicles. The increase in private vehicles along with the insufficient growth in the PMPML (Pune Mahanagar Parivahan Mahamandal Ltd.) has reduced the usage of public transport. There is an immediate need to enhance the capacity and quality of public transport so that people will prefer it over personal vehicles. Congestion results in lower-traffic speeds, more specifically for public transport vehicles. The increase in travel times and inefficient public transport system forces commuters to opt for personalized modes of travel. The objective of congested charging is to reduce peak vehicular traffic to optimal levels and facilitate a switch to other sustainable transport alternatives. Thus, discouraging the use of private vehicles. Generally, transportation funding always falls short of the city transportation needs required to enhance mobility. This persistent funding gap can be addressed by adopting new funding and financing strategies through congestion charging [15]. Road congestion charging promotes efficient use of the existing road network, and boost usage of the transport system, thereby addressing congestion and pollution issues. The congestion charge will improve the AQI (air quality index) and reduce noise pollution by reducing the excessive use of private vehicles. It will also have a positive impact on the ease of living quotient through efficient and more reliable public transit options [16].

3. STUDY METHODOLOGY

As a first step, the congestion problem needs to be identified, defined and the study area is then selected as per the identified problem. Based on the problem and its definition, the congestion charging goals are formulated. Then the traffic, pedestrian, and parking survey data analysis can be carried out for possible traffic congestion solutions. For this case study, the authors have identified the problem of heavy congestion for the core city area (Peths) of Pune. The city core area for congestion charging is selected considering the congestion problem. This was then followed by the traffic volume survey at key locations. The traffic survey was carried out for the identification of classified traffic volume and its distribution over time, for identification of peak hours. Also, a sample questionnaire survey was carried out to identify, users' psychology and behavioural trends for checking the feasibility of congestion charging implementation. The data obtained from these two surveys and pedestrian data from the comprehensive mobility plan [15] was analysed to obtain a conclusion considering various parameters such as the parking issues, traffic spillover impacts, etc.

The formulated goals of proposed congestion charging are reduction in the vehicular traffic volume, improved flow of traffic, motivation to public transport facilities etc.

For efficient planning and implementation of congestion charging all related data need to be studied. The study data include present traffic scenario, traffic congestion, identification of major entry and exit traffic locations, traffic volume study at cordon key points, checking the possibility of alternative routes/traffic diversions for the cordon area. The traffic survey also aims at identifying the purpose of journey/trip characteristics, to check the trip origin and destination (possibility of staggering of traffic peak flow). The data about parking issues and characteristics of the existing public transport system are indirectly obtained through a survey.

3.1. Selection of Study Area

The centrally located Peth areas viz the old core Pune including the areas such as Budhwar, Shukrawar, Shaniwar, Narayan Sadashiv Peth and Laxmi Road, Kumthekar Road, Kelkar Road, Shivaji Road. and the adjoining areas are regarded as congested areas of the city. The roads, lanes and by-lanes in these areas were planned more than 300 years ago as per the then prevailing needs and modes of transport. The same roads are more or less being used for today's traffic needs of a thickly populated city. The road widths within this area are not sufficient for the present traffic requirements. The operational traffic volume within the area is huge, making it one of the most congested city areas. Most of these roads cannot be widened due to the scarcity of land. It might be costly to acquire the land for widening and may also attract more traffic leading to further congestion and pollution issues. The pollution created by the vehicles makes it difficult for the residents to live in this environment. This core area is the city centre catering for the major commercial activities due to which the amount of traffic increases drastically. The lack of an efficient public transport system for the present needs also worsens the traffic congestion. The pedestrian's usage of this area has increased with an increase in the population and commercial activities; however, the space available for pedestrians is very inadequate.

