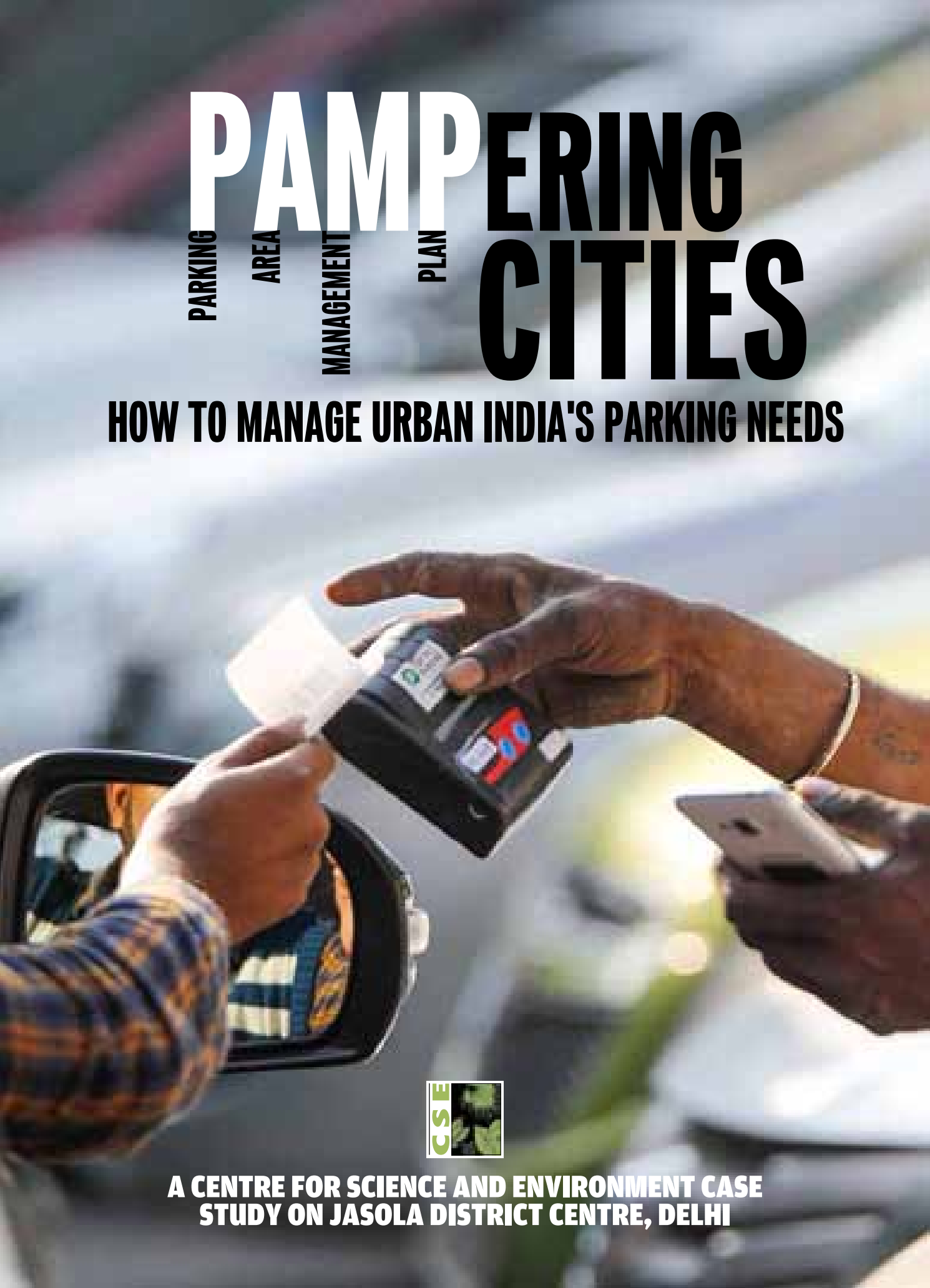
PAMPERING CITIES

PARKING AREA MANAGEMENT PLAN

HOW TO MANAGE URBAN INDIA'S PARKING NEEDS



A CENTRE FOR SCIENCE AND ENVIRONMENT CASE STUDY ON JASOLA DISTRICT CENTRE, DELHI

PAMPERING PARKING

How to manage urban India's parking needs

A Centre for Science and Environment
case study of Jasola district centre, Delhi

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PART 1
A. Why this study?

Several city governments are framing parking policy and rules to reduce parking pressure and congestion on roads and public spaces to make cities more livable. Among them Delhi, Chandigarh, Pune, Hyderabad and Bengaluru have taken the lead. Their challenge is to design parking rules that balance the need to provide parking with efforts to reduce the overall demand for parking.

Conventional parking policy aims to increase parking supply infinitely by earmarking public land for parking, constructing multi-level parking structures, and mandating all buildings to have a minimum number of parking slots. The underlying assumption is that the demand for parking will continue to grow with motorization, therefore, adequate parking spaces will have to be set aside to meet this growing demand.

But this parking policy has failed to reduce parking pressure and the attendant problems of motorization, congestion and pollution. Decades of experience in India and across the world bear testimony to the fact that the demand for parking is insatiable. This results in land needed for other crucial uses being diverted to meet parking needs. Moreover, uncontrolled parking supply encourages more car ownership and driving. This increases toxic exposure to pollution and the energy intensity of transportation infrastructure, worsens congestion, locks in enormous emissions of heat-trapping carbon dioxide, and makes the climate of cities insecure and more polluted.

Globally, the governing principles of parking policy have changed. Instead of promoting unlimited supply of free parking, parking demand and personal vehicle usage is now sought to be restrained.

Since India faces similar challenges, it is only natural that the official response would also resonate with action taken across the globe. The National Urban Transport Policy (NUTP) of 2014 has already taken onboard the principle of demand management.[1] This entails earmarking and limiting legal parking spaces and pricing suitably to restrain dependency on cars. NUTP has recommended a graded scale of parking fees to recover the economic costs of land used for parking.

The Supreme Court has also given a nod to these demand management principles for Delhi. The Court-appointed Environment Pollution (Prevention and Control) Authority (EPCA), in its submission in 2006, stated that provisions of parking for personal vehicles cannot be considered a matter of public good. Land is a limited resource, so there is a limit to the additional parking spaces that can be created in a city. An intelligent pricing policy to control the demand for parking is required. Users of personal vehicles should pay for the space they use for parking. The 'user pays' principle should govern the pricing of parking. Government should not subsidize this cost.

Why do cities need parking area management plans?

Unsustainable pressure on land for a wasteful use

As per some rough estimates, a car runs only for 400 hours on an average in a year, and is parked the rest of the time (8,360 hours or 95 per cent). This is reflected in the enormous demand for urban land for parking. It has been estimated that the annual demand for additional parking spaces (for cars) can be equivalent to as much as 471 football fields in Delhi, 100 in Chennai, 58 in Chandigarh, and 179 in Gurgaon. This is a wasteful use of land. Surveys in key commercial areas in Indian cities indicate that personal vehicles occupy more than 85 per cent of the parking spaces but meet only a small percentage of the travel demand—typically as low as 4–15 per cent. In contrast, for example, buses take up barely 4–5 per cent of the total 'equivalent car space' (ECS) of parking spaces, but carry 20 times more people than cars.

Parking encroachment on public spaces and walkways compromise use of sustainable modes

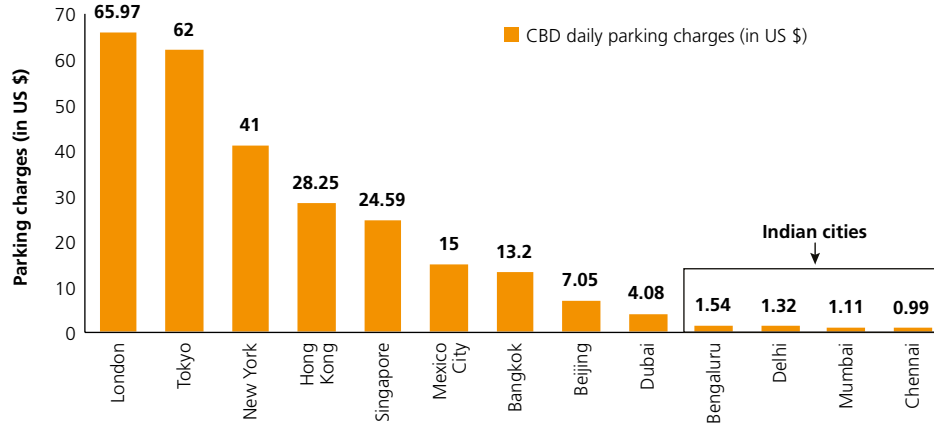
Parking pressure is maximum on the roads, walkways and available surface areas in busy areas. A 2008 study by Wilbur Smith Associates for the Union Ministry of Urban Development shows that a very high share of road networks in most cities is under parking pressure.

This is more serious in smaller cities with a closely knit and compact urban fabric. In Delhi, which has the maximum percentage of its land under roads in the country, about 14 per cent of the road-length is used for parking. In Jaipur, this share is 56 per cent, while in Kanpur it is 45 per cent. Many other cities, including Nagpur, Surat, Patna, Kochi, Pune, Agra, Madurai, Bhopal, Varanasi, Amritsar, Shimla, Thiruvananthapuram, Guwahati, Puducherry and Ahmedabad have more than 40 per cent of their road networks under on-street parking. Parking takes away safe walking space from people and redoubles unsafe conditions on the carriageway. It not only converts short-distance zero-emission walking trips to motorized trips, but also undermines the utility of bus and metro systems, as safe access to these modes get compromised.

Cheap and free parking is a subsidy to rich car owners and loss to the exchequer and the environment

In all Indian cities, on-street parking is mostly free or is minimally priced. According to the 2016 Handbook of Urban Statistics of Ministry of Urban Development, Indian parking fees are lowest in the world (see Graph: *Daily parking charges in cities across the globe*). It is ironic that car users pay next to nothing for using valuable public spaces to park their personal vehicles, nor are these costs recovered through proper taxes. Even in expensive parking structures, parking rates are minimal and not adequate to recover the cost of investment. This subsidy amount will work out to be much larger if the rental or land cost is

Graph: Daily parking charges in cities across the globe



Source: Handbook of Urban Statistics, 2016, Ministry of Urban Development, Government of India

taken into account. Increased investment in expensive and prime areas for parking further enhances this subsidy as parking rates are not expected to recover this cost.

This also implies that urban local bodies have failed to garner enough revenue from parking to invest in local area improvements. Parking demand is market-driven and its price should also be determined by the market.

Parking pressures degrade quality of life in residential neighbourhoods

As parking pressure builds up in residential neighbourhoods with scarce land area, neighbourhood brawls, road rage, and even heinous killings become commonplace. This is the most ugly and scary social ramification of the parking crisis. This trend is likely to worsen as ownership of multiple cars takes off on a mass scale. Residential neighbourhoods will never have enough land to provide for adequate parking for them. Consequently, parking pressure will force encroachment of green areas and playgrounds, and block access to houses, bus stops, market places etc. Parking on roads or footpaths also blocks access of emergency vehicles like ambulances, fire trucks and police to homes, offices and buildings. It also affects severely safe walking and cycling by elderly people, children and disabled people within the residential neighbourhoods.

Parking skews equitable use of land

Scarce urban land is getting diverted from other important uses like social amenities and services and compromising equitable use of urban land. A car needs about 23–26 square metres of land for comfortable parking and as circulation space. In comparison, under the housing schemes for the economically weaker households, the government allots only 25–40 square metres of land per dwelling unit.[1] Thus, parking takes away land from housing for the poor and community infrastructure such as schools, healthcare centres, old age homes and so on. Increasingly, higher share of public land is being diverted to meet the parking need of car owners, who are a minority. This has also led to the neglect of parking requirements by public transport buses, para-transit and bicycles in public spaces. In fact, in Delhi, augmentation of the bus fleet has slowed down as the city is finding it difficult to find space to park new buses.

Traffic and parking impact of new development in cities not accounted for Indiscriminate commercial development is taking place in Indian cities without proper planning norms for impact of the traffic and consequences of the parking demand. With no mitigation measures in place and given the rapid pace of development in cities, urban India will crumble under the pressure of congestion and parking if these issues are not addressed promptly and judiciously.

Unorganized and free parking lead to law and order problems

It is scary how serious injuries and homicides are being reported from different neighbourhoods of Delhi due to parking brawls. Such crimes, including forced capture of parking spaces by neighbours, or people from other neighbourhoods, creates an atmosphere of fear and a serious law and order problem.

Lack of awareness about impact of parking and hostility towards parking restraints

As the state of public transport, walking and cycling remains poor, dependency on private vehicles is growing. This creates support for populist car-centric policies and infrastructure and fans opposition to car-restraint policies. Governments find it increasingly difficult to reform parking prices and enforce parking measures in the face of hostility from car owners. Local governments need to take the lead in informing people about the benefits of organized parking and restraining policies, thereby helping build support for such programmes. Globally, it has been demonstrated that such measures open up a large number of alternatives for people in the form of car sharing, reducing unnecessary car trips, more efficient travel planning, and use of public transport and para-transit. This allows emergency-service vehicles to move freely. It prevents crowding and spillover of parked cars from surrounding neighbourhoods. It has also been proven that parking restraints, along with pedestrianization, in targeted commercial areas lead to more pedestrian volumes and increase in business volumes.

Indian cities are now expected to frame a parking policy that will allow this paradigm shift. There is, however, very little policy or public understanding of key elements and principles of parking policy and how better organization of parking and its management is possible while reducing parking demand. There is even less clarity about parking management strategies and operations on ground.

There is no single silver bullet or step that can define the method and approach towards parking management. These are complex set of interventions that need to be detailed out for an effective programme. This requires a guidance framework on interlinking all elements of parking management and operations.

An opportunity to implement such a management approach has arrived with Delhi taking the lead in developing parking rules and guidelines under the Central Motor Vehicle Act and Rules. Delhi has already revised the Delhi Master Plan 2021 (MPD–2021) in 2012 and, for the first time, has provided for a 'parking management districts' (PMDs) approach that requires 'parking area management plans' (PAMPs) for area-wide parking strategies as opposed to spot-fixing in a few congested areas.[2] This is the only way to address the parking chaos associated with unorganized and free parking (see *Box: Why do cities need parking area management plans?*)

B. What is a PAMP?

A parking area management plan (PAMP) is a comprehensive set of measures that are pre-defined for a designated area in an integrated way. A PAMP can be successful and effective only if it is applied uniformly across an area of contiguous neighbourhoods with a clear and well-defined boundary. These plans are prepared by urban local bodies in consultation with local residents and stakeholders (see Box: *What are the elements of a parking area management plan?*).

While preparing a PAMP, ground-level surveys are organized to identify and earmark areas where legal on-street and off-street parking can be provided; meet the requirement of all modes of transport; and take into account all essential uses of and activities on the street, including bus stops, walking and cycling, vending, hawking, and intersections etc. in the neighbourhoods. Spaces are demarcated for non-motorized transport and halting spaces for intermediate public transport, vending zones, bus stops and public amenities. These are planned in an integrated way and not in isolation. Isolated steps can be counter-productive.

PAMPs promote shared and priced public parking to maximize access and availability in cities which have land constraints. They cap the supply of legal parking and penalize illegal parking. An area plan demarcates short- and long-term legal parking spaces depending on how convenient the space is. The most convenient spaces are prioritized for short-term parking, where users pay a higher premium but park for less than three hours. Areas not so readily accessible are used for remote and long-term parking (for more than three hours). The plan helps clear encroachments, promote 'park and walk', or 'park and ride' facilities, identify key corridors for on-street parking, earmark 'no parking' zones, provide parking information, and promote shared parking. Illegal parking is penalized and a graded parking fee is enforced to influence commuting choices and parking durations.

Even though PAMPs are not planned as revenue-generating sources, the pricing strategies for demand management have the potential to achieve municipal improvements in an area with the involvement of local communities.

The role of PAMPs becomes even more important with further expansion of mass transit networks. This will have a profound impact on the organizing principles of parking within the influence zones of the metro rail system (hereafter just metro). It is estimated that when all lines of the Delhi metro become fully operational, nearly 80 per cent of Delhi will be within the influence zone (approximately 400 metres from the nearest metro station). To facilitate and improve access to and use of public transport systems, Delhi's Transit-Oriented Development (TOD) policy has asked for limiting area-wise cap for private motor vehicle parking in these zones. Public parking supply, in terms of equivalent car space (ECS)—a measure for defining a parking slot requirement for motorized modes—will be restricted in these influence zones. Parking for intermediate public and non-motorized transport modes will be prioritized at-grade and on-street. Long-term on-street parking for private modes will not be permissible in standard and intense TOD zones. Rather, these zones

What are the elements of a parking area management plan?

There is no precise definition of a parking area management plan (PAMP). The concept has evolved encompassing a wide variety of integrated management approaches. More comprehensive the plans, more effective their results. While Delhi Master Plan 2021 has provided for such plans, the detailed rules and guidelines are still taking shape under the aegis of the parking committee set up by the Lt Governor of Delhi under the transport department.

Some key elements and steps towards preparation of a PAMP are as follows.

- **A PAMP is prepared by a local body in consultation with local stakeholders,** planning bodies and departments, and supported by professionals, including transport planners and urban designers.
- **Delineation of a PAMP's boundary:** For the purpose of preparation and implementation of a PAMP, either natural boundaries like large drains, district or zonal forests, or arterial roads are taken into consideration to define distinct PAMP zones. Several contiguous neighbourhoods are part of a single PAMP.
- **Ground-level surveys:** Ground-level surveys in the delineated area are needed to assess parking demand, nature of parking accumulation, traffic and circulation patterns in the area, road alignment, and walkability of pavements. These surveys evaluate the ground situation in terms of public transport connectivity; traffic pressure and management systems; parking demand on road and surface; placement of hawkers, parks, green areas, public amenities, and street furniture; and land use patterns in terms of commercial, residential and mixed land use.
- **Demarcation of legal parking areas based on ground-level survey in residential and commercial areas:** After taking note of vehicular and pedestrian circulation in all land uses; public amenities and utilities; green and open areas; and hawkers; legal parking areas are earmarked and demarcated.
- **Demarcation of 'short' and 'long' term parking spaces:** Parking spaces for short- and long-term parking users are identified and priced appropriately to reduce demand. Both categories need to be managed by a single agency. On-road parking needs to be prioritized for short-term parking with higher parking rates than long-term parking facilities in surface areas.
- **No parking allowed in green areas and parks**. Delhi Master Plan 2021 has been amended to mandate that green areas and parks cannot be used for parking. Additionally, green areas should constitute at least 10–20 per cent of an area overall.
- **Identification of underutilized areas, parking lots or community centres that can be used for parking**. Ground survey opens up opportunities to identify underutilized areas in neighbourhoods which can be made available on a shared basis to augment local supply of parking.
- **Demarcation of one lane for movement of emergency vehicles in all residential areas should be mandatory.** In all residential areas, a dedicated lane for emergency vehicles that will have to be kept free of all encroachments including parking is needed.
- **Multi-level parking is decided on the basis of a PAMP and not as a standalone project.** Multi-level parking is provided only after a ground survey identifies its need. Where a multi-level parking facility is provided, proper entry and exit is planned, with adequate circulation areas, so as to not choke circulation in the area. To leverage such structures and reduce on-street pressure, on-road parking within at least 200 square metre radius of the structure is curtailed. If on-street parking is allowed around it, it is made costly.
- **Promoting sharing of parking facilities and building typologies with shared public parking facilities**. Instead of standalone multi-level parking, building typologies in commercial areas and large residential blocks in which sizeable share of parking facilities can be shared are promoted. Parking in new developments are usually detached structures with separate inlets and outlets that do not interfere with the movement and normal life of the occupants of the building. A single parking facility is intended for use by multiple types of users with different peak demands. An office building shares its parking with restaurants or theatres as their peak

demand hour does not coincide.