Figure 1. Map showing the boundary of proposed cordon area



Figure 2. Cumulative PCU Vs. time. (morning & evening traffic peak hours)

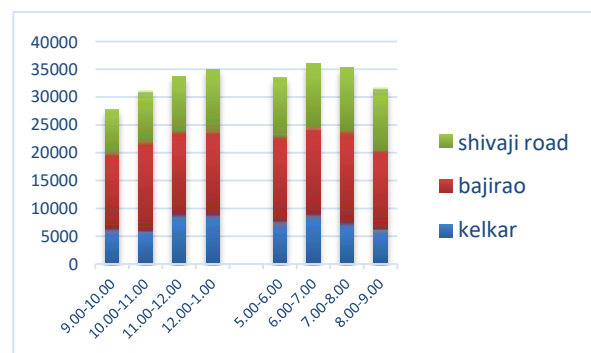


Figure 1. shows the marked boundary line for the selected area. The roads marked in red are excluded from the congestion charging zone. These major roads of the area are -Tilak Road, Shankarsheth Road, Ambedkar Road, Congress House Road. The number of entry and exit points identified for this cordoned area consists of- 34 Two-way points (entry and exit), 10 One-way points (entering the area) and 8 One-way points (exiting the area). These identified key locations can serve as congestion charging stations as well as strategic points for managing the traffic spillover effect.

3.2. How is the Program expected to work?

Traffic congestion has been a major problem in Pune city, mainly in the core areas. Private vehicles are the major vehicles causing the problem of traffic congestion for which the Pune Municipal

Corporation (PMC) has not yet come up with the desired solution. The motorists entering into this cordoned area during peak hours are proposed to be charged. The privately-owned four-wheelers, two-wheelers and auto-rickshaws are to be charged at a flat rate. All the emergency services like ambulance, fire brigade, police, etc. are to be exempted from charging while entering this zone. Various entry and exit points were marked on the cordon ring where the motorists will be charged for entering the cordon area. The CC zone along with the entry and exit points will be marked with signboards on the roadside and on-road paintings. The entry-exit points of this zone will be having boards displaying the tolls according to the vehicle type.

3.3. Data Collection: -Traffic Volume Count- Cordon Flow

Outer Cordon is the boundary of the Local Planning Area, along which, three locations were selected. Strategically important entry and exit points of the proposed charged area at Alka Chowk, Bajirao Road (Shaniwarwada), and Shivaji Road (Swargate) are selected as survey stations. The 8-hour classified directional traffic volume count were conducted across these key location for three days (Friday, Saturday and Sunday). Considering the increased shopping activities at weekends, along with the working day, these days are also considered for traffic count. Manual traffic counts were carried out using real-time video coverage for a typical working day. At these identified entries and exit locations, both directional classified vehicle counts were carried out. The field traffic volume data was processed, converted to the Passenger Car Unit (PCU) value and used in the traffic volume analysis [17, 18]. The data analysis results have helped in deciding the peak hour for congestion charging as 11 am to 1 pm and 6 pm to 8 pm.

3.4. Data Collection- Questionnaire Survey

The user and other stakeholders' surveys can be carried out in the core area of Pune city where the traffic congestion problem is observed. The survey can be carried out to know the present traffic conditions and problems faced by the commuters in this area and also to know their opinion/feedback regarding the present traffic conditions and their opinion towards congestion charging. Considering the objective of the study, the data requirement, unbiased questions were framed. The manual questionnaire survey was conducted in the cordon area to collect the requisite data.

Table 1. shows some of the key elements and respective objectives of the questionnaire survey

No	Question	Options				
1	Mode of your journey?	Bicycle	walking	Taxi	Bus	Own Vehicle
		0%	2%	16%	28%	12%- 4W, 42% 2W
To check contribution to traffic and scope for shifting to public transport.						
2	Purpose of Trip	Other	Through route	work	Shopping	-
		1%	20%	32%	47%	
To check Users' requirements and the possibility of the shift in peak hours on holidays (shopping activities)						
3	Time of Day for your journey (a trip from home)?	8.00-9.00am	9.00-10.00am	10-11.00am	-	-
		32%	54%	14%		
For comparing peak hrs. of morning traffic. (Data in addition to the traffic count)						
4	Time of Day for your journey (trip to home)?	6.00-7.00pm	7.00-8.00pm	8.00-9.00pm	-	-
		16%	34%	50%		
For comparing peak hrs. of evening traffic. (Data in addition to the traffic count)						
5	How frequently do you	3-5/week	1-2 /week	Few Times	Rarely	

	use the Laxmi road and other allied roads?	62%	21%	17%	0	-
	For checking the possibility of CC on a mass basis for program implementation					
6	How much is the congested during the peak hours according to you?	Unmanageable	Manage uncomfortably	Manage comfortably		
		87%	13%	0%		
	To know the reflection of the existing traffic scenario.					
7	What do you think is the reason for traffic congestion?	Traffic volume	Traffic Management		Poor Infrastructure	
		19%	73%		8%	
	To know probable causes of traffic congestion, and identify public opinion about areas of improvement. Also deciding the priority for improvement through CC revenue generated.					
8	Do you plan a trip during non-peak hours to avoid congestion?	Yes	No	-	-	-
		38%	62%			
	To check the psychology of users to shift to non-peak hrs.					
9	How much time do you save for the same journey during nonpeak?	0-5 min	5-10 min	10-15 min	15-20 min	20-30 min
		4%	12%	32%	47%	5%
	To check the possibility of normalizing traffic volume, to improve trip time. Peak-time travel optimization.					
10	Do you find parking space in the core city Area during peak hours?	Always	Sometimes	Difficult	-	-
		0%	9%	91%		
	To check Adequacy of existing parking and need for adding new facilities					
11	Do you use available paid parking lots? at Sambhaji Park /Mandai / Narayan Peth etc.	Yes	No	-	-	-
		23%	77%			
	To know parking habits and awareness of users.					
12	As a shopper will you prefer efficient public transport over a private vehicle in the area?	Yes	No	-	-	-
		100%	0%			
	To know stakeholders' preferences- Improving the public transport facilities through revenue generated.					
13	Customers' parking and shopping habits.	shop in multiple stores		go to the specific shop to buy		
		76%		24%		
	To know parking and shopping habits of shoppers and parking needs.					
14	As a user, which is the most severe problem for the core city area?	Congestion	Pollution	bad public transport		parking space
		37%	12%	31%		20%
	To know users' requirements and preferences.					
15	What will you prefer if congestion pricing is charged for entering	use the same route	divert along other routes	shift to CC free duration	use public transport	avoid a trip to all area

	into a traffic-congested area?	34%	36%	3%	27%	0%	together
	To check the psychology of users towards CC, public transport, alternative route etc. To check the effect on behaviour.						
16	At what price point would you avoid CC period -For 4 wheelers	Rs.50/-	Rs.75/-	Rs.100/-	Rs.125/-	-	-
		83%	17%	0%	0%	-	-
	For Two Wheelers	Rs.25/-	Rs.30/-	Rs.35/-	Rs.40/-	-	-
		98%	2%	-	-	-	-
	To know the reasonable highest amount for CC to optimally discourage the traffic during peak hours.						
17	Give the peak business hours?	10.00-12pm	12-2.00pm	2.00-4.00pm	4-6.00pm	6.00-8.00pm	
		26%	12%	1%	11%	43% (other7%)	
	For comparing peak hrs. to morning & evening peak of vehicular traffic.						
18	Parking space for business person & their employee?	No. of Bicycle	Motor Cycle	No. of Car	-	-	
		12%	78%	10%			
	To know shopkeepers- parking needs.						
19	Where do you park your vehicle? (Shopkeepers)	Multi-storied parking		Parking lot	Roadside parking		
		7%		6%	87%		
	Shopkeepers' on-street parking needs and the possibility of shifting to off-street.						
20	Do you think your business is affected by congestion?	YES	NO				
		83%	17%	-	-	-	-
	To check objection of Shopkeepers to CC by shop-owners and part of the solution.						
21	Where according to you should the revenue generated in CC be utilized? (Rank 1 to 5)	For Bus Transport	For Bicycle Tracks	Walkways Development	Pollution control	Eco-friendly schemes	
		52%	14%	21%	7%	6%	
	To know stakeholders' preferences- Benefits to stakeholders to be planned through generated revenue						
22	would you prefer some other business space in the same area, (Shops & hawkers on footpaths)	YES	NO				
		94%	6%	-	-	-	-
	To know hawker encroachment issues and efficient use of the existing footpaths						