- **Parking spaces sold separately and not bundled with property or apartments**. This makes people aware of the true cost of parking, and pay separately for parking. This also helps them to take decision accordingly.
- **Cap parking supply:** Demarcation of legal parking areas, penalty on illegal parking, and priced parking help limit parking supply. This encourages use of public transport, walking, cycling etc. and creates more aesthetic streets by providing public amenities and vending zones.
- **Elimination of free parking and introduction of effective parking charges.** Parking charges are aimed to be optimal and not so high as to reduce occupancy drastically or too low to induce more demand.
- **Methods for fixing parking base price and making it variable according to peak and non-peak demand** to influence demand are adopted.
- **Penalty for illegal parking is aimed to be stringent enough to be a deterrent.** Enforcement is achieved through surprise checks. Junk vehicles are identified and impounded so that they do not occupy road spaces and they are disposed of properly.
- **Annual or monthly lump-sum or one-time payment for parking is not allowed.** One-time charges and annual passes allow unlimited use and do not reduce demand. Commuter behaviour remains unresponsive to pricing in such cases.
- **Parking rates (even if differential) are applied to the entire PAMP area and not to a few streets,** to avoid massive spillover to non-priced or low-priced areas.
- **Introduction of residential parking permits for equitable access to legal parking areas in the neighbourhood.** The rate of the permit is decided together by the residents and urban local bodies based on the method adopted. In residential areas, if night-time parking demand is high, and if both private and public parking are limited, prices are adjusted accordingly.
- **Addressing parking needs of public transport buses and commercial vehicles.** Public transport buses require adequate depot space, and areas or roads are identified for night-time parking of commercial vehicles.
- **Reforming parking contract agreements.** Agreement with the parking contractors are modified to include the requirements of a PAMP. Parking contractors are made accountable for revenue sharing and enforcement of parking rates as decided by urban local bodies, and are liable for violation of parking rules. They invest in signages, metering, improving infrastructure with automated boom barriers, radio-frequency identification (RFID) tags for motor vehicles, electronic guidance systems for motorists, and vacancy display boards. Online reservation of parking is provided at central business districts or high priority areas. Charging facilities for electric vehicles are also provided. The contractors also improve access, provide feedback for further refinement of the system, and prevent violation of parking rules and pricing.
- **'Park and walk'.** In congested areas or old city areas, 'park and walk' or 'park and ride' facilities are planned. Street improvements are implemented in about 10-minute walking catchment of such facilities to make it comfortable and convenient for commuters or shoppers. Improving walkability increases 'park-once' trips, which means parking at one location and walking to other destinations.
- **Remote parking and shuttle services.** It often involves the sharing of parking between different use premises. Parking facilities can be located at a distance from the main commercial centre. This is incentivized by providing a special transit service from the parking to the commercial centre.
- **Addressing spillover problems:** Spillover parking occurs when, due to suboptimal utilization of an off-street or priced parking facility, users park in a cheaper, free or illegal parking zone in the vicinity. To address this, information about appropriate parking spots is made available, providing time limits and other information.

will have shared public parking facilities. This will help reclaim street space, especially footpaths and bicycle tracks, from vehicle parking.

While implementing a PAMP, resistance from residents builds up as the range of benefits is not clear to them. Often the attempts to reorganize parking spaces, pricing strategies, and steps against illegal parking are seen as curtailment of parking rights and an inconvenience. Therefore, urban local bodies need to reach out to residents and other end-users to explain the benefits of PAMPs. For instance, paid parking facilities and permits assure availability of parking spaces in neighbourhoods and safety of vehicles. Fees levied for parking can be used for improvement of pedestrian facilities and other local area improvements, including improving universal accessibility, street lighting, maintenance etc. Commuters can get advance information about availability of parking slots. With residential parking permits and fees in place, there are less chances of encroachment by neighbouring localities. Fees will also allow equitable sharing of local parking spaces. People may decide not to buy multiple cars to save on permit fees.

Overall, there will be improvement in the quality of life in neighbourhoods as PAMPs will help reduce traffic congestion and chaos. The long-term objective of residential parking permits is to gradually reduce the demand for permits to match the limited supply (of overnight on-street and sometimes public off-street parking as well).

Parking pricing can prompt people to consider several options. They may lease off-street parking nearby or shift to an area with cheaper parking. Players in the real-estate sector may even consider investing in the creation of off-street parking. Private parking that is empty at night may become available for rented parking.

C. Zeroing in on implementation

In view of the fact that the concept of PAMP is a new approach to parking management, it is important to demonstrate how it should be implemented. Centre for Science and Environment (CSE) has, therefore, carried out a study (the first in a series) to demonstrate ways and methods of implementing a PAMP by applying the concept in a defined area. The objective of the study is to understand the ground realities in the targeted area and offer a set of guidelines to the implementing agencies—urban local bodies and land-owning agencies—for the adoption of area management plans.

To this end, CSE has selected a prominent commercial area in South Delhi—Jasola district centre, which is a major planned commercial centre with a growing parking demand. Although it has good public transport connectivity in terms of metro, buses and para-transit, it is already facing chaotic parking pressure. It is a relatively newly developed area but is emerging as an important commercial hub of South Delhi. Jasola station, on the violet line of Delhi metro, is located less than 100 meters from the Centre and the Jasola Vihar/Shaheen Bagh station on the magenta line is also within walking distance. Six routes of Delhi Transport Corporation (DTC) and five routes of the cluster bus scheme connect the Centre with the rest of Delhi. National Highway 2 (NH-2), to the west of the district centre, connects Delhi to its satellite town of Faridabad. To its south, road no. 13-A connects it with Noida in Uttar Pradesh.

The Jasola project was introduced in the Delhi Master Plan of 2001 by the Delhi Development Authority (DDA). At that point of time, DDA was developing new sub-cities and creating the physical infrastructure for roads, sewerage, drainage, water supply, power lines and recreational facilities etc. for such urban extensions. In the 2021 Master Plan, Jasola is defined as the commercial centre adjoining metropolitan passenger terminal, Okhla, developed as a non-hierarchical commercial centre. Jasola is located in South Delhi, near Sarita Vihar and comes under Zone-F of the National Capital. It is under the jurisdiction of South Delhi Municipal Corporation (SDMC).

CSE has taken a step-by-step approach to assess the ground reality and propose a plan. It has carried out local area surveys to inventorize the areas that are being used for parking—on-street, off-street and structured; assess parking demand, current management practices, and pricing; ascertain the willingness-to-pay of users to assess responses of parking demand to change in parking charges; perform an assessment of public transport connectivity; and find out the nature of peak demand by mode, among others.

While this assessment has helped in arriving at several strategies that can be deployed in an integrated manner for better parking management, it has also helped bust several commonly held myths and beliefs related to the parking crisis. This understanding is critical to garner support for robust parking management strategies. In this section, were are presenting some key highlights and findings of this assessment.

Parking supply exceeds demand, yet there is chaos

Although, it might seem commonsensical to officials of urban local bodies as

well as the average person on the street that parking chaos and pressure is a result of unavailability of parking spaces, this study found that it may not necessarily be true. The actual parking supply in Jasola district centre exceeds peak parking demand. Parking supply within buildings is 2,100 slots or equivalent car space (ECS). In addition, there are 648 parking ECS (450 ECS off-street and 198 ECS on-street) spaces outside. Together, about 2,748 legally ECS are available in the area. Peak parking demand in the area is 1,620 ECS, which is close to 59 per cent of the actual supply. Available parking slots have been created in accordance with parking standards for buildings as per MPD 2021, which is three ECS for every 100 sq m of floor area in commercial and institutional buildings.

Even though actual availability is higher than the peak demand, there is enormous spillover due to poor management and enforcement. Parking inside the buildings is not properly utilized, so there is massive spillover on surface in the form of off-street and on-street parking, where regulations are poorly enforced.

Poor management and lack of demarcation of parking spaces

Building owners in the area are renting out parking space separately to different offices. While the unbundling of parking spaces from office property is good in principle, in practice it is being misused by the offices which pay only for parking spaces to be used by company heads and directors, forcing the rest of their employees to find their own parking. These employees then crowd the space outside, leaving the parking space within the building underutilized.

The actual demand because of this spillover from buildings is as high as 843 ECS, whereas the maximum legal on-street parking supply is 198 ECS (and off-street is 450 ECS). Thus, most of the demand is crowding outside, in on-street and off-street facilities that can accommodate 648 ECS or about 76 per cent of the current demand. Parking operators are allowing more than the maximum parking that properly demarcated off-street locations can accommodate. There is no marking of parking bays and lack of on-ground demarcation allows the operator to extend and encroach. This implies proper management and utilization of the available parking spaces can minimize the need for creation of additional parking spaces.

Shared and paid public parking in buildings

To maximize use of available parking areas to reduce load and spillover, a new strategy is needed. The vacant capacity within buildings needs to be utilized by opening it for public and priced parking to meet the current demand. Jasola district centre's layout plan, prepared by DDA, has already provided for a multi-level parking with an area of 9,000 sq m that can accommodate an additional 400 ECS. But this may not be required if the current capacity is fully utilized and the draft parking rules of the Delhi government for parking demand management come into effect. It might be more advisable to create office or retail building with shared parking facilities.

Moreover, the approach to building multi-level parking has to change. DDA will be well-advised not to plan standalone multi-level parking structures with some commercial and office component and transfer land based on that. Instead, they should plan and build office buildings that meet the requirements of office spaces and provide for accessible public parking. Office and commercial buildings can be constructed with shared public spaces and architectural design solutions can be adopted to plan separate entry and exit into the building parking lots for

office goers and the general public.

Cars dominate three-fourths of the parking areas

The ground-level survey shows that parking areas are almost entirely dominated by personal vehicles—99 per cent. As much as 75 per cent of the parked fleet is cars—sedan, SUVs and hatchback. Two-wheelers constitute 24 per cent of the fleet. This indicates that a good management and pricing policy and intensification of public transport accessibility can help reduce parking demand quite significantly in the area. Jasola is already well-connected by metro rail and bus services. These are further supported by para-transit—both autos and aggregator taxi services.

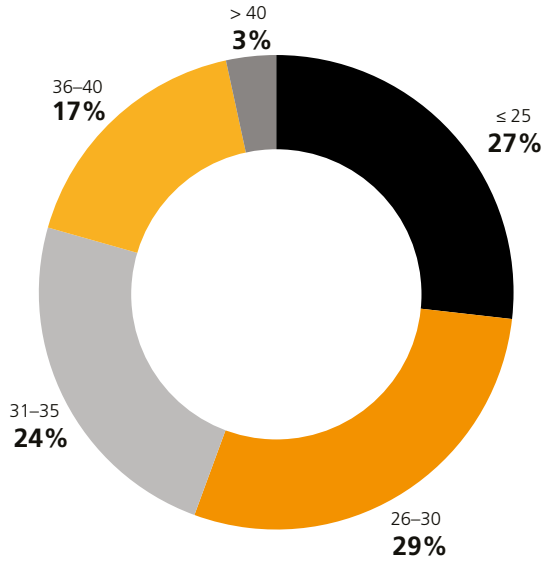
Most parkers are employees and business owners

About 58 per cent of parkers in the area are employees and business owners. They come to work and are long-term parkers and need to be accommodated in the off-site parking spaces and inside buildings. These users can also be encouraged to shift to other alternatives. Among all parkers, the share of shoppers is 24 per cent. About 16 per cent users visit the Jasola district centre for recreational purposes. They are short-term parkers and need to be managed with variable parking pricing in on-street facilities. About 71 per cent of the parking users are male and 29 per cent female. More than half of the parking users—58 per cent—who are office goers, come to Jasola district centre every day and are daily users of the parking area. Among the rest, 15 per cent visit the area once in a week, 14 per cent twice a week, and only 13 per cent users visit less than once a week.

Almost all parkers are 40 years old or less

The age profile of the parkers shows that almost all parking users in the study area are 40 years old or less. Only 3 per cent of users are more than 40 years of age. The share of users of age less than or equal to 25 years was 27 per cent and that between 26–30 years was 29 per cent (see *Graph 1: Age-wise share of willingness-to-pay parking survey*). This indicates that the majority of parkers are younger, and this is an opportunity to promote active modes of transportation to access the district centre.

Graph 1: Age-wise share of users as per willingness-to-pay survey



Source: CSE analysis

Share of short and long duration parking is closely balanced

The parking survey shows that 52 per cent parkers are long-term users as they use parking spaces for more than three hours every day. Short-term parkers, who use parking lots for less than three hours daily, constitute 48 per cent. The average duration of off-street parking is more than six hours. The average duration of parked vehicles on-street in Jasola district is not more than an hour. Both will require a well-thought-out strategy. It is important to prioritize short-term parkers over long-term parkers on-street through a variable parking pricing strategy for quick turnover and maximize utilization of available parking. Longer-term parkers like office goers can park in off-site spaces.

Parking demand is sensitive to parking charges

A willingness-to-pay survey was carried out in this areas as part of this study to understand how parking demand will be affected at different parking rates. The current hourly charge for parking a car is Rs 20 per hour, both on-street and off-street. The survey revealed that about 34 per cent of parkers are willing to pay upto Rs 25 per hour for on-street parking and will stop using the parking if there is further increase. About 60 per cent will stop using on-street parking if the rate exceeds Rs 30 per hour.

Interestingly, parkers are willing to pay more for off-street parking as they expect it to be safer and more secure. For off-street parking, at least 50 per cent will pay upto Rs 30 per hour (see *Graph 2: Percentage of users priced off at different parking charges in existing parking facilities*). This has an important policy message. Parking charges in off-site and multi-level parking should be kept lower than on-street sites to lessen chaos, congestion and encroachment. The parking policies that are being designed in Delhi and other cities are keeping this principle in consideration. At the same time, keeping in view the public perception about off-street parking being safer, the management of on-street parking lots will also have to be improved to be made equally safe and secure.

People will pay more for better and modern parking

The willingness-to-pay survey found that people are willing to pay more if they are provided with upgraded facilities including on-street parking with parking information systems, meters and digital payment. In the existing on-street parking lots without any technical upgradation, more than 60 per cent users will stop using the on-street parking lots if the rates increase to Rs 30 per hour. If the on-street parking lots are upgraded technically, nearly 49 per cent are willing to pay this rate. Similarly, after the addition of the parking information systems, meters and digital payment to the existing off-street parking facility the share people willing to pay more increased (see *Graph 3: Percentage of users priced off at different parking charges in existing parking with information systems, meters and digital payment*).

Dynamic pricing might result in shift to public transport

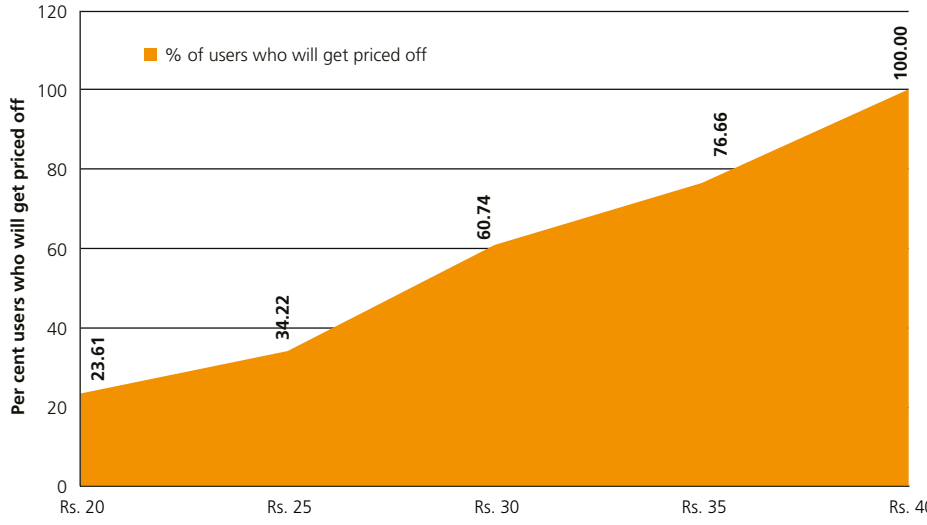
The survey also indicated that proper pricing management might result in sizeable shift to sustainable modes of transport. The area is within walkable distance from the metro system and is connected to it by footpaths. Raising the parking charges to around Rs 30–35 per hour may result in this shift.