4. IDENTIFICATION OF KEY ISSUES

The literature review has identified the key elements that need to be emphasized for successful implementation. The major step in the project is to identify critical recurrent issues to be addressed by the experts and scheme implementers [8]. Some of these relevant elements are studied and elaborated for the proposed charged area of the core city area.

4.1. Citizen's Opposition to Congestion Charges

Along with the other issues public acceptability has been the main obstacle to congestion pricing implementation [19]. The public acceptance of congestion pricing is mainly determined by equity, privacy, uncertainty, and complexity factors [13]. To ensure that congestion charges are not opposed by citizens at large, it is necessary to seek their cooperation and positive participation. The cooperation can be secured if the objective of the initiative is made known to them. People need to be educated about the objectives of congestion pricing for successful implementation. It is necessary to launch intensive awareness campaigns to educate people on the benefits of congestion charges on their health and well-being, as well as on the overall development. The awareness part consisted of creating awareness amongst the public about congestion charging, its benefits, the utilization of the revenue generated from congestion charging, etc. However, it may be more difficult to achieve public awareness about the adverse environmental effects of congestion [20].

4.2. Political Risk and Public awareness: Pune

With weak political support and public acceptance, congestion charging projects are very difficult to implement [21]. Before introducing the scheme, it is desirable to have a political consensus and strong will, and consultation with all stakeholders [2]. The lack of political support was the major challenge to congestion charging. Political and social acceptance when is a key function in implementing a road-pricing program. [11, 22] A major issue in accordance to Pune is, the political parties are influential to people. If the political parties are made aware of the advantages of the scheme and benefits the city will gain, may acquire votes in favour of their party proving beneficial to them and the public. It may also happen that if people do not support the scheme the party may lose votes. So, the party may not support the scheme. With this political nervousness, it would be very difficult to implement congestion charging. [23] The charging zone in Pune will reduce a large quantum of traffic. This will make the area more pedestrian-friendly and walking ability may improve. The reduction in traffic will make the residents of the area more liveable. Public attitudes and perceptions have a major influence on the acceptance of congestion pricing. People are more agreeable to congestion pricing if they are aware of its environmental and economic benefits [24]. It is therefore important to educate the general public through trials to ensure the successful implementation of congestion pricing policies [10].

4.3. End-Use of Revenue, Land Use Effects and Equity:

The revenue generated after utilizing for operating cost and management cost should be utilized for tangible public benefits such as creation of additional facilities and as an investment for public welfare. If the people are not made aware of the scheme and the revenue used for the public, it may be a risk in implementing the scheme and also may invite risk of scheme opposition.

Equity is one of the most commonly referred issues about congestion charging. The imposition of a charge at the point of use may raise the fairness issues: such as, the solutions for people without alternative routes and residents of the cordoned zone, the policies for low-income groups, defaulters' issues, property prices, business or commercial activities of the cordoned area etc. All these equity issues are valid obligations. The policymakers have to address these areas of concern and make a scheme fairer and thus more acceptable.

In Singapore, practically nobody is exempt from congestion pricing [25]. In the London CC scheme residents within the cordon, area pays the subsidised charge of only 10% [26]. Congestion charging equity can also have a dynamic component that can be used to encourage behavioural change. Exemptions can be made for certain categories of stakeholders such as low-income groups, delivery vehicles and cordon area residents. They will be given free passes and/or a discount on the charge. The congestion charged area may have lower prices and the land rates may fall due to false ideas affecting the land use. The case studies indicate that such changes may be inconclusive and uneven. However, other factors greatly influence the economy compared to congestion pricing [9]. The congestion charging for the core cordon area will reduce traffic volume. The area will be quiet and free of pollution, fewer vehicles more free space and liveability will increase.

4.4. Traffic Spillover Impacts

Traffic spillover in the adjoining area may be the major impact, of CC implementation. [10]. For Pune Tilak road, Ambedkar road, M.G. road, Shankarsheth road will be out of the cordon area. These roads will be free of the congestion charge and will divert the traffic from the congestion charge area.

Figure 3. Spillover traffic diversion non-charged roads



Specifically, the Tilak road, Lal Bahadur Shastri road or Riverside road as in this case as shown in figure 3 will be available for the traffic. Thus, it may solve the problem of the core city area but has the risk of forming new congested roads. The present traffic scenario for these roads is already a serious issue. But during parking studies, it is observed that these roads are not being fully utilized in terms of their capacity. These roads have parking on both sides, also hawkers and other encroachment are seen which decrease the road capacity. The problem created due to the encroachments should be given due consideration in mitigation of problems created due to spillover of traffic due to implementation of congestion charging. Hence, immediate measures are required to increase the traffic capacity of these roads. Firstly, parking on both sides of roads is to be prohibited as it nearly reduces a lane on each side. Off-street parking facilities such as parking lots/ multi-storeyed parking should be created. This will reduce roadside parking. Secondly, traffic management on these roads needs to be adjusted to anticipate the traffic spillover. Thirdly, hawkers should not be allowed on the footpaths and at intersections. Also, the road conditions should be good to sustain the traffic. These measures will surely help to better the road's capacity. The authority can also use the CC revenue collected for widening the roads and creating other user facilities. For Pune, the traffic up to Swargate and going to various Peths can use Tilak road for their non paid journey. Then those going beyond Swargate can use Lal Bahadur Shastri road. The traffic from the core area going towards Kothrud can use the riverside road for their journey where they won't be charged. For the proper traffic management and flow of the traffic, suitable strategies can be used. There is the tendency of traffic to shift to toll-free alternatives, however, this will offer the opportunity for some of the traffic to shift to decongested, more efficient priced roadway. The congestion charging during the peak hours will also encourage the users to shift to public transport, carpooling and other non-peak travel times. The congestion charging revenue generated can be utilised for freeway widening and accompanied increase in transit capacity of spillover affected parallel roads. Here the suggested alternative routes have the potential to accommodate the spillover that is expected to be created after congestion charging, particularly the suggested recommendations viz. parking free and the encroachment free roads will further improve its capacity.

5. MITIGATION OF RISKS

The residents of the cordoned zone may be given a discount (say 90%) for their vehicles at any particular time and also a monthly pass system may be provided. The regular users can purchase weekly, monthly passes on discounted rates (say 15%). These users may be given coloured tags to identify in the semi-automatic method and in the automatic method the number plates may be

registered on the servers. The payment options for daily users will be such as prepaid facility where the customer will have to buy a monthly pass, another option may be the barcode system, ANPR system, RFID technique etc. These advanced systems can be progressively implemented considering the needs of financial aspects. [22]

5.1. Charge Payment, Product Mix and Enforcement Administration:

The users can avail of prepaid or post-paid weekly, monthly and annual payment options with the advantage of subsidised rates. The scheme should identify all its members and publicize the fleet schemes to help fleets manage the administration related to congestion charging. Early registration should be encouraged. It is believed that this would have a positive impact on uptake. The enforcement process may be burdened by high traffic volumes. To manage the enforcement challenge, the campaign should deter the attempts at evasion. The scheme should have a contingency plan for the high number of representations and appeals. To mitigate the risk of errors of manual checking during high traffic volume, the scheme should have proper quality control measures to validate the manual checking.