Importance of variable parking pricing

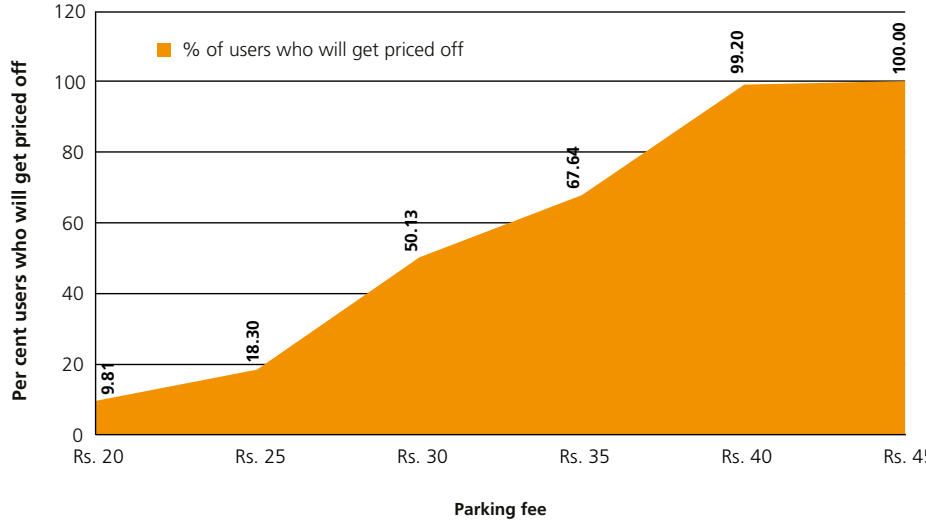
Different cities are adopting different methods for deciding base parking pricing (see *Box 3: How base parking charges are fixed in other Indian cities*). CSE has not proposed any new method for calculating the parking price in Jasola district centre. Instead, it has focused on simply demonstrating the impact of

Graph 2: Percentage of users priced off at different parking charges in existing parking facilities

ON-STREET



OFF-STREET



Source: CSE analysis

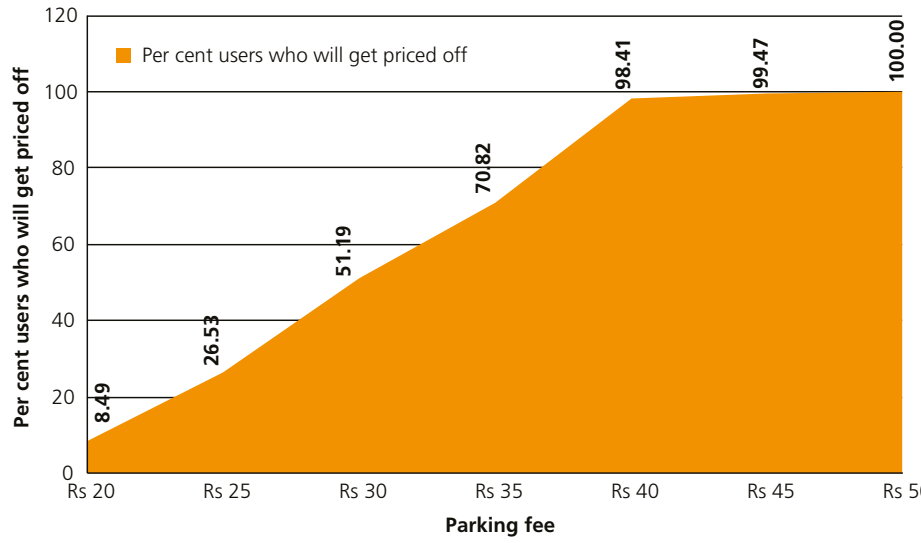
variable pricing on parking demand if the current SDMC parking rates are taken as the base price.

The parking survey gave an estimate of the hourly parking demand. After capping the parking supply in the study area, pricing for parking was done in a way ensuring that demand did not exceed the supply for any given hour from 8 a.m. to 8 p.m. For this, data collected from the willingness-to-pay survey relating to the percentage share of users who will stop using the off-street parking at different rates was used along with the hourly off-street parking demand.

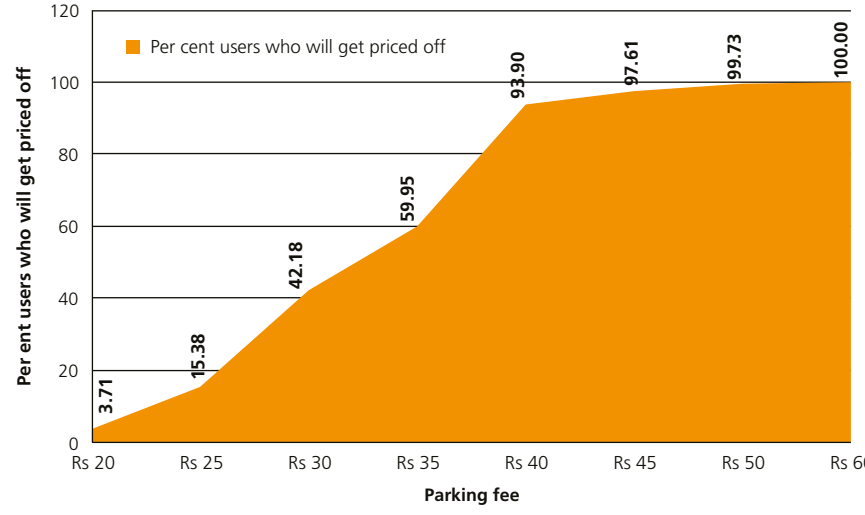
For instance, the demand for parking in the study area between 8 a.m. and 9 a.m. was 138 ECS, which increased to 310 ECS between 9 a.m. to 10 a.m.—the supply was as high as 559 ECS. The supply for these two hours far exceeded the

Graph 3: Percentage of users priced off at different parking charges in existing parking with information systems, meters and digital payment

ON-STREET



OFF-STREET



Source: CSE analysis

demand, so the price of parking needs to be less than the base price of parking (Rs 20, according to CSE's calculations). Similarly, for hours when demand exceeds supply, the price of parking can be increased accordingly.

The way forward

This case study has shown that many opportunities for improving parking management and enforcement with clear strategies are available. Based on this assessment, SDMC of Delhi can adopt the PAMP approach for integrated management.

How base parking charges are fixed in other Indian cities

Chandigarh

The draft parking policy for Chandigarh proposes to consider several aspects for fixing parking charges. The base price of parking for each type vehicle is determined on the basis of space occupied by each vehicle, cost incurred in maintaining the parking space, and circle rates (prevailing collector guideline rates for the residential plot) of land in that particular area. The following formula is used for determining the base tariff of parking per hour for any area:
Base tariff = Tariff as determined for the core area * (circle rate of interest/circle rate of core area)

The actual parking fee per hour is calculated for each area of the city or town as follows:

Actual parking tariff = Base tariff * Public transport factor * Congestion factor
where,
Transit factor =
1.25, if the parking location is within the 600 m service area of a public transport stop
1, if the parking location is outside the 600 m service area of a public transport stop
1.5, if the parking location is within the 600 m service area of a mass rapid transit stop

Congestion factor =
1.5, during peak hours of traffic
1, during non-peak hours of traffic

Parking pricing in parking-benefit districts

Parking to be priced for every half hour slots, increasing exponentially as per the formula (1.5 X + 10), where X is the charge for the previous hour, up to a maximum of three hours.

Pune

The Pune Municipal Corporation, in its parking policy, linked the rates with rise in vehicular registration numbers and ready-reckoner rates (these rates are the prices of residential or commercial property and land for a given area and are published and regulated by the respective state government). The annual parking rates are derived using the formula given below:

Revised parking charge = Base parking charge + (0.6 R1 + 0.4 R2)
Where,
X = Base parking charge
R1= Percentage rise in vehicle registration in a financial year
R2= Percentage maximum rise in ready-reckoner rates applicable in the city for that year

Auctioning for parking pricing

This system has not been adopted in India yet. Globally, auctions for parking permits have a well-established precedent. Uniform-price auctions are often used when selling a large number of identical items. The lowest bid among the selected bids is chosen as the base price. This ensures that the selected bidders have to pay the lowest amount possible. The bid determines whether a car user receives a permit but not what they pay for it.

Generously available parking spaces—off-site and on-site—need to be demarcated on ground. A common management or supervisory system for all available parking lots needs to be adopted. It needs to be ensured that all parking spaces in commercial buildings are fully utilized by the employees and visitors and there is no spillover onto the roads. To prevent spillovers, stringent enforcement and pricing on roads and surface parking areas should be enforced in the entire area. All available parking spaces should be used as shared public parking.

As the supply of parking already exceeds demand, there is no need for the construction of more standalone parking structures in the area. However, new commercial buildings, as and when built, should have the provision of shared public parking. That will be enough to take care of any escalation in demand in future. This area has ample public transport connectivity—metro lines, bus systems, para-transit and aggregator taxis, effective parking pricing, limiting the legal parking area, and strong penalties for parking violations can help to effect a shift to other modes of transportation. However, the PAMP should specify local area improvements in terms of safe access to metro stations and bus stations and walkability in the area.

In future, it is important to explore how the existing parking facilities in the commercial district can be shared for night-time parking for other modes and also neighbouring residential areas.

Parking contracts for the area should be worked out to include pricing and management principles and for adoption of technology for management of parking operations, monitoring, and public information systems. Parking operators have to use methods like mobile apps and parking space display boards to ensure real-time data transmission.

At a city-wide level, taking a PAMP approach to parking management is not a matter of choice but necessity. There is no other way to ensure parking management. Sooner city governments adopt and mandate this approach with enforceable rules, more beneficial it will be.

To enable implementation of a PAMP, parking area management rules and guidelines must be adopted. This will require an oversight authority with representation from all key implementation agencies, land owning agencies, enforcement agencies like traffic police, and professional experts in the city. Powers and authority of the concerned implementing bodies will have to be clearly defined and established. The same authorities will also take a decision on parking pricing and its periodic revision.

Preparation of a PAMP should be done by urban local bodies by ensuring participation of a large body of stakeholders, including local residents and resident welfare associations.

The agreements with parking contractors and tendering of parking contracts must be done based on parking rules, and PAMP design and strategies. Parking contractors will have to be made liable and accountable for carrying out changes and upgradation of parking lots, including ITS for information, monitoring and management. Common management of on-street and off-street parking facilities must be promoted in a PAMP area for more efficient use and management.

A proper revenue-sharing model between urban local bodies and parking contractors must be developed. Part of the revenue should be earmarked for local area improvement.

PAMP plans must get translated into local area maps demarcating all intervention points including legal parking provisioning, no parking areas, green areas that cannot be utilized for parking, underutilized places that can be developed for parking, areas that require alignment modification to improve circulation as well as walkability for better access. These maps will be the basis of implementation of every PAMP.

PART II

Case study
PAMP for Jasola district centre, Delhi

A. About Jasola district centre

The Jasola project was introduced in the Delhi Master Plan of 2001 by the Delhi Development Authority (DDA) when it was continuing its development activities to expand the city limits. At that point of time, DDA was developing new sub-cities and was creating the physical infrastructure for roads, sewerage, drainage, water supply, power lines and recreational facilities etc. for such urban extensions. Other projects that came up during the period were Dwarka Phase-I and II, Narela, Dheerpur, Rohini Phase-IV and V, and Vasant Kunj Phase-II. The 2021 Delhi Master Plan defines Jasola as the commercial centre adjoining metropolitan passenger terminal, Okhla, which was developed as a non-hierarchical commercial centre. Other than Jasola, the Master Plan for Delhi 2021 also proposes to develop non-hierarchical commercial centers at Asaf Ali Road, Laxmi Bai Nagar, and Nehru Nagar near the ring rail.

Location and land use

Jasola is located in South Delhi near Sarita Vihar and comes under Zone F of the National Capital (see *Figure 2: Location of Jasola in 'Zone F')*. It has a gross area of 160.21 ha and was planned for a population of about 40,000. Residential components were given 100.77 ha, commercial centre, 19.44 ha, facility centre, 12 ha, and green area, 28 ha. Residential use was further sub-divided into village, group housing pockets, plotted clusters, parks, facilities and roads[3].

How did the district centre of Jasola come?

The 2001 Master Plan for Delhi proposed the development of two non-hierarchal commercial centres in 'Zone F' of Delhi.[4] One was at Khel Gaon in the vicinity of Siri Fort and the other at Okhla, adjoining the passenger terminal, which is now called Jasola district centre and was earlier known as the media centre. The district centre is spread over an area of 19.43 ha. It is bound by road no. 13-A to the south, the district park to the north, Jasola Sports Complex to the east, and Mathura Road to the west. The district centre is surrounded by various residential areas like Jasola Vihar, Shaheen Bagh, Sarita Vihar and Madanpur Khadar (see *Figure 1: Areas in the vicinity of Jasola district centre*).

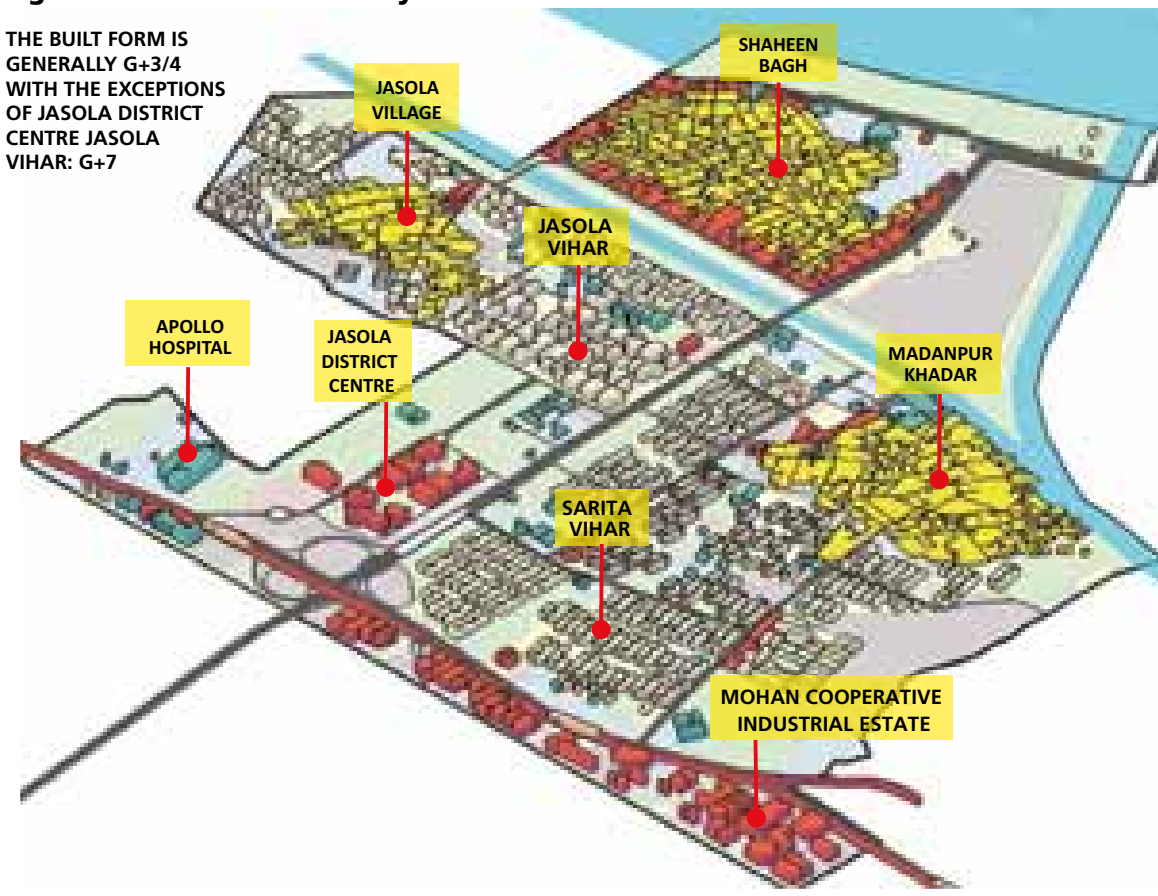
Connectivity

The study area is well-connected through public as well as private modes of transport. Jasola metro station on the violet line of the Delhi metro is located less than 100 meters from the district centre; Jasola Vihar/Shaheen bagh metro station on the magenta line is also within walking distance. There are six routes served by Delhi Transport Corporation (DTC) buses and five routes served by buses under the cluster scheme that connect the district centre with the rest of Delhi. National Highway 2 (NH-2), on the west of the district centre, connects Delhi to its satellite town of Faridabad. To the south, road no. 13-A connects it to Noida in Uttar Pradesh (see *Figure 3: Connectivity of the area and land use distribution*).

Building use pattern

The study area has 10 fully constructed commercial towers. Eight of them are under use, two—Splendor Mall and Salcon tower—are not yet fully occupied. Five towers have commercial components like retail shopping, restaurants,

Figure 1: Areas in the vicinity of Jasola district centre



Source: Adapted from Retrofitting Plan To Promote Non-motorized Transport and Pedestrianization, Jasola–Sarita Vihar, Town and Country Planning Organization, Ministry of Urban Development, Government of India

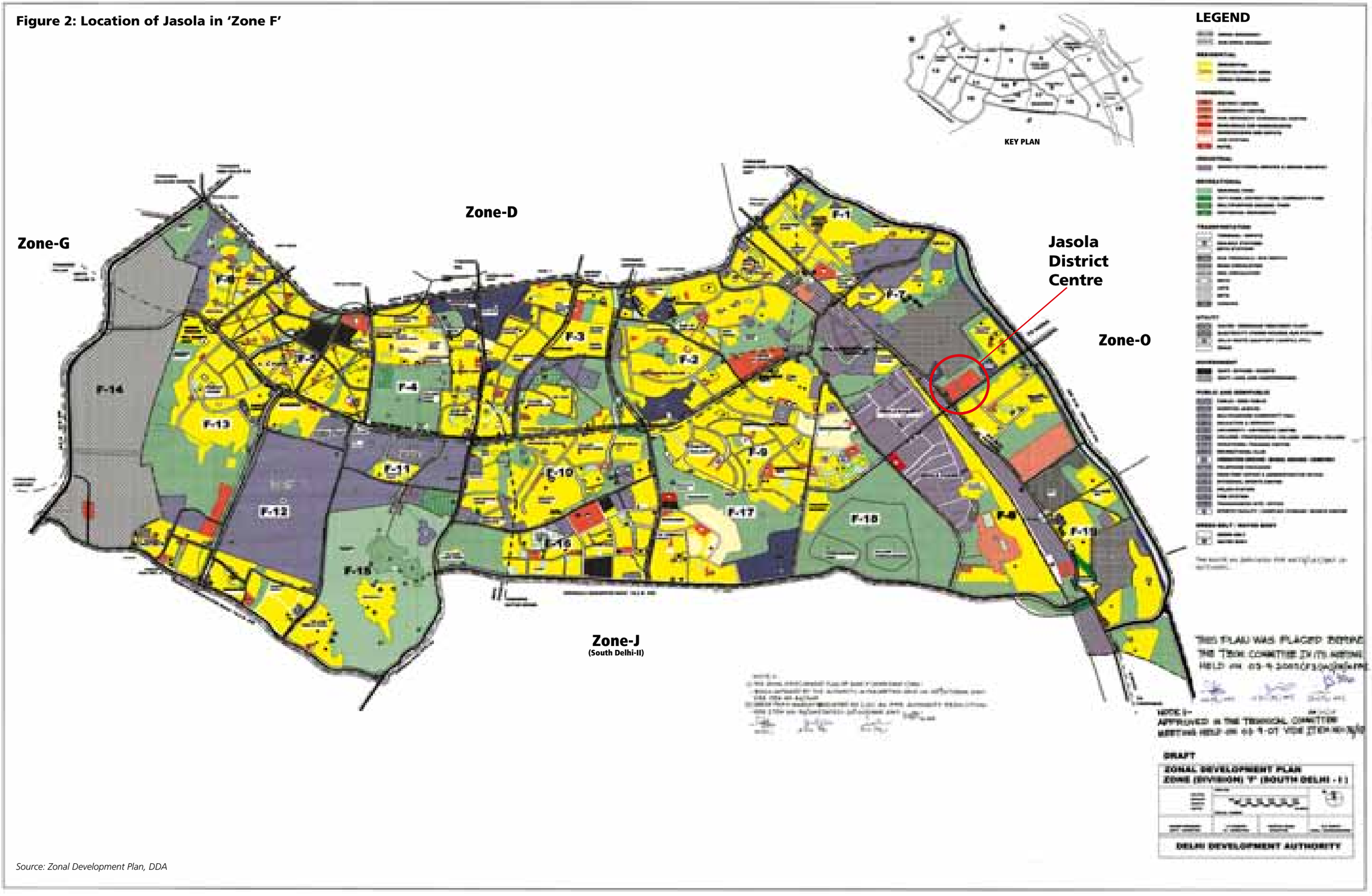
banks, ATMs etc. on their ground floors and offices on other floors. The other five are exclusively utilized as business spaces (Table 1: *Building use in Jasola district centre*).

Table 1: Buildings use in Jasola district centre

S. no.	Building name	Use
1	Salcon Aurum	Retail shopping and restaurants on the ground floor, offices in the rest
2	Banni	Retail shopping and restaurants on the ground floor, offices in the rest
3	Uppal	Only offices
4	DLF (Tower B)	Retail shopping, restaurants, banks and ATMs on the ground floor, offices in the rest
5	Splendor Mall	Retail shopping, restaurants, banks and ATMs on the ground floor, offices in the rest
6	TDI Centre	Retail shopping, banks and ATMs on the ground floor, offices in the rest
7	Elegance tower	Only offices
8	Copia Tower	Only offices
9	DLF (Tower A)	Only offices
10	MODI Enterprises—Omaxe	Only offices

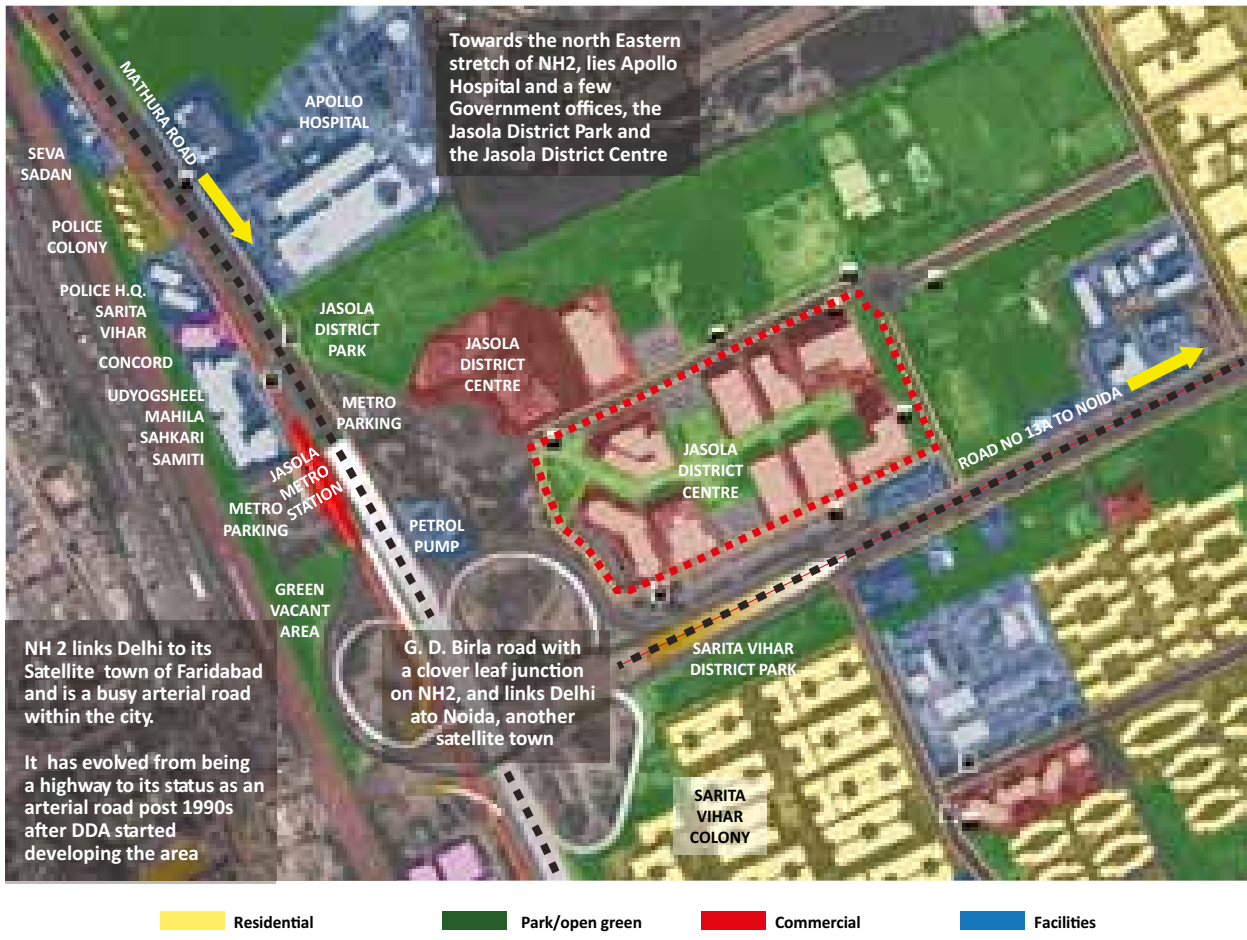
Source: CSE

Figure 2: Location of Jasola in 'Zone F'



Source: Zonal Development Plan, DDA

Figure 3: Connectivity of the area and land use distribution



Source: Adapted from Retrofitting Plan To Promote Non-motorized Transport and Pedestrianization, Jasola–Sarita Vihar, Town and Country Planning Organization, Ministry of Urban Development, Government of India

Parking supply

Proper knowledge of legally available parking spaces in an area is essential for creating a parking management district (PMD), as strategies have to be tailor-made accordingly.

There are two main types of parking spaces in Jasola district centre. The first comprise those that were developed by the DDA and are managed by SDMC-appointed contractors, and the second comprise those within the commercial towers. Parking spaces within the towers can only be used by business owners. Not all employees are allowed to use them. A survey of the area by CSE revealed that a limited number of car spaces, depending on the office or commercial space area, are allocated to each business owner (see *Figure 4: On-street and off-street parking locations in Jasola district centre*). According to the Master Plan for Delhi 2021,[5] the permissible parking in these towers is three ECS per 100 sq m floor area.

How much off-street parking is available?

Jasola district centre has five off-street parking lots of varying sizes. CSE was not able to get the data on the officially notified parking supply in these parking lots. However, since it was very critical to know the parking supply in these sites, certain assumptions were applied to calculate it. Firstly, the area of all five off-street locations was calculated. The land required to park a car is

Figure 4: On-street and off-street parking locations in Jasola district centre

Source: CSE

approximately 23 sq m, which includes the space occupied by the vehicle as well as the minimum space needed to move it into and out of the space. This is called equivalent car space, or ECS. So, an ECS of 23 sq m was applied in the off-street parking areas to know the parking supply. Calculations revealed that the available off-street parking supply in the area was 450 ECS (see *Table 2: Off-street parking supply*). Location 3, near the Hanuman Mandir, has the highest parking supply at 207 ECS, whereas Location 5, near DLF Tower-B has the least supply at 42 ECS (see *Figure 5: Off-street parking supply in the study area*).

Table 2: Off-street parking supply

Off-street parking	Area (in sq m)	ECS* available
Location 1	1,692	74
Location 2	1,692	74
Location 3	4,765	207
Location 4	1,207	52
Location 5	972	42
Total	10,348	450

*(*ECS = 23 sq m)*

Source: CSE

Figure 5: Off-street parking supply in the study area

Source: CSE

Availability of on-street parking

The data on on-street parking supply was also not available. To calculate on-street parking supply, the lengths of the roads were measured. Parallel parking arrangement was assumed in the study area as the widths of these roads are only 18 meters and 30 meters and in parallel on-street parking, the least width of right-of-way (ROW) is used. The ECS for on-street parking is 12.5 sq m, based on which the on-street parking supply was calculated (see *Table 3: On-street parking supply in the study area*). It was noted during the field survey that the complete stretch of roads could not being utilized for parking. Due to entry and exit gates of buildings and off-street parking, only a certain kerb

Table 3: On-street parking supply in the study area

On-street	Length (in meters)	Effective length for on-street parking	ECS* available (on single sides)	ECS* available (on both sides)
Stretch 1	400	200	40	80
Stretch 2	160	80	16	32
Stretch 3	400	200	40	48
Stretch 4	190	95	19	38
Total	1,150	575	115	198

*(*ECS = 12.5 sq m)*

Source: CSE

length is available for on-street parking. Based on this information, only 50 per cent of the stretch length is assumed to be effectively available for on-street parking. The on-street parking supply in Jasola district centre was calculated to be 230 ECS.

Parking spaces within the commercial buildings

A total of 10 commercial towers are located in the study area. Almost all of them have three-level basements reserved for parking. Approximately, 2,100 ECS of parking space is available within the buildings located in the study area (see *Table 4: Parking available within the buildings in the area*).

Table 4: Parking available within the buildings in the area

Building name	Basement parking: No. of levels	Parking capacity (in ECS)
Salcon Aurum	3	230
Banni	3	200
Uppal	3	100
DLF (Tower B)	3	333
Splendour Mall	3	250
TDI Centre	3	270
Elegance tower	3	150
Copia Tower	3	300
DLF (Tower A)	3	120
MODI Enterprises—Omaxe	2	150
Total car parking (in ECS)		**2,103**

Source: CSE

Existing parking pricing in the study area

As already discussed in the previous section, the parking in the study is managed by SDMC-appointed contractors. They pay a fixed amount of the parking revenue to the SDMC annually.

Table 5: Current parking charges in the study area

Category of vehicle	Duration	Fees
Two-wheeler	5 hours	Rs. 20
Two-wheeler	8 hours	Rs. 40
Four-wheeler	1 hour	Rs. 20
Four-wheeler	8 hours	Rs. 100
Two-wheeler	Monthly Pass	Rs. 600
Four-wheeler	Monthly Pass	Rs. 1200

Source: CSE

Figure 6: On-street parking supply in the study area

Source: CSE

B. Parking demand

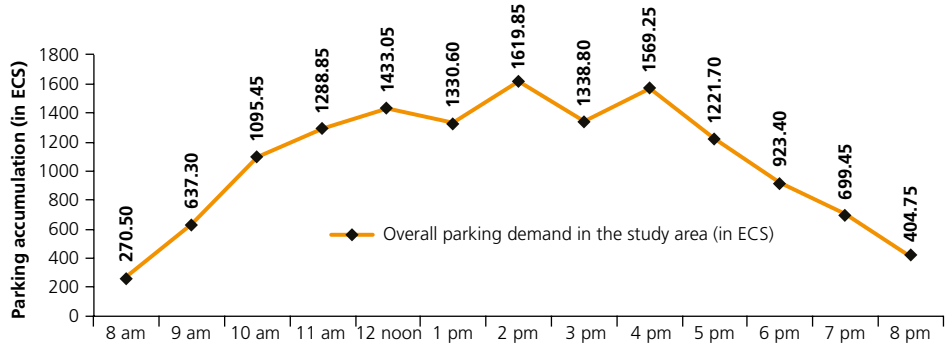
CSE hired a survey agency to carry out the parking surveys in the study area. The parking usage survey was carried out on a working day from 8 a.m. to 8 p.m. The purpose of the survey was to get data on the pattern of parking demand at various locations within the study area. The license plate method survey was conducted to collect the parking data. In this, a surveyor notes down the license plate numbers of all parked vehicles after every 30 minute time interval in case of an on-street parking location and similarly notes down the license plate numbers of all vehicles entering and exiting an off-street parking location for each 30 minute duration. This will give the data regarding the duration for which a particular vehicle is parked in the study area.

Based on the survey results, the overall parking accumulation for the study area was calculated. Parking accumulation refers to the total cars (or ECS) parked at any given point in time, thus, it is an accurate reflection of the parking demand at different times during the day.

From the survey, it was observed that the peak demand of parking in the study area was 1,620 ECS, which occurred at 2 p.m. The demand for parking in the area increased continuously from 270.5 ECS at 8 a.m. onwards to 1,620 ECS by 2 p.m. It was also noted that the demand for parking between 8 a.m. to 12 noon increase by nearly five times. The reason behind this was the arrival of employees and business owners. Similarly, from 5 p.m. onwards the demand for parking began falling as people started to leave their work stations for their homes (see *Graph 1: Hourly parking demand in the study area*).

Parking demand has been assessed in terms of ECS, whereby the parking demand for vehicles other than cars is converted into equivalent car spaces based on the relative area they occupy during parking with respect to a car. Thus, for a bicycle, the ECS comes to about 0.1; for a two-wheelers, it is about 0.25; for an auto-rickshaw, it is about 0.5; for a mini-bus or light commercial vehicle, it is 1.5; and for a bus, it is about 4.

Graph 1: Hourly parking demand in the study area



Source: CSE analysis

More permissible parking supply than demand

The parking supply in the area mandated under building bye-laws far exceeds actual demand. Delhi Master Plan, 2021 mandates a parking area of three ECS for every sq m of floor area for commercial or institutional land use. This comes to around 2,100 ECS in the study area (see *Table 4: Parking available within the buildings in the area*). In comparison, average peak demand is only about 1,620 ECS (see *Graph 1: Hourly parking demand in the study area*).

Off-street parking demand

It was observed that the maximum off-street parking accumulation or demand in a day was 785 ECS at 1 p.m. This exceeds the parking supply of 450 ECS, which indicates that demand is higher than the supply that is designed to ensure optimal movement of vehicles in and out of the parking locations (see *Table 6: Off-street parking demand*).

It was understood from the parking survey that the demand for off-street parking in the study area increased continuously from 8 a.m. in the morning till 4 p.m. in the evening. The demand peaked at 1 p.m., reaching 785 ECS. The reason for this is the presence of several restaurants in the area, creating a crest during lunch-hour. Parking accumulation was found to be 138 ECS at 8 a.m., which increased to 780 ECS by 4 p.m. During the time between 8 a.m. to 10 a.m., the demand rose by more than four times. This is mainly because of the people arriving to the study area for work or business purposes. Similarly, from 5 p.m. onwards, when the demand is 742 ECS, it fell to 182 ECS by 8 p.m. as people began leaving for their homes.

Figure 7: Off-street parking in Jasola district centre

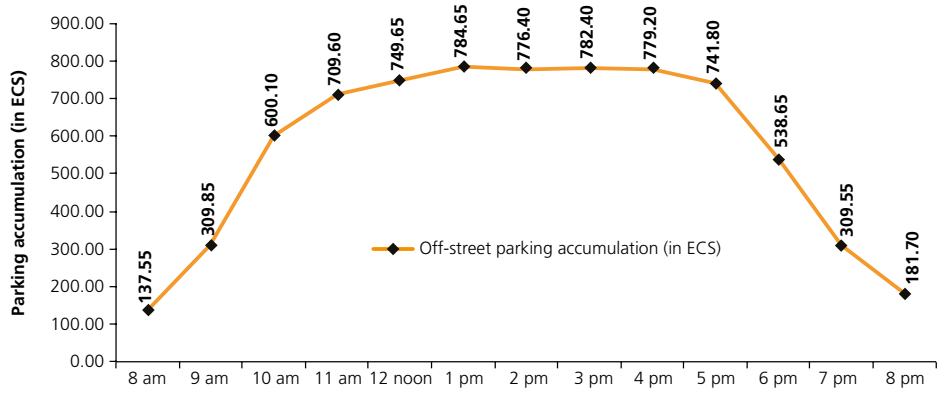
Source: CSE

Table 6: Off-street parking demand

Off-street parking	Area (in sq m)	Parking Supply (in ECS)	Peak Parking Demand (in ECS)	Time of peak demand
Location 1	16,912	74	219	12 noon
Location 2	1,711	74	143	2 p.m.
Location 3	4,765	207	232	2 p.m.
Location 4	1,207	52	172	4 p.m.
Location 5	972	42	35.75	11 a.m.
Overall	10,347	450	802	

Source: CSE

Graph 2: Hourly off-street parking demand



Source: CSE analysis

Location-wise off-street parking demand analysis (see *Graph 3: Location-wise hourly parking demand*)

a) Location 1 (between Salcon and Banni)

The parking is located between Salcon and Banni towers. The ground floors of these two towers—Salcon and Banni—have shops and restaurants. The demand for parking at this location increased from 67.5 ECS at 8 a.m. to 219 ECS at 3 p.m. From 8 a.m. to 11 a.m., the demand increased by almost four times. This is mainly because of people arriving to the study area for work or business purposes. The peak demand was reached at 12 noon, when the parking demand rose to 220 ESC. From 4 p.m. onwards, when the demand was 211 ECS, the demand decreased to 14.2 ECS by 8 p.m. as people began leaving for their homes.