5.2. Temporary Traffic Displacement in adjoining Area and Technological Issues

There is a risk of traffic diversion around the charged cordon zone following the implementation. Separate traffic plans for different areas around the CC zone may need to formulate. The traffic plans may be based on possible anticipated traffic scenarios around the cordoned area. For congestion charging projects there may be several technological challenges during actual implementation. During the development of the project, proactive steps can be taken to minimize the risks and will avoid further significant threats. Proper service and operation management can minimize these problems. There should be a sufficient (e.g. 3/6 months) testing period before actual implementation where all the support components of the system will be verified. Collection of congestion charging may be invariable form. The charge collection may be adapted to suit the available implementation infrastructure and initial investment option. The CC system can be gradually shifted to automatic based on the availability of funds. [6]

6. CONCLUSIONS

Based on the results analysis of traffic survey and questionnaire survey following conclusions and associated recommendations are made.

- i The existing traffic-congested during the peak hours in the core area are unmanageable and there is an urgent need to address the problem. The possibility of varying the peak hours can offer a solution for congestion and other related issues. As the majority of the traffic volume is contributed by personal vehicles; implementation of congestion charging will have a direct effective impact on this class. Increasing the efficiency of the public transport system can accommodate more users decreasing congestion due to private vehicles.
- ii Existing partial through route traffic can be suitably diverted to alternative routes reducing congestion in the area. Congestion charging will divert traffic along the alternative route, it will reduce the congestion in the core area. Considering the issue of mini-jams i.e. traffic jams created just before the charging period, the vehicles can be charged at some lesser rate so that the traffic jam possibilities will be averted. Difficulty in traffic management due to high traffic volume for peak hours is the major factor leading to congestion. However, the willingness and the possible psychology of users to shift to the non-peak hour will normalize peak traffic volume improving the overall traffic conditions. The result of the survey indicates that people are willing to shift to non-peak periods. This can be supported by administrative steps for normalising the traffic peaks.
- iii The cordoned area being the shopping/commercial area indicates the need for addressing the parking requirement. On-street parking condition is very poor, which reduces the traffic capacity on these roads. The new multilevel parking facilities can increase effective space increasing traffic handling capacity. The survey indicates the majority of the shoppers use on-street parking and very few utilize the existing multi-storied parking, keeping them unutilized during most of the

weekdays except on holidays and weekends. The parking space consumed by the employees working in shopping areas can also be shifted to off-street parking.

- iv On-road parking can be charged at higher rates to avoid occupancy on these roads. It will provide more space for traffic and pedestrian facilities. It also is recommended to shift the parking to the unutilised riverside (low parking rates) and put on heavy parking charges in the cordoned area to discourage parking. This will give additional space for traffic and pedestrian facilities. The parking can be shifted to off-street parking spaces or crossroads. Parking control is important considering aspects: such as limiting the personal vehicles in the system, potential to facilitate the public transport system, revenue generation through parking charges, and the integration of parking with public transport facilities. In line with Pune's Public Parking Policy 2018 [27], paid parking will reduce personal vehicle trips and people will be encouraged to use pooling, public transport, walking or cycling. This will reduce overall vehicular emissions.
- v Revenue generated through congestion charging can be used to promote schemes, such as better public transport facilities, improvement in the existing infrastructure facilities such as footpaths, pavements, street lights, providing bicycles for hire in the cordon area, etc. The questionnaire survey also indicates this public opinion.
- vi Administrators, Pune Municipal Corporation (PMC) should take strong measures against the present encroachment conditions. The hawkers and vendors should be given suitable places in the city for their businesses. In general, even the conditions of existing footpaths should be maintained so that people are encouraged to use the footpaths. By shifting the hawkers to suitable places in the same area, the footpath will be encroachment free and existing footpath facilities can be improved efficiently for pedestrians. It's a minimal possibility of negative impact on business in the pricing area, due to decreased commercial activities. On contrary, congestion-free areas, better pedestrian, and public transport facilities will encourage the shopper and other commercial activities in areas. The case studies are indicating the rise in business in the cordon area [2]. The pedestrianization of important portions of the core city area and linking them with strategic parking places will encourage people to walk in such areas. The core area with high commercial uses and narrow streets is well suited for pedestrianization. The studies show that regardless of, the initial opposition, pedestrianization often encourages the businesses along with the social benefits. Hence any objection to CC by shop owners can be rejected. Congestion charging and suggested parking recommendations will be helpful in these aspects.