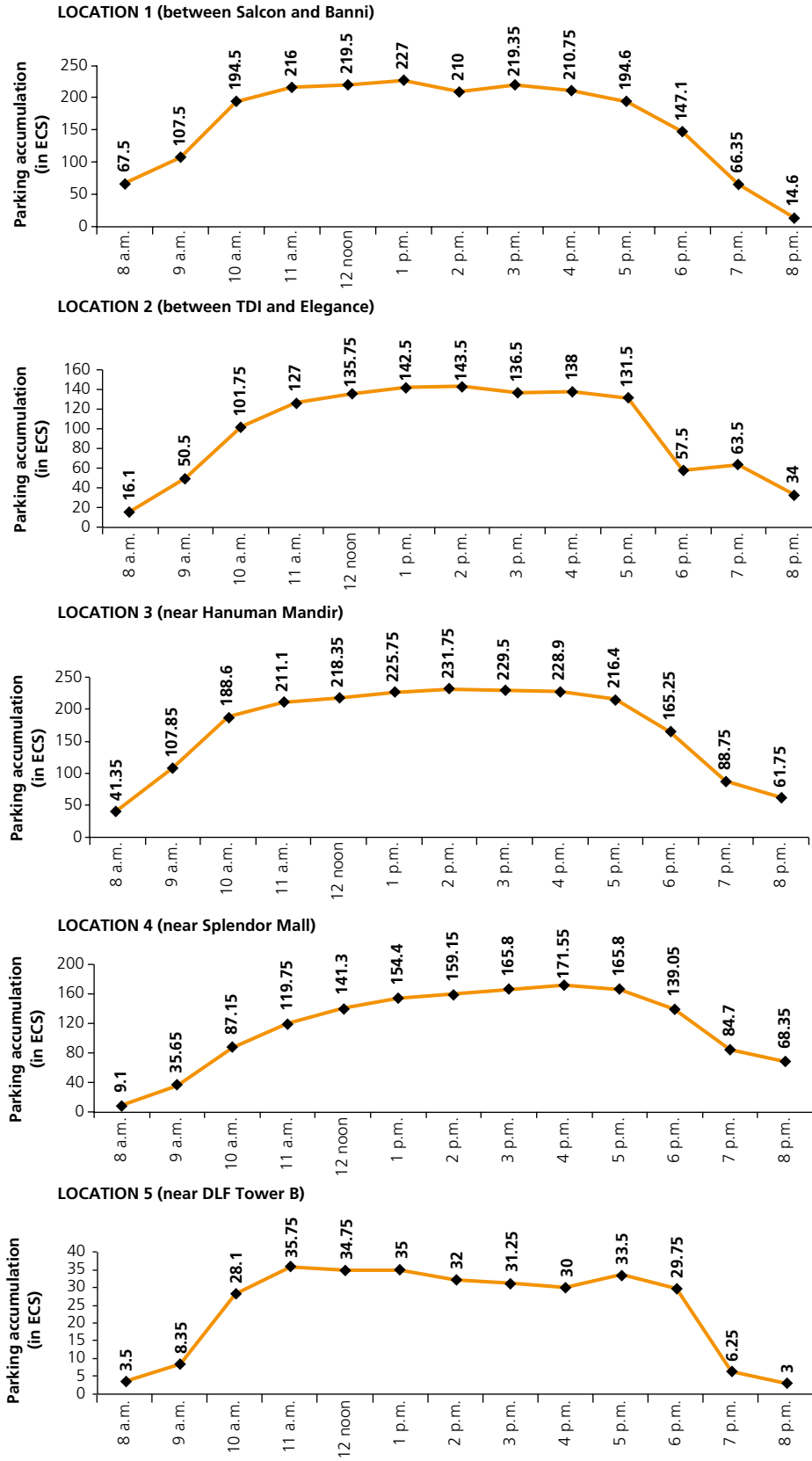
b) Location 2 (between TDI and Elegance)

This parking is located between TDI and Elegance towers. Only TDI has shops and banks located on its ground floor; Elegance is fully occupied by office spaces. The demand at 8 a.m. was only 16 ECS which reached to 143.5 ECS by 2 p.m. The peak demand of 143.5 ECS was observed at 2 p.m. The demand dropped to 63.5 ECS by 7 p.m. from 131.5 ECS at 5 p.m. The parking accumulation observed at 8 p.m. was 34 ECS.

c) Location 3 (near Hanuman Mandir)

This parking is located near Hanuman Mandir. The parking is the largest off-

Graph 3: Location-wise hourly parking demand



Source: CSE analysis

street parking location in the study area. For this reason, all heavy commercial vehicles likes buses and trucks are parked here. The demand at 8 a.m. was only 41.35 ECS, which reached 229 ECS by 4 p.m. The peak demand of 232 ECS was observed at 2 p.m. The demand dropped to 61.75 ECS by 8 p.m., from 216 ECS at 5 p.m.

d) Location 4 (near Splendor Mall)
This parking is located opposite the Splendor Mall and is mainly used by shoppers visiting the mall. The demand at 8 a.m. was 9.1 ECS, which continuously increased to 171.55 ECS by 4 p.m. The demand dropped to 68.35 ECS by 8 p.m. from 165.8 ECS at 5 p.m.

e) Location 5 (near DLF Tower B)
The parking is located opposite the DLF Tower B. The major users of this site were two-wheelers.

On-street parking demand

Figure 8: On-street parking in Jasola district centre

Source: CSE analysis

How much is the on-street parking demand?

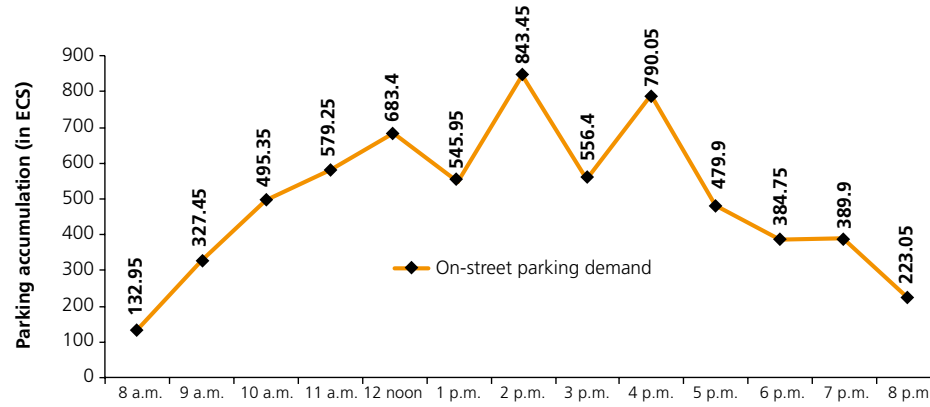
Peak parking accumulation figures for each stretch as well as overall for all on-street locations are given in *Table 7: On-street parking demand*. As in the case of off-street parking, the demand outmatches the supply; and for similar reasons.

Table 7: On-street parking demand

On-street	Parking Supply (in ECS)	Peak Parking Accumulation (in ECS)	Peak hour
Stretch 1	80	250	4 p.m.
Stretch 2	32	400	2 p.m.
Stretch 3	80	175	4 p.m.
Stretch 4	38	53	3 p.m.
Overall	230	878	

Source: CSE compilation

Graph 4: Hourly on-street parking demand



Source: CSE analysis

Stretch-wise on-street parking demand (see *Graph 5: Stretch-wise hourly parking demand*)

a) Stretch 1 (Omaxe to DLF Tower B)

The stretch from Omaxe to DLF Tower B is 400 meters long. As of now, both sides of the roads are being used for parking vehicle, mainly cars and two-wheelers. The parking demand at 8 a.m. was 47.6 ECS which increased to 178 ECS by 10 a.m. Between 12 noon and 3 p.m., the demand dropped from 211 ECS to 142 ECS. After this, the demand again increased to 250 ECS by 4 p.m., which was also the peak demand. From 5 p.m. onwards, the demand decreased from 174 ECS to 45.6 ECS by 8 p.m.

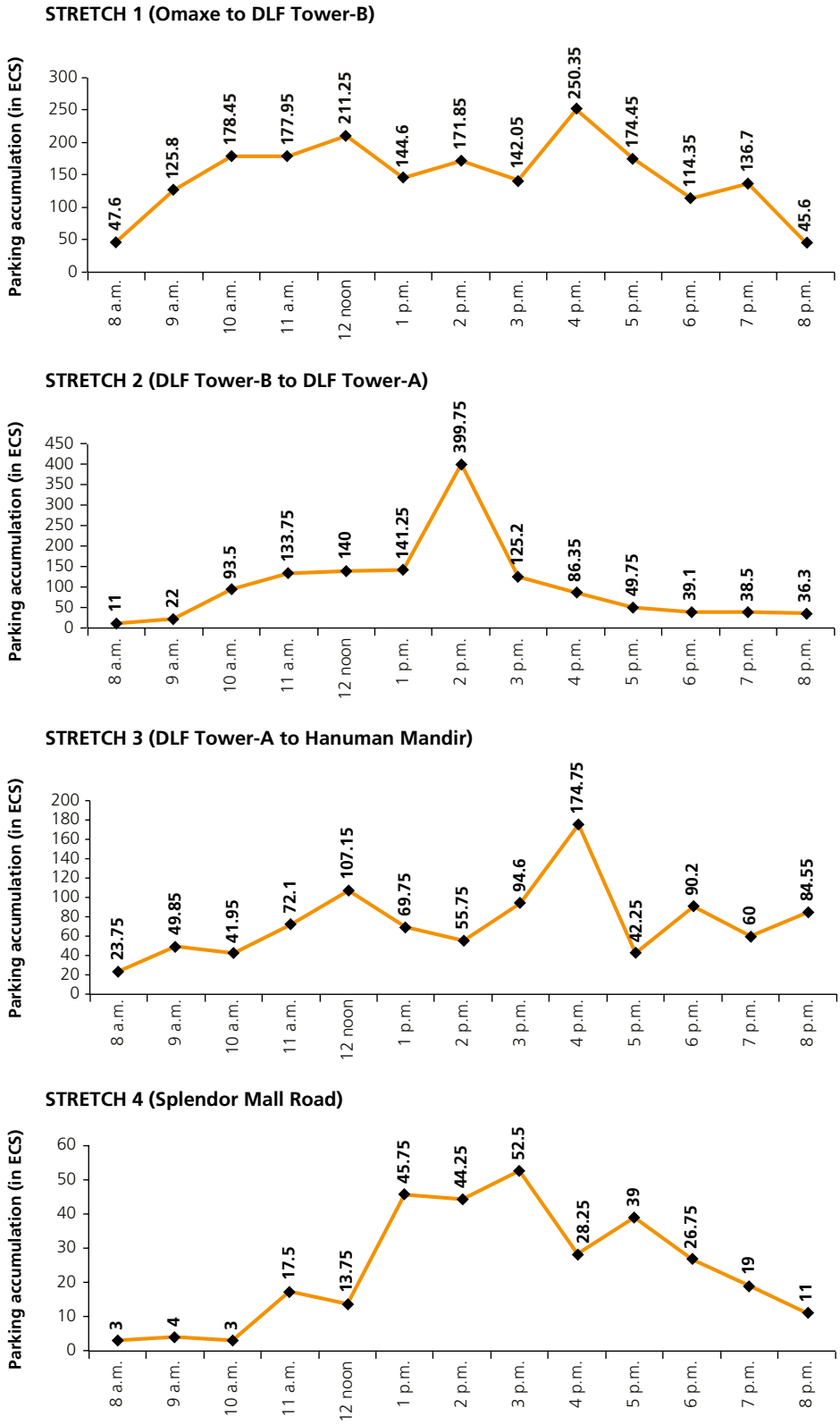
b) Stretch 2 (DLF Tower B to DLF Tower A)

The stretch from DLF Tower B to Tower A is 160 meters long. The east side of the road has a park and Jasola district centre lies to the west. There was a continuous increase in the parking accumulation from 8 a.m. onwards. The demand at 8 a.m. was 11 ECS, which increased to 141.25 ECS by 1 p.m. The peak demand was observed at 2 p.m., when the demand reached almost 400 ECS. This could be because of the people coming to the restaurants located near the stretch during the lunch-hour. From 3 p.m. onwards, the demand began falling continuously from 125.2 ECS to 36.3 ECS by 8 p.m.

c) Stretch 3 (DLF Tower A to Hanuman Mandir)

The stretch from DLF Tower A to Hanuman Mandir is 400 meters long and 18 meters wide and runs parallel to Stretch 1. Currently, both sides of the road are being used for parking, which creates congestion. As of now, the stretch

Graph 5: Stretch-wise hourly parking demand



Source: CSE analysis

is majorly used by two-wheelers. During the survey, it was observed that the demand for parking at 8 a.m. was 24 ECS and the demand remained under 100 ECS till 8 p.m., except at 4 p.m., when the demand peaked at 175 ECS. This may be due to the existence of Hanuman Mandir located at one end of the stretch.

d) Stretch 4 (Splendor Mall road)

The stretch is located opposite the Splendor Mall. The main users of the parking here is shoppers coming to the mall. As compared to other stretches in the study area, this has relatively less demand. For instance at 8 a.m. the demand was only three ECS and increased to 14 ECS by 12 noon. The peak accumulation was at 3 p.m. when the demand reached 52.5 ECS. From 5 p.m. onwards, the demand began falling from 39 ECS to 11 ECS at 8 p.m.

Table 8: Duration of off-street parking by type of vehicle

Off-street parking	Two-wheeler	Auto-	Car	SUV	Mini-bus	Bus	Bicycle	Mini-LCV	Four-tyre LCV	Six-tyre LCV	E-rickshaw
Location 1	6:10:00	4:20:00	6:52:42	6:01:30	-	-	1:00:00	3:30:00	-	-	-
Location 2	4:24:41	-	6:19:31	5:21:26	7:15:00	-	0:30:00	-	-	-	-
Location 3	8:26:08	9:30:00	7:38:07	7:24:00	9:50:00	10:37:30	7:30:00	4:52:30	-	-	-
Location 4	5:19:50	5:35:00	5:05:38	3:41:42	-	-	-	9:00:00	5:30:00	-	9:00:00
Location 5	6:02:27	-	4:30:50	3:15:00	-	-	1:30:00	-	8:30:00	5:00:00	-
Average (in hr:min:sec)	6:04:37	6:28:20	6:05:22	5:08:44	8:32:30	10:37:30	2:37:30	5:47:30	7:00:00	5:00:00	9:00:00

Source: CSE analysis

Table 9: Duration of on-street parking by type of vehicle

Location	Two-wheeler	Auto-rickshaw	Car	SUV	Mini-bus	Bicycle	Mini-LCV	Four-tyre LCV	Six-tyre LCV	E- rickshaw
Road 1	1.06	0.50	0.86	0.97	0.55	0.53	0.58	0.58		
Road 2	0.74	0.50	1.17		0.50		0.50			1.00
Road 3	0.56	0.50	0.61	0.64	0.50	0.50	0.50	0.50	0.69	
Road 4	0.57	0.50	0.79	0.77		0.50				
Average duration	0.73	0.50	0.86	0.79	0.52	0.51	0.53	0.54	0.69	1.00

Source: CSE analysis

C. Strategies and proposals

The strategic framework adopted for parking management is as follows:

1. Capping the legal parking supply at a given limit, which is ideally lower than the current demand.
2. Distributing capped parking supply within the overall district.
3. Setting parking prices to adjust demand to the capped parking supply.
4. Providing supportive strategies for parking management, including parking fare collection and enforcement.

These steps have been discussed in the following sections in detail.

Capping and demarcating legal parking supply

Fixing the supply of legal parking is the first step of parking management, if one has to use it as a travel demand management tool. Conventional policy on parking in Indian cities, based on the assumption that demand for parking will continue to grow with motorization, has always aimed at increasing parking supply to meet the growing demand by earmarking ever higher amount of public land for parking, constructing multi-level car parks and mandating that all buildings set aside fixed minimum parking. But this policy assumption and logic has been under scrutiny in recent years because it has failed to address the problems which beset vehicle parking in urban centres.

How we capped the parking supply in Jasola district centre

A review of the literature on parking management revealed insufficient insights on standard procedures for capping parking supply (see *Box: Some principles adopted for capping parking supply*). Capping parking supply has not been undertaken as part of any parking management exercise in Indian cities. Therefore, CSE has adopted a new approach for capping the parking supply.

Principles of equitable distribution of public space among all users have been used to cap the parking supply. 'Public space' has been defined as the total area of the site that is available for providing public amenities, which equals the area remaining after subtracting the area held by private plots and carriageway of roads from the total area of the district. In order to determine equitable distribution of public space for all users, it has been further posited that modal share of motorized vehicles (which essentially require parking) should be used as the determining factor. Further, instead of adopting the existing modal share, the proposed modal share for 2021 as per MPD 2021 has been adopted. Since this exercise aims at using parking management to influence travel demand, it only makes sense to align the management principles with the modal share figures that are held desirable for Delhi, rather than those that are existing. MPD 2021 declares that by 2021, the share of personal modes like cars, two-wheelers, taxis, hired slow modes (manual rickshaw, hand cart etc.) and bicycles in total trip numbers will be 20 per cent. Accordingly, 20 per cent of public space within the district has been allocated to parking.

Calculating the capped parking supply

The methodology used for calculating the area that can be utilized for parking in Jasola district centre is explained in the *Figure 9: Methodology for calculating parking supply in Jasola district centre*.

Some principles for capping parking supply

No fixed rule available for capping the parking supply

There is no fixed rule which can be applied in a given location for calculating the maximum parking supply. Different places cap parking supply depending on their respective characteristics. For instance, Portland (US) sets maximum parking limits based on type of use and availability and frequency of transit service, and allows transfer of unused parking entitlements. That is, areas that are zoned for more intense development and are easily reached by alternative modes of transportation have lower maximums than areas of less intense development or less frequent or no transit services. The minimum parking requirement for general office use is one space per 500 sq ft of floor area, and the maximum parking requirement is one space per 294 sq ft of floor area. However, if the development is located more than 0.25 mile from a transit stop with a 20-minute-interval peak-hour bus service, and more than 0.25 mile from a transit stop or station with a 20-minute-interval peak-hour light rail or streetcar service, the maximum number of parking spaces is increased to 125 per cent of what otherwise would be the maximum requirement.[1]

Examples of limiting parking supply

In Seattle (US), a maximum of one parking space is available per 1,000 sq ft of downtown office area. The city is planning to extend the rule of maximum parking to areas outside the downtown. The minimum parking requirement has been reduced from 1 to 0.5 spaces per unit of housing. San Francisco allows parking equal to only 7 per cent of downtown building floor area. The Portland City Code has implemented parking maximums to complement parking minimums in areas outside the central city district. In 1975, Portland set an overall cap of approximately 40,000 parking spaces for its downtown. During the 1980s, it was raised to 44,000. This has increased transit use from 20–25 per cent in the 1970s to nearly 48 per cent in the 1990s. In Santa Monica, California (US), there has been a reduction in parking spaces from 2 to 1.5 for two-bedroom affordable housing units. Eugene, Oregon (US) allows reduction of parking requirements on a case-by-case basis and documents the sufficiency of reduced amount of parking. Hartford, Connecticut (US) allows reductions of up to 30 per cent of the required parking in exchange for implementing better and efficient transport demand management programmes, which include discounted carpool parking, rideshare promotions, subsidized transit passes and shuttle services to off-site parking.

London (UK) has abolished parking minimums for all boroughs and imposed maximums more uniformly. A study carried out by Fei Li and Zhan Guo found that this led to 45 per cent reduction in the number of parking spots built in the new developments and 60 per cent of such developments in inner London became car free.[2]

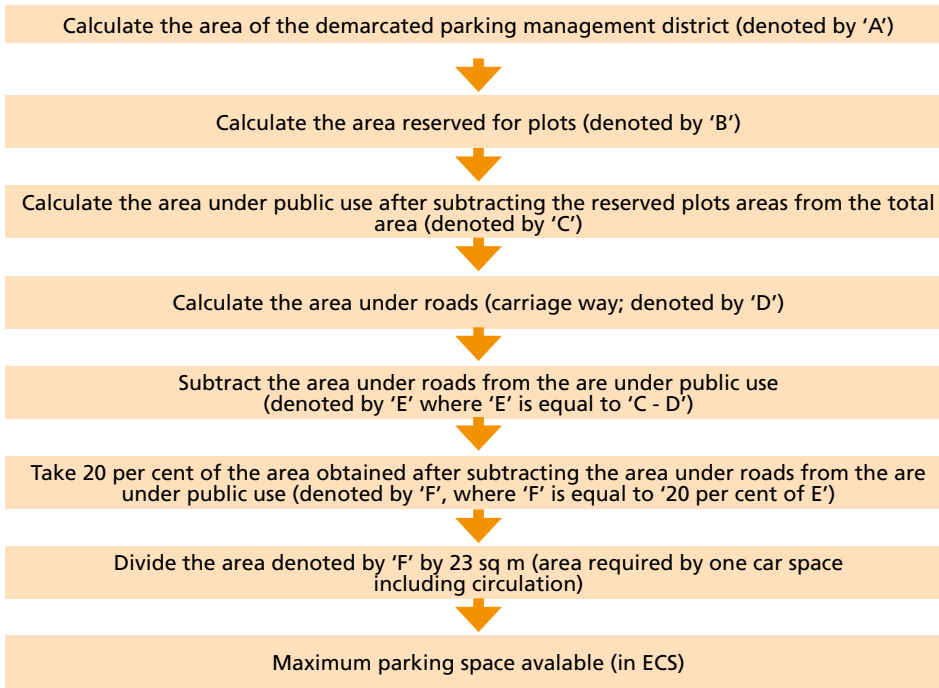
Recently, Sao Paulo adopted a new master plan abolishing parking minimums for the whole city.

The area of Jasola district centre is 220,166 sq m and the area reserved under commercial and private plots is 90,280 sq m (see *Figure 11: Public space in the Jasola district centre*). Therefore, the area available for public use (including roads) comes out to be 129,886 sq m. The area under the carriageway is 17,900 sq m, which when subtracted from 129,886 sq m, gives the public area or area under public use to be 111,986 sq m. Finally, following the Master Plan approach as explained already, 20 per cent of this space is taken out, which would be the maximum space available for parking. Dividing this space by a parking standard of 23 sq m per ECS gives the figure for the capped parking supply, which is 974 ECS (see *Figure 10: Calculation of maximum parking supply in Jasola district centre*).

Allocating the parking supply

The next step after capping the parking supply in the study area was to locate the parking spaces among different 'on' and 'off' street locations. Firstly, all the parking locations in the study area were allotted the maximum parking spaces that they can accommodate. It has been observed that all the existing five 'off-street' and four 'on-street' parking locations can accommodate a maximum of 648 ECS, with off-street accommodating 450 ECS and on-street accommodating

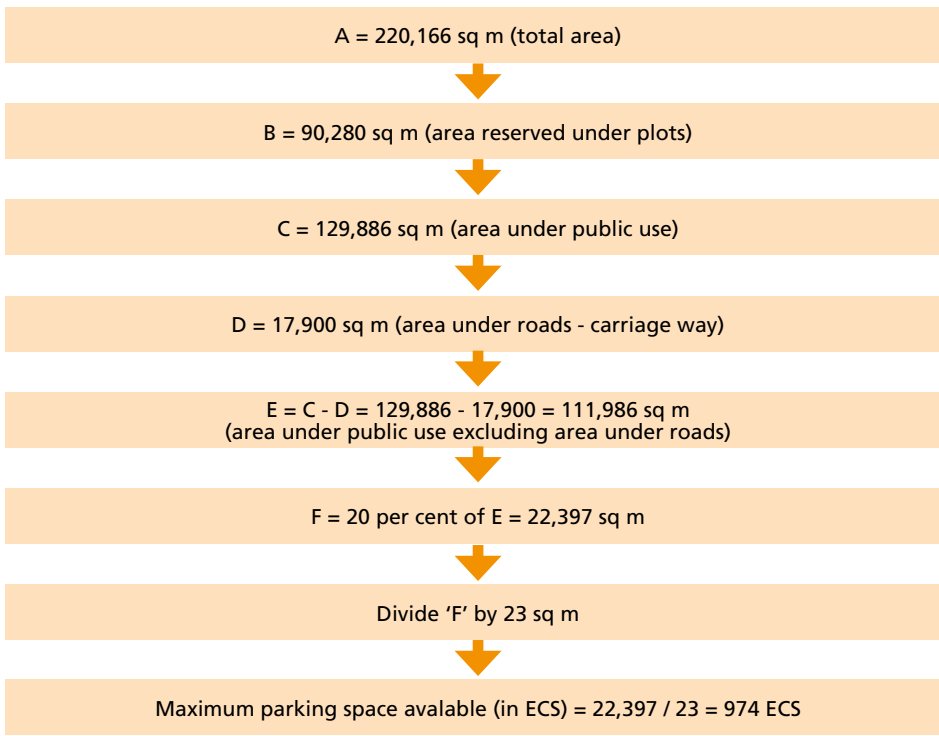
Figure 9: Methodology for calculating parking supply in Jasola district centre



Source: CSE

198 ECS. In order to adjust the remaining 326 ECS, a site currently proposed for developing multi-level parking with an area of 9,456 sq m and which can accommodate 400 sq m, has been taken up. The area remaining after

Figure 10: Calculation of maximum parking supply in Jasola district centre



Source: CSE

Figure 11: Public space in Jasola district centre

Source: CSE

Table 10: Allocation of off-street parking location in Jasola district centre

Off-street parking	Area (in sq m)	Allocated parking space (in ECS)
Location 1	1,692	74
Location 2	1,711	74
Location 3	4,765	208
Location 4	1,207	52
Location 5	972	42
Proposed (off-street parking)	9,456	326
Total	**19,803**	**776**

Source: CSE

Table 11: Allocation of on-street parking location in Jasola district centre

On-street parking	Length (in meters)	Effective length for on-street parking	Allocated parking space on both sides (in ECS)
Stretch 1	400	200	80
Stretch 2	160	80	32
Stretch 3	400	200	48
Stretch 4	190	95	38
Total	**1,150**	**575**	**198**

Source: CSE

accommodating 326 sq m under this site has been proposed to include other public amenities such as toilets and shelters for car drivers (see *Table 10: Allocation of off-street parking location in Jasola district centre* and *Table 11: Allocation of on-street parking location in Jasola district centre*).

Space for other uses

After considering the space in the public area that has to be utilized for parking, a huge chunk was left for other public uses. It has been proposed that this area include vending zones, plantation, facilities like repair shops and toilets, and continuous footpaths on both sides of the roads.

Reserving parking spaces

It is critical to provide reserved parking spaces for certain group of users. For instance, parking provision for users with physical disability cannot be ignored. There are several government documents laying down rules for reserving parking for such groups, like the Bureau of India Standard's National Building Code of India, 2016.[15] Indian Road Congress's Codes (IRC:SP:12:2015) and the Ministry of Urban Development's harmonized guidelines and space standards for barrier-free built environment for persons with disability and elderly persons, 2016.[16]

At the same time, it is also important to reserve parking for people coming to Jasola district centre in their electric vehicles. Undoubtedly, the government of India's current agenda is to promote use of electric vehicles. According to a 2014 UNEP (United Nation Environment Programme) report on promoting low

carbon transport in India, reserving parking spaces for electric vehicles works as an incentive.[17] The third and last group of users for whom parking must be reserved are cyclists, being a zero emission mode of transport.

How the reserved parking spaces were calculated?

Calculating reserved parking space for physically disabled

The National Building Code of India, 2016 madates six accessible parking spaces in the first 200 parking spaces and one for each additional 100 parking spaces for physically disabled users. Ministry of Urban Development's (MOUD) harmonized guidelines specify that two accessible parking lots should be provided for every 25 car parking spaces. The MoUD approach was selected for calculating reserved parking spaces for physically disabled persons in Jasola district centre. As the total parking was capped at 974 ECS, reserved parking for the disabled came to about 78 ECS.

Calculating reserved parking space for electric vehicles

There are not any standards for parking provisions for electric vehicles in India. So, the Barcelona (Spain) approach for providing parking spaces to electric vehicles was adopted for Jasola district centre. According to these standards,[9] 2 per cent of parking supply should be reserved for electric vehicles. Applying the same approach to Jasola district centre, the total parking supply to be reserved for electric vehicles came out to be nearly 20 ECS.

Calculating reserved parking space for bicycles

The Victoria Transport Policy Institute has calculated that 5 per cent of the total parking supply should be reserved for bicycle parking in commercial (retail or office) areas.[10] Applying the same to Jasola district centre, the reserved parking space for bicycles came out to be almost 50 ECS.

Allocating reserved parking in Jasola district centre

Keeping the accessibility and areas of different 'on' and 'off' street parking locations in mind, the reserved parking spaces for physically disabled people, electric vehicles and bicycles were uniformly distributed in Jasola district centre. In particular, users with physical disability have been allotted parking near the entry of off-street parking and nearest to the footpaths in the on-street parking areas. For electric vehicles, the places have been identified near charging facilities. Bicycle parking has also been kept near entry gates (see *Table 12: Reserved parking spaces*).

Table 12: Reserved parking spaces

Parking type	Off-street parking						On-street parking				Total (in ECS)
	Location 1	Location 2	Location 3	Location 4	Location 5	Proposed new location	Stretch 1	Stretch 2	Stretch 3	Stretch 4	
Physically disabled	6	6	16	4	4	26	6	4	3	3	78
Electric vehicles	2	2	4	1	1	6	2	1	1	1	20
Bicycles	4	4	10	3	3	16	3	2	2	2	50
Total (in ECS)	12	12	30	8	8	48	11	7	6	6	148

Source: CSE

Figure 12: Existing parking situation in Jasola district centre

Source: CSE

On-street parking locations : **STRETCH 1, STRETCH 2, STRETCH 3, STRETCH 4**

Off-street parking locations : ❶ ❷ ❸ ❹ ❺ ❻

Figure 13: Proposed parking plan for Jasola district centre

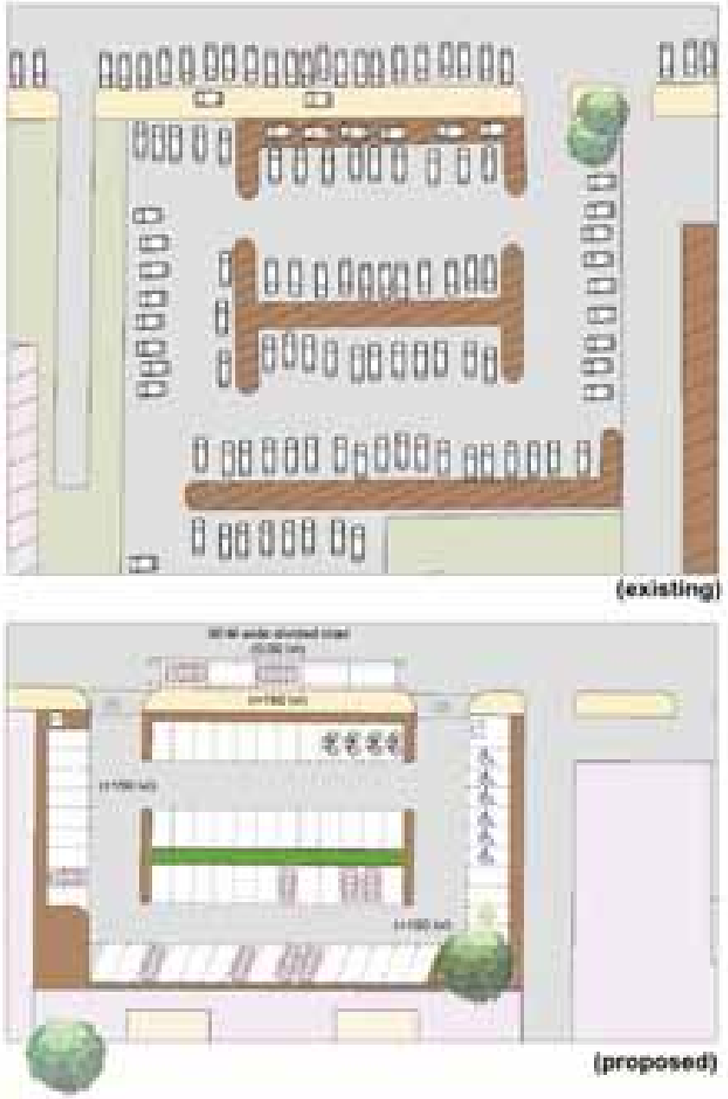
Location	Parking lots (in ECS)		Physically disbled	Electric vehicles	Cycles
Stretch 1	80	RESERVATIONS	8	2	3
Stretch 2	32		3	1	2
Stretch 3	48		6	2	4
Stretch 4	38		3	1	2
Location 1	74		8	2	4
Location 2	74		8	2	4
Location 3	207		16	4	10
Location 4	82		4	1	3
Location 5	42		4	1	3
Location 6	326		24	4	16

Source: CSE

Figure 14: Proposed off-street parking design

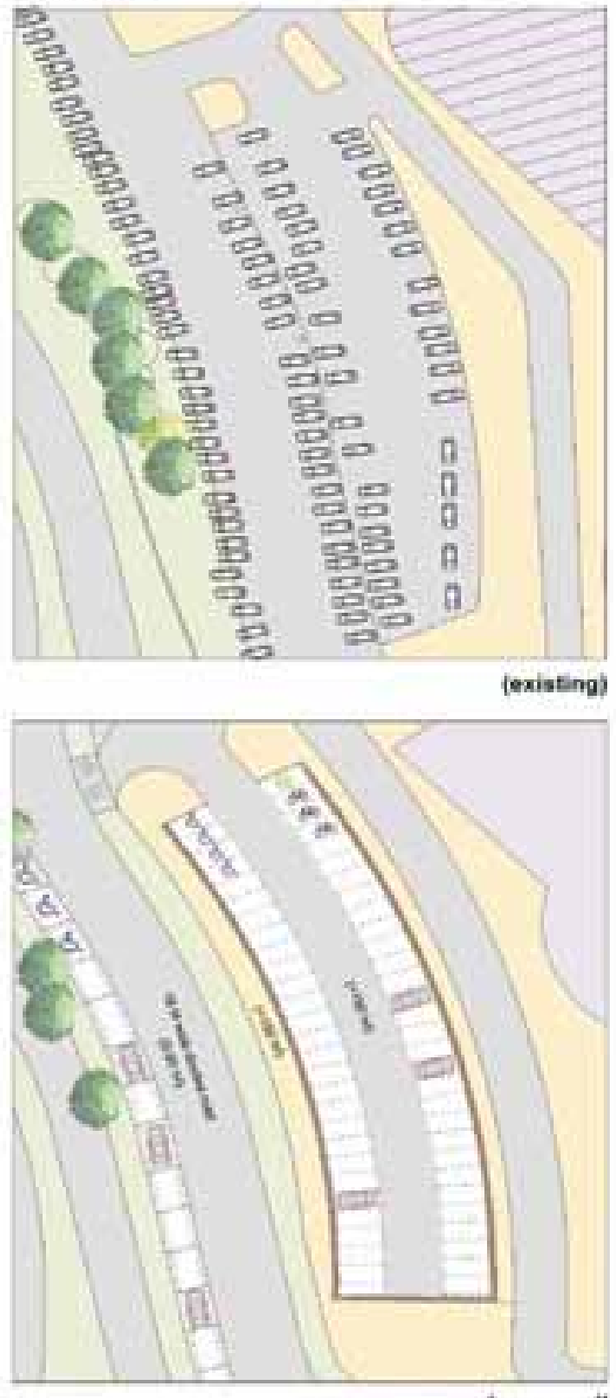
At present, cars are parked in disorganized manner, often along dividers and footpaths. On-street parking usually occupies half of the carriageway space. In the new plan, we propose designated parking spaces in every off-street parking lot as well as on-street location.

Location 1



Location 2

Location 4

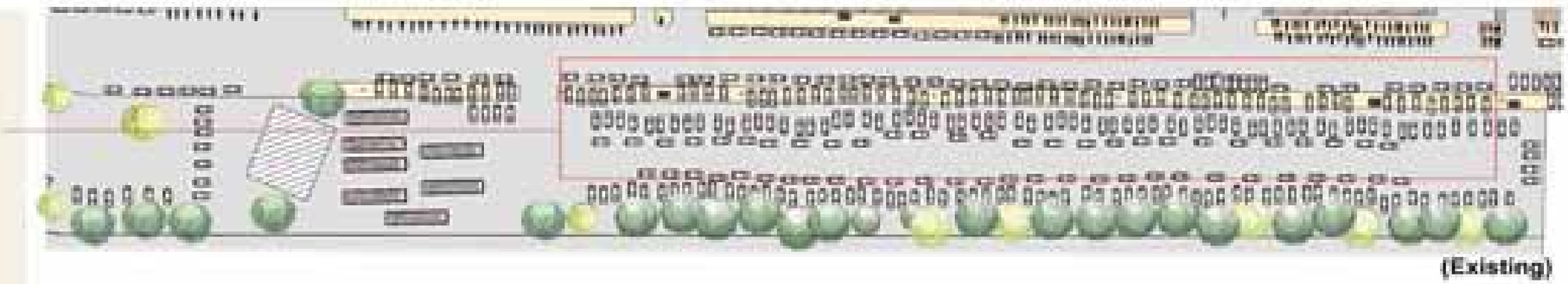


Source: CSE

Figure 14: ...continued

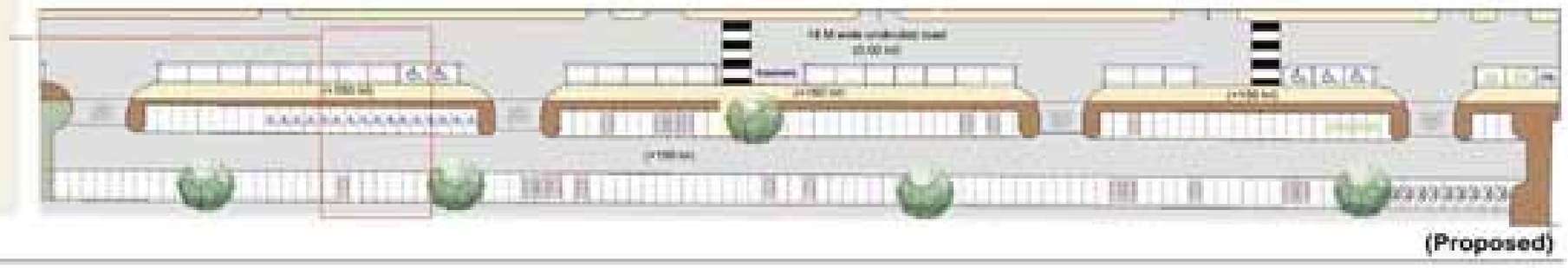
Location 3

Congested location with disorganized parking. Hawkers occupy footpaths and walkability of the street is minimal. Illegal on-street parking eats away carriageway space.



Proposed off-street parking area with designated spots for parking by the physically disabled, and bicycle and electric car users.

Trees to be planted in between to create a green buffer between the monotonous parking lots.



Location 5

The footpaths in the location are completely blocked with hawker's installations as well as unauthorized parking. Even cars are parked in a haphazard manner.

Two-wheelers are parked in three two four tiers along the pedestrian pathway. At present, the site doesn't have proper exit or entry. The parking spills into the neighbouring plots.

Proposed off-street parking area with designated provisions for parking by the physically disabled, and bicycle and electric car users. A small strip of green buffer to be provided between footpaths and the parking location.