7. RECOMMENDATIONS

- i Congestion charging is an efficient and environmentally beneficial tool for a congested core city area of Pune. The result of the questionnaire survey indicates the Pune city core area is facing the problem of serve traffic congestion. Prima facie the people are in favour of an efficient transportation system, congestion pricing and associated benefits. However, considering the experiences from past studies, the administrators may have a set of challenges about planning, mitigating the hurdles, implementing and successfully continuing the self-sustain CC program. Along with the CC measures, the implementation of non-pricing measures like carpooling, vehicle quota system, free ride in public transport for nonpeak hours etc. should be promoted. Congestion charging must be seen as a part of a comprehensive transport policy, which includes substantial improvements in public transport and alternative transport modes, environmental enhancements and usages of intelligent transport systems. Public awareness about the benefits of congestion charging and its positive social impacts need to be made clear. However, the congestion charging alone may not be self-sufficient in solving the traffic problems in the core city area, it should go hand in hand with the development of other allied facilities too.
- ii For the analysis of parameters affecting the successful implementation of the scheme, various supporting in-depth studies need to be conducted. Some of the suggested studies include the study

of effects of proposed CC on users, volume-speed study to maintain desired traffic flow rate for optimum efficiency, calculation of optimum charging to maintain desired traffic flow. Also, detailed economic studies for the optimal tariff and revenue generated and its use for creating recreational facilities need to be carried out along with the associated financial risk and its mitigation. An unbiased, scientific and elaborate survey with a sufficient number of samples needs to be conducted with greater sample size.

Congestion charging can be coupled with an intelligent traffic management system (ITMS) for better management [16]. ITMS data will help to analyse congestion patterns, mapping peak time traffic directions. The dynamic traffic data with the central control system can be used for efficient traffic management. and also, for providing dynamic, real-time congestion pricing. A cashless system such as the FASTag can be used to collect congestion charges reducing human interference and minimizing delays. ITMS can be linked to the users via a mobile application used for commute decisions such as journey time, route selection, optimizing charges and travel time Successful case studies around the world show the potential application of congestion charging practice. However, the characteristics of vehicular traffic, users' approach may be variable. All these issues need to analyse in detail for effective implementation of the scheme [28, 29]. Few case studies in India have witnessed variable outcomes. There is a marginal benefit of congestion charging in shifting the traffic to non-peak hours. However, the improvement in travel time during the peak hours is found out to be unresponsive to traffic volume, in contradiction to findings for developed countries [30]. The congestion pricing can marginally improve travel times, but the benefits may be less considering the cost of shifting the users to different non-peak hours. Though for this congestion study the attempt had been made to include all the relevant parameters, however the sample size of the questionnaire (opinion) survey and traffic volume data over the small duration of three days may have some inherent shortcomings. It is suggested to carry out a detailed survey on appropriate sample size to know the public opinion and to collect the data for planning the detailed program.

ACKNOWLEDGEMENT

The authors are thankful to the Parisar organization, for guidance for the traffic congestion study. The results of the study are still relevant and appreciate the problems faced by the congested core Pune city. It's our humble efforts to initiate and put the findings in the public domain for further study.