*Levels are in millimeters

Source: CSE

Figure 15: Proposed parking design

Location 6

PROPOSED OFF-STREET SURFACE PARKING

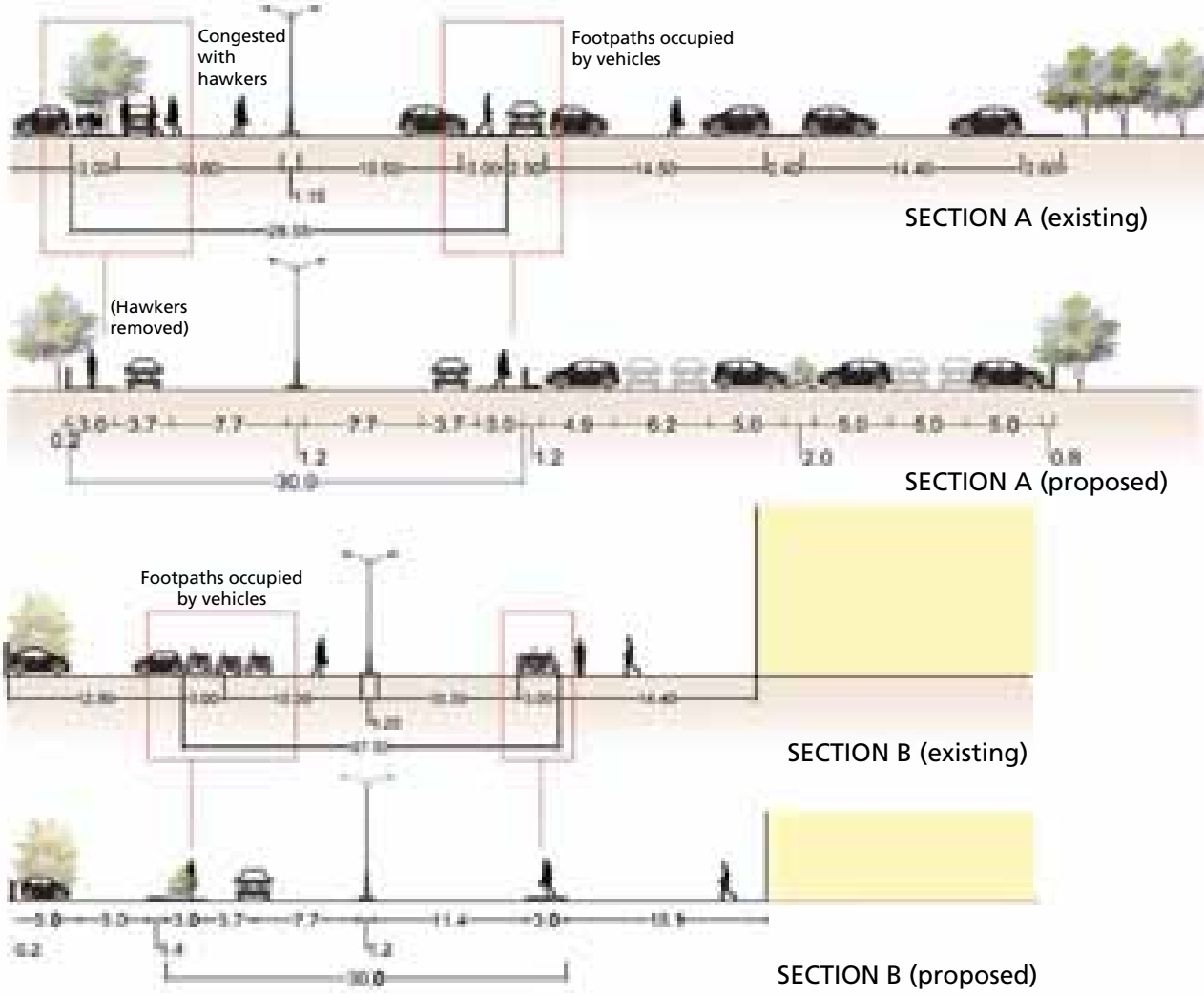
Area : 9,456 sq m
Capacity : 326 ECS

According to the layout plan of Delhi Development Authority, a multi-level parking facility was proposed at a particular site within Jasola district centre. After distributing the supply of maximum parking spaces, i.e. 974 ECS, in the existing on-street and off-street locations, a supply of 326 ECS was left.

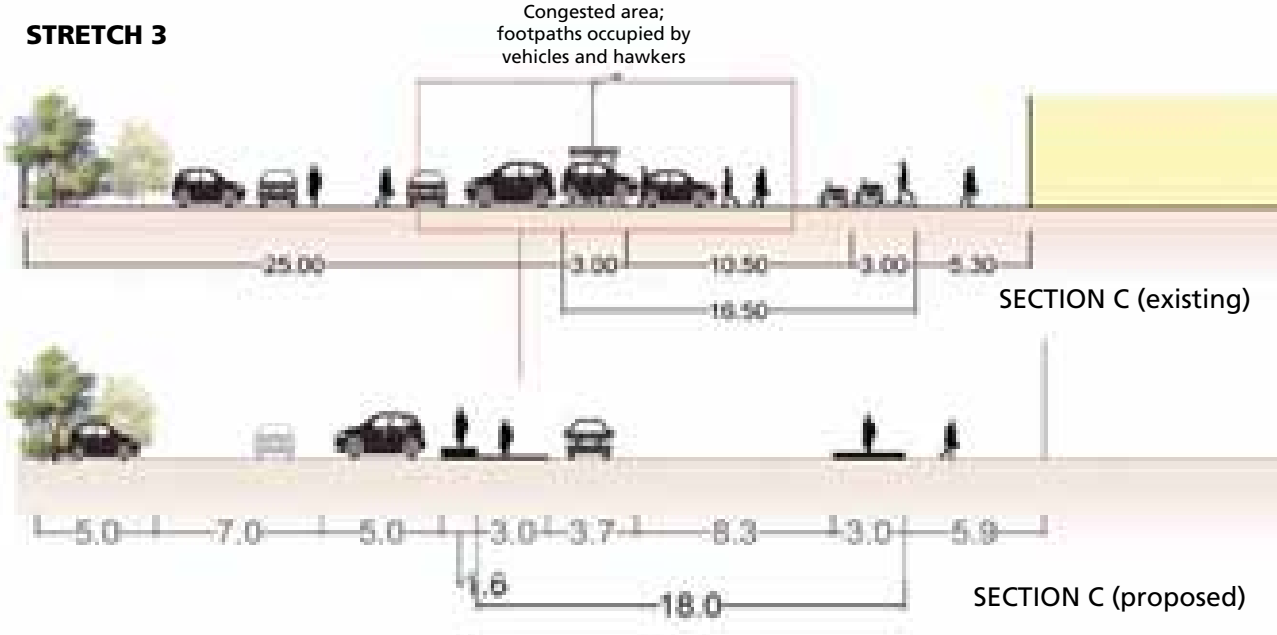
The area of the particular site is 9,456 sq m, which can accomodate about 400 ECS. So we propose surface-level parking which can accomodate the remaining parking supply as well as necessary facilities. The centre doesn't need a capital-intensive multi-level parking.

Source: CSE

STRETCH 1



STRETCH 3



Adjusting the parking demand–supply gap

After fixing the supply of parking and distributing it on different 'on' and 'off' street parking locations in the district centre, the next and most crucial step is to adjust the parking demand so that it can meet the capped parking supply. This has been done by adjusting parking charges. The approach adopted for setting the parking prices in the study area comes from the survey carried out to know the hourly parking demand from 8 a.m. to 8 p.m. and the money people are willing to pay for the existing 'on' and 'off' street parking.

Effective capped parking supply

As already discussed in the previous sections, the maximum parking supply in Jasola district centre was 974 ECS. This includes reserved parking spaces for physically disabled, electric vehicles and cyclists—a total of 148 ECS. Deducting the latter, one obtains a total supply of 826 ECS that can be used for parking by other vehicles. Prior to fixing the prices, Goldilocks Principle has been applied, which recommends that prices should be such that occupancy is at 85 per cent in order to prevent glutting. Therefore, the effective capped parking supply has been put at 85 percent of 826 ECS, which is 702 ECS (off-street parking: 559 ECS; and on-street parking: 143 ECS) (see *Table 13: Capped parking supply in Jasola district centre*).

Table 13: Capped parking supply in Jasola district centre

	Maximum parking supply (in ECS)	Reserved parking spaces (in ECS)	Available parking space without reserved parking (in ECS)	Capped parking supply from Goldilocks Principle (in ECS)
Off-street	776	118	658	559.3
On-street	198	30	168	142.8
Total	**974**	**148**	**826**	**702**

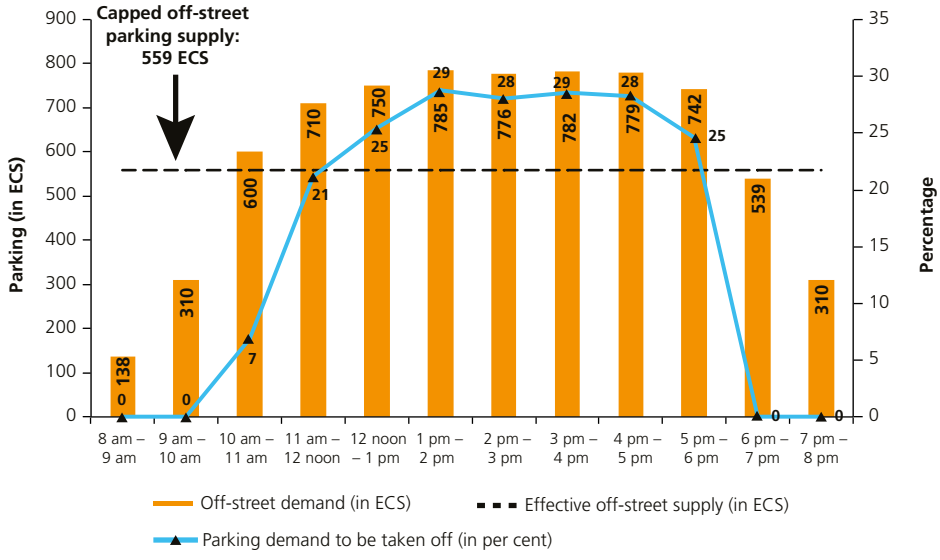
Source: CSE

How off-street parking charges were set?

After capping the number of off-street parking supply in the study area, the pricing for off-street parking was done in a way so that the demand does not exceed the supply for any given hour from 8 a.m. to 8 p.m. To achieve this, the data collected from the willingness-to-pay survey (see *Appendix: Willingness-to-pay*) relating to the percentage share of users who will stop using off-street parking at different rates was used, along with the hourly off-street parking demand.

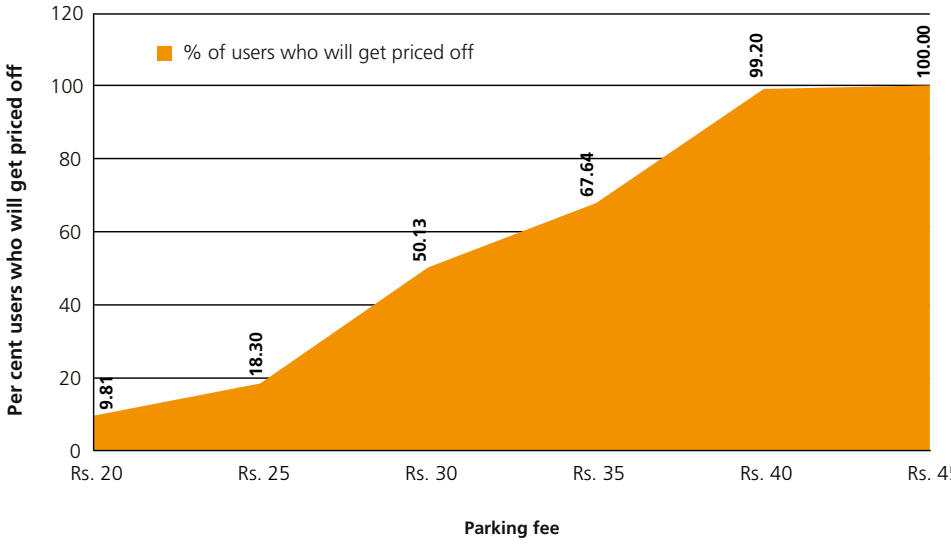
As already discussed, the off-street parking supply in the study area was capped at 559 ECS. The prices were calculated in a way so that hourly demand does not exceed the capped parking supply. The demand for off-street parking in the study area between 8 a.m. and 9 a.m. was 138 ECS, which increased to 310 ECS between 9 a.m. to 10 a.m., whereas the supply was as high as 559 ECS. This clearly means that the supply is more for these two hours than the demand. From 10 a.m. onwards until 5 p.m., the demand exceeded the supply. Between 10 a.m. and 11 a.m., the demand reached 600 ECS and by the evening (at 5 p.m. and 6 p.m.), it was as high as 742 ECS. The demand needed to be reduced to meet the supply. The demand that needs to be reduced between 10 a.m. and 11 a.m. was 7 per cent, between 11 a.m. to 12 noon it had to be reduced by 21 per cent, between 3 p.m. and 4 p.m. it had to be reduced by 29 per cent (see *Graph 6: Off-street parking supply-demand gap*).

Graph 6: Off-street parking supply-demand gap



Source: CSE analysis

Graph 7: Percentage of users priced off at different parking charges in existing off-street parking facilities



Source: CSE analysis

This was then related with the willingness-to-pay survey. It was observed from the survey that 9.81 per cent of the users will stop using car parking if the rates reached Rs 20 per hour, 18 per cent at Rs 25, and 50 per cent at Rs 30 (see *Graph 7: Percentage of users priced off at different parking charges in existing off-street parking facilities*). Accordingly, to reduce the demand by 7 per cent between 10 a.m. and 11 a.m., the price should be Rs 20 and for the remaining hours till 5 p.m., it should be Rs 30 (see *Table 14: Hourly off-street parking charges*).

Table 14: Hourly off-street parking charges

Off-street parking price per hour	Percentage of users who will stop using parking
Rs. 20	9.81
Rs. 25	18.30
Rs. 30	50.13
Rs. 35	67.64
Rs. 40	99.20
Rs. 45	100

Source: CSE

Table 15: Effective hourly off-street parking price for an hour to meet the demand

Time	Percentage of off-street parking demand exceeding the capped parking supply at different hours (8 a.m. to 8 p.m.)	Effective off-street parking price meeting the demand (in Rs per hour)
8 a.m.–9 a.m.	0	Rs 20
9 a.m.–10 a.m.	0	Rs 20
10 a.m.–11 a.m.	0	Rs 20
11 a.m.–12 noon	7	Rs 20
12 noon–1 p.m.	21	Rs 30
1 p.m.–2 p.m.	25	Rs 30
2 p.m.–3 p.m.	29	Rs 30
3 p.m.–4 p.m.	28	Rs 30
4 p.m.–5 p.m.	29	Rs 30
5 p.m.–6 p.m.	29	Rs 30
6 p.m.–7 p.m.	25	Rs 30
7 p.m.–8 p.m.	0	Rs 20

Source: CSE

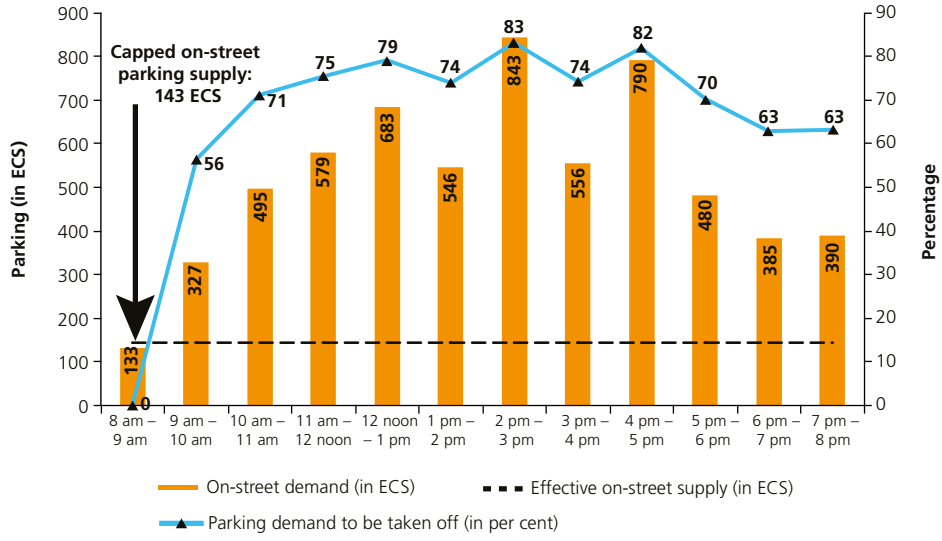
It was also decided that these rates are for parking cars. It is up to the operator if they want to collect Rs 20 per hour from four two-wheelers parked at one car parking space.

How on-street parking charges were set?

The on-street parking supply in the study area was capped at 143 ECS. Prices were calculated in a way to ensure that hourly demand does not exceed the capped parking supply (see *Graph 8: On-street parking supply–demand gap*). The demand for on-street parking in the study area between 8 a.m. to 9 a.m. was 133 ECS, whereas the supply was as high as 143 ECS. This clearly means that the supply is more than the demand. From 9 a.m. onwards, until 8 p.m., the demand exceeded the supply. From 9 a.m. to 10 a.m., the demand reached 327 ECS and by 2–3 p.m., it was as high as 843 ECS. The demand needed to be reduced to meet the supply—from 9 a.m. to 10 a.m., 56 per cent; from 11 a.m. to 12 noon, 75 per cent; and from 2 p.m. to 3 p.m., 83 per cent.

This was then related with the willingness-to-pay survey. It was observed during the survey that 24 per cent of users will stop using on-street car parking

Graph 8: On-street parking supply-demand gap

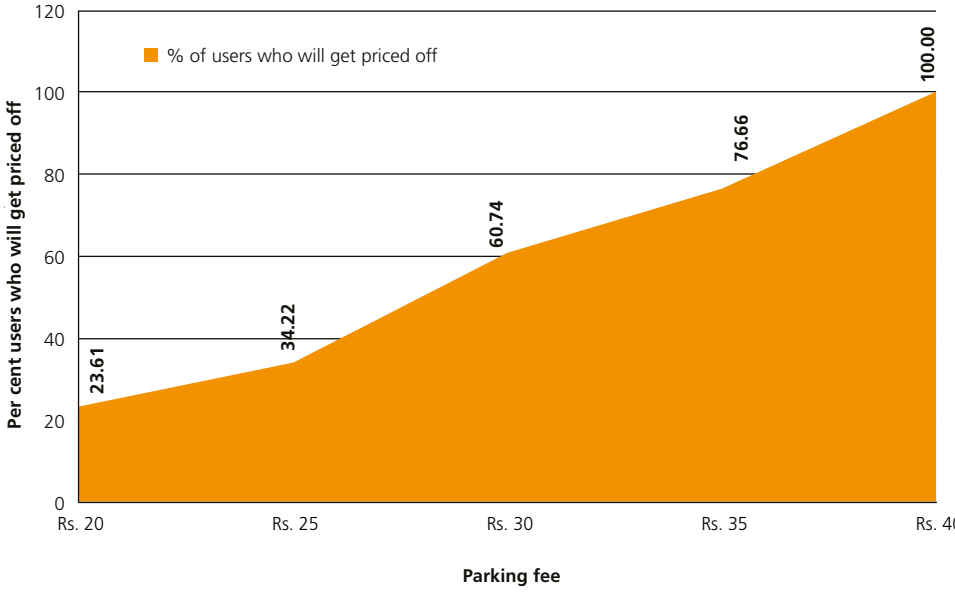


Source: CSE analysis

if the rates reached Rs 20 per hour, 34 per cent at Rs 25, and 100 per cent at Rs 40 (see *Graph 9: Percentage of users priced off at different parking charges in existing off-street parking facilities*). Accordingly, to reduce the demand by 56 per cent between 9 a.m. and 10 a.m., the parking price should be Rs 30; from 10 a.m. to 11 a.m., it should be Rs 35; and from 2 p.m. and 4 p.m., it should be Rs. 45.

It was also decided that these rates are for parking cars. It is up to the operator to collect Rs 20 per hour for parking four two-wheelers or 10 bicycles at one car parking space (see *Table 16: Hourly on-street parking charges*).

Graph 9: Percentage of users priced off at different parking charges in existing on-street parking facilities



Source: CSE

Table 16: Hourly on-street parking charges

On-street parking price per hour	Percentage of users who will stop using parking
Rs 20	23.61
Rs 25	34.22
Rs 30	60.74
Rs 35	76.66
Rs 40	100

Source: CSE

Table 17: Effective hourly on-street parking price for an hour to meet the demand

Time	Percentage of on-street parking demand exceeding the capped parking supply at different hours (8 am to 8 pm)	Effective on-street parking price meeting the demand (in Rs./hour)
8 a.m.–9 a.m.	0	Rs 20
9 a.m.–10 a.m.	56	Rs 30
10 a.m.–11 am	71	Rs 35
11 a.m.–12 noon	75	Rs 35
12 noon–1 p.m.	79	Rs 35
1 p.m.–2 p.m.	74	Rs 35
2 p.m.–3 p.m.	83	Rs 40
3 p.m.–4 p.m.	74	Rs 35
4 p.m.–5 p.m.	82	Rs 40
5 p.m.–6 p.m.	70	Rs 35
6 p.m.–7 p.m.	63	Rs 30
7 p.m.–8 p.m.	63	Rs 30

Source: CSE

Higher charges for on-street parking

It is one of the accepted principles of parking management that prices for on-street parking should always be higher than off-street parking. In fact, it was proposed in the draft Delhi maintenance and management parking rules that on-street parking charges should be three times higher than off-street parking charges. The proposed charges drawn from the willingness-to-pay survey are aligned with this principle (see *Table 18: Comparison between off-street and on-street hourly parking charges*).

Table 18: Comparison between off-street and on-street hourly parking charges

Time	Off-street parking price (in Rs per hour)	On-street parking price (in Rs per hour)
8 a.m.	Rs 20	Rs 20
9 a.m.	Rs 20	Rs 30
10 a.m.	Rs 25	Rs 35
11 a.m.	Rs 30	Rs 35
12 noon	Rs 30	Rs 35
1 p.m.	Rs 30	Rs 35
2 p.m.	Rs 30	Rs 45
3 p.m.	Rs 30	Rs 35
4 p.m.	Rs 30	Rs 45
5 p.m.	Rs 30	Rs 35
6 p.m.	Rs 20	Rs 30
7 p.m.	Rs 20	Rs 30
8 p.m.	Rs 20	Rs 25

Source: CSE

D. Enforcement strategies

Strong deterrence and compliance

There must be provisions of strict penalty against misuse, encroachment of public land and pedestrian space, diversion of parking area for other purpose, over charging, etc. All recommendations and measures will amount to nought without strict enforcement. As per the 2017 draft *Management and Maintenance of Parking Places in Delhi Rules*, in addition to Delhi traffic police and transport department, officers of civic agencies are empowered to challan vehicles and realize fines under the Motor Vehicles Act, 1988.

Use of technology

Global experience proves that, as an enforcement strategy, technology plays a critical role in efficient parking management. The latest draft parking rules also emphasize on the use of technology for parking enforcement and management. The technology employed in parking management should be able to do the following:

- Assess parking demand
- Reduce parking violations with the help of parking meters and other similar smart technologies
- Make it easy to pay through mobile payment platforms, including e-wallets, and debit and credit cards
- Be able to manage differential rates
- Be able to convey the availability of parking lots in a particular area, with the help of a parking app or equivalent to reduce the time people spend searching for parking spaces, thereby reducing vehicle kilometres travelled and fuel consumption

For instance, a popular system for collection of parking fare and management in many developed countries is the use of 'pay and display' system. Customer park their vehicle, purchase a ticket from a pay and display ticket machine for the duration of their stay and display this ticket on the dashboard of their vehicle. They are free to leave the car park when or before their ticket expires with no need to enter or exit via a boom gate.

The 'pay and display' includes seamless entry and exit experience for customers, with virtually no risk of restriction of access or loss of revenue, accepts coins and credit card payment, ensures full and total audit and reporting functions, the communication and management software allows parking tariffs to be amended as and when required, and machine malfunctions and full cash boxes are reported immediately to a central computer in a control room, thus reducing labour costs as the car park does not need to be manned.

Walking and cycling improvements

Building infrastructure for walking can significantly reduce the parking need in an area. It expands the range of destinations that a parking facility serves. Improving walkability increases 'park once' trips, which means parking at one location and walking to other destinations, thereby reducing vehicle trips and the amount of parking required at a given destination. Similarly, improvement in the cycling infrastructure can significantly reduce parking demand as well as traffic congestion. Large parking lots should have marked walkways that protect the pedestrians from the traffic and conveniently connect to footpaths.

Uniform code for parking contracts

Parking management and contracts must be governed by uniform conditions. These should include, among others, full details of contractors (through affidavits and physical verification) to prevent cartelization, adequate security deposit to check against misuse. No subcontracting should be allowed. Demarcation, signage, contract details and rates of the contract should be clearly displayed. It should be ensured that all contractors use hand-held devices. The tenure of the contracts should be a minimum of three–five years to achieve adequate technological upgradation.

Promoting shared parking

The most important strategy is the sharing of parking among different types of building premises and users. It essentially means that a single parking can be used by multiple types of users. This strategy is most successful when the parking facility has different peak periods corresponding to different type of users. The sharing can be within the same parking lot, where users share the parking space rather than being assigned reserved spaces. Off-street parking located in Jasola district centre can be used by DTC to park their buses at night when it remains vacant. Off-street parking locations in Jasola district centre have the capacity of parking almost 200 buses. Seeing the space crunch at depots in Delhi, the government is not been able to augment bus numbers. Not only will parking buses help solve the problem, but it will also reduce dead kilometers of DTC buses. In addition, parking spaces both 'off' and 'on' street can be utilized by residents of the nearby Jasola Vihar.

E. The way forward

This case study on Jasola district centre has demonstrated the application of PAMP. Similar exercises will have to be carried out for all delineated PAMP areas across the city. PAMP requirements will vary according to local land use in terms of commercial, residential or mixed land use, connectivity and nature of the parking demand. This case study has shown how all the issues are addressed comprehensively in an area. All urban local bodies will have to develop the capacity to prepare PAMPs.

This case study has shown that there are opportunities for improving parking management and enforcement with clear strategies. Based on this assessment SDMC can adopt PAMP approach for integrated management.

The generously available parking spaces—off-site and on-site—need to be demarcated on ground. A common management system or supervision for all available parking lots for harmonized management needs to be adopted. It needs to be ensured that all parking spaces in commercial buildings are fully utilized by the employees and visitors and there is no spillover on roads. To achieve this, stringent enforcement and pricing on roads and surface parking areas should be enforced in the entire area. All available parking spaces should be used as shared public parking.

As there is already oversupply of parking—in fact supply exceeds demand—there is no need for more standalone parking structures in the area. However, new commercial buildings, as and when built, should have provisions of shared public parking. That will be enough to take care of any escalation of demand in the future.

Since this area has ample public transport connectivity—metro line, bus systems, para-transit and aggregator taxis, effective parking pricing, limiting the legal parking area, and strong penalty for parking violations can help to effect a shift to other modes of transportation. However, the PAMP should indicate local area improvement in terms of safe access to metro stations and bus stations and walkability in the area.

In future, it is important to explore how the existing parking facilities in the commercial district can be shared for parking at night by other modes and also the neighbouring residential areas.

Parking contracts for the area should be worked out to include pricing and management principles, and for adoption of technology for management of parking operations, monitoring, and public information systems. The parking operator has to use different methods like mobile apps and parking space display board etc. to achieve optimal utilization.

At a city-wide level, taking a PAMP approach to parking management is not a matter of choice but should be mandated. There is no other way of doing parking management and enforcement. Sooner city governments adopt and mandate this approach with enforceable rules, more beneficial it will be.

Parking area management rules and guidelines that enable implementation of PAMP should be adopted. This requires an oversight authority with representation from all key implementation agencies, land owning agencies, enforcement agencies like traffic police, and professional experts in the city. Powers and authority of the concerned implementing bodies should be clearly defined and established. The same authority must also take a decision on parking pricing and its periodic revision.

PAMP must be prepared by urban local bodies by ensuring participation of a large body of stakeholders, including local residents and resident welfare associations.

Contract agreements with parking contractors and tendering of parking contracts must be done based on parking rules and PAMP design and strategies. Parking contractors will have to be made liable and accountable for carrying out changes and upgradation of parking lots, including ITS for information, monitoring and management. Common management of on-street and off-street parking facilities in a PAMP area for more efficient use and management must be promoted.

A proper revenue-sharing model between urban local bodies and parking contractors must be developed. A part of the revenue must be earmarked for local area improvements.

PAMP plans must get translated into local area maps demarcating all intervention points, including legal parking provisioning, no-parking areas, green areas that cannot be utilized for parking, underutilized places that can be developed for parking, and areas that require alignment modification to improve circulation as well as walkability for better access. These maps will be the basis of implementation of PAMP.

Monitoring and compliance with a strong deterrence will be critical for the success of PAMP strategy.

APPENDIX
Willingness-to-pay survey in Jasola district centre

What is willingness-to-pay survey?

Contingent valuation techniques are based on surveys for the assessment of non-market resources. While these resources provide people utility, certain aspects of them do not have a market price as they are not directly sold in the market. People receiving benefits from a beautiful view of a mountain would be a perfect example of such a resource.

Contingent valuation is in contrast to a price-based revealed preference model. Both models are utility-based. Typically, the survey asks how much money people would be willing to pay (or willing to accept) to maintain the existence of (or be compensated for the loss of) an environmental feature, such as biodiversity.

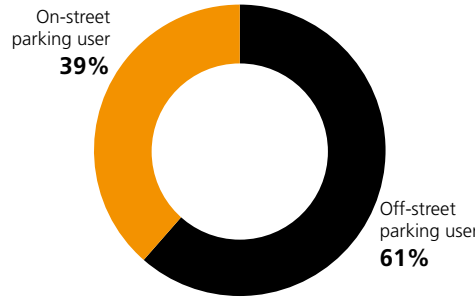
The same concept of contingent valuation can be extrapolated to semi-market goods, i.e., goods that are not explicitly commodities sold in the market, yet form an example of goods that are priced in many regions. Parking is one such good. The amount a person is willing to pay for parking one's vehicle in a commercial business district (CBD), for instance, would constitute such a contingent valuation study.

People must be given choice of alternative modes of transport; alternative parking areas; varying parking timings, fees and vehicle safety; proximity to the area of interest etc. It is these choices that would ultimately reveal people's preferences regarding these parameters. Based on this, a parking demand can be estimated at varying parking rates.

What have we done in our study area?

CSE hired a survey agency to carry out the willingness-to-pay parking survey in Jasola district centre. The survey was carried out from 8 a.m. to 8 p.m. at different 'on' and 'off' street parking locations. A total of 511 samples were taken. The samples were divided in a way so that they represent the actual parking picture. It was observed that the demand for off-street parking was 61 per cent and for on-street parking 39 per cent. Keeping the same fact in mind the samples were divided into 61:39 ratio (see *Graph: Share of samples taken for willingness-to-pay survey*).

Graph: Share of samples taken for willingness-to-pay survey



Source: CSE analysis

What have been the findings of the willingness-to-pay parking survey?

Almost two-thirds of parking users are male

The survey revealed that the majority of parking users in the study area were male. Out of the total 511 samples, 364 (or 71 per cent) were male and 147 (or 29 per cent) were female (see *Graph: Gender ratio of parking users*).

Almost all users are less than 40 years old

One of the interesting revelations of the study is that almost all parking users in the study area 40 years old or less. Only 3 per cent of the parking users are more than 40 years of age. The share of users of age less than or equal to 25 years was 27 per cent and that of those between 26–30 years was 29 per cent (see *Graph: Age-wise share of parking users*).

Majority of the users are employees and business owners

The majority of parking users (58 per cent) are employees and business owners. The second highest number is of shoppers (24 per cent). Only 16 per cent come to the area for recreational purposes (see *Graph: Purpose-wise share of parking users*).

Three-fourths are cars users in the study area

Cars (including taxis) occupy 75 per cent of parking spaces in the study area. Two-wheelers occupy 24 per cent of the parking space (see *Graph: Category-wise share of parking users*).

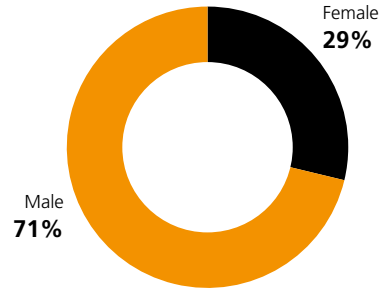
Most parking users come daily to the study area

58 per cent of parking users come daily to the area. 15 per cent visit the area once a week, 14 per cent twice a week, and only 13 per cent of users visit less than once a week (see *Graph: Frequency of users visiting the study area*).

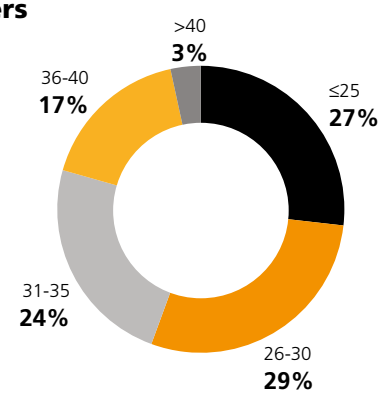
About one-fifth of the users park for more than eight hours daily

Nearly 21 per cent of the parking users in the study area park their vehicles for

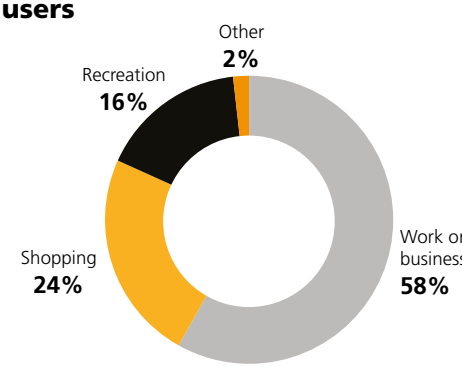
Graph: Gender ratio of parking users



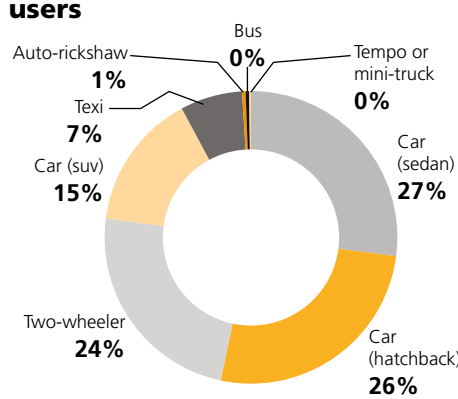
Graph: Age-wise share of parking users



Graph: Purpose-wise share of parking users

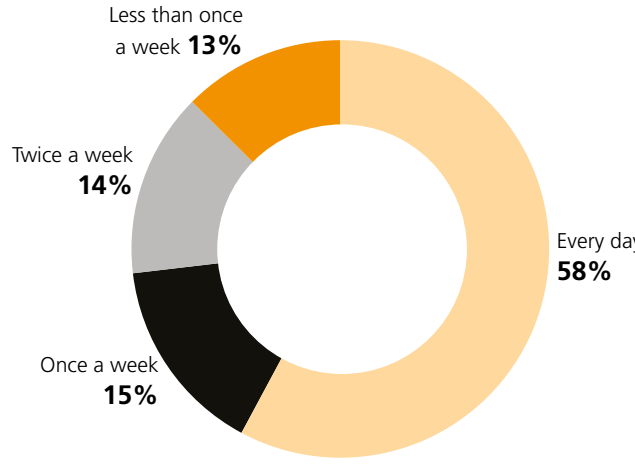


Graph: Category-wise share of parking users



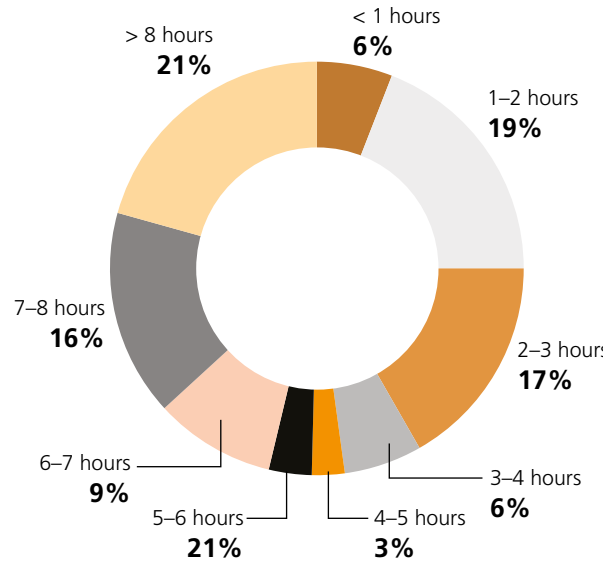
Source: CSE analysis

Graph: Frequency of users visiting the study area



Source: CSE analysis

Graph: Duration of parking in the study area



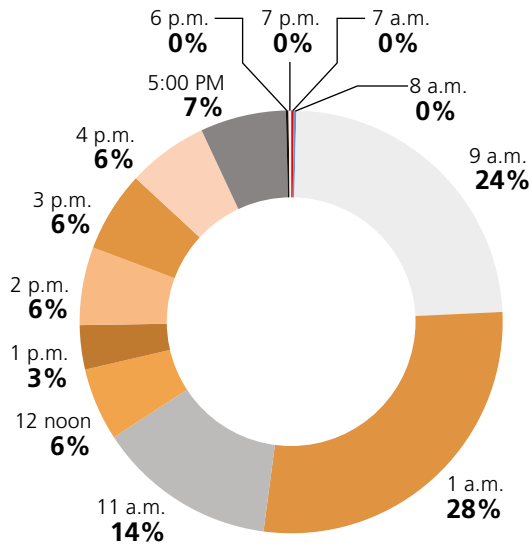
Source: CSE analysis

more than eight hours a day. The share of people using for five–eight hours was 31 per cent and those using for two-four hours was 21 per cent. The share of short-term parkers was as high as 25 per cent (see *Graph: Duration of parking in the study area*).

Two-thirds of the users arrives by 11 a.m.

This is in relation to people coming to work in the area. By 11 a.m., almost 66 per cent of these users reach Jasola district centre (see *Graph: Time of arrival