REFERENCES

- [1] Sun Ye 2012 Research on urban road traffic congestion charging based on sustainable development, Physics Procedia volume 24 part B pp 1567-1572
- [2] Litman Todd 2011 London congestion pricing, Victory Transport Policy Institute
- [3] Boston Consulting Group 2013 BCG-Uber report on car-sharing and traffic congestion, Press releases
- [4] Times of India 2013 Congestion charge for improved mobility faces feasibility question TNN
- [5] The NZ Transport Agency 2010 Integrated planning toolkit, road pricing (congestion charging)
- [6] Gomez, Ibanez and Small 1994 Road pricing for congestion management: a survey of international practice." working paper no. NCHRP synthesis 210 of highway practice, NRC, Washington D.C.
- [7] Jeromonachou P, Potter, and Enoch 2004 Adapting strategic Niche management for evaluating radical transport policies - the case of the Durham road access charging scheme International Journal of Transport Management 2(2):75-87 DOI:10.1016/j.ijtm.2004.09.002.
- [8] Booz Allen Hamilton, Wellington 2006 Investigation of implementation issues for congestion charging, Land Transport New Zealand Research Report 286, ISBN 0-478-25397-4 ISSN 1177-0600
- [9] Herve Commeignes 1991 Road traffic congestion: an issue for the 90s. report for the Roads and Traffic Authority of New South Wales Pricing Strategy Sydney

- [10] Transport for London 2003 Central London congestion charging scheme: three months on. Transport for London Congestion Charging Division
- [11] Deloitte Consultants 2003 Survey of European cities local authorities on congestion charging: analysis
- [12] Jonathan Maus 2018 The ODOT files: portland mercury checks in on freeway tolling efforts
- [13] Hensher D A and Li Z, Referendum voting in road pricing reform: a review of the evidence,” Transport Policy vol 25 pp 186-197
- [14] Wikipedia 2021 <https://en.wikipedia.org/wiki/Pune>
- [15] Pune Municipal Corporation 2008 Comprehensive mobility plan for Pune city-, Wilbur Smith associates and urban infrastructure Services Limited
- [16] Ponkshe A accessed 2021 Congestion pricing economics, urban futures <https://www.orfonline.org/expertspeak/congestion-pricing-economics-55360> ORF Observer Research Foundation
- [17] Indian Roads Congress, IRC -106-1990 guidelines for capacity of urban roads in plain areas
- [18] Indian Roads Congress, IRC: SP:30-2009. Manual on economics. evaluation of highway projects in India.
- [19] Allen S, Gaunt M 2006 An investigation into the reasons for the rejection of congestion charging by the citizens of Edinburgh EuroTransport vol. 32 pp 95-113
- [20] Hugosson M B and Jonas E 2006 Stockholm congestion charging system an overview of the effects after six months Association for Euro Transport
- [21] Jones P 2003 Acceptability of road user charging: meeting the challenge, Emerald Group Publishing, UK
- [22] Ieromonachou P, Potter S and Enoch M 2004 Adapting strategic niche management for evaluating radical transport policies - the case of the Durham road access charging scheme International Journal of Transport Management vol. 2 pp 75-87
- [23] Goh M 2002 Congestion management & electric road pricing in Singapore. Transport Geography
- [24] Zheng Z, Liu Z, Liu C, and Shiwakoti N 2014 Understanding public response to a congestion charge: a random-effects ordered logit approach Transportation Research Part A: Policy and Practice vol.70 pp 117–34
- [25] Goh Shou Xian 2012 Electronic road pricing in Singapore: policy, technology and impact, Land Transport Authority Singapore
- [26] Steve Kearns 2014 The move towards sustainable transport, Transport for London
- [27] Pune Municipal Corporation 2018 Public parking policy
- [28] Swamy Shivanand H et al 2016 Congestion pricing: a case of Delhi. 9th Urban Mobility India Conference & Expo
- [29] Mumbai Metropolitan Region Development Authority (MMRDA and the Institute for Transportation and Development Policy (ITDP) India Programme 2019 Congestion Pricing: A panacea to Mumbai’s transport woes”, <https://www.itdp.in/congestion-pricing-panacea-to-mumbais-transport-woes>
- [30] Kreindler Gabriel, Duflo Esther, and Olken Ben 2018 Benefits and costs of road traffic congestion pricing evidence from Bangalore policy brief, International Growth Centre (IGC) study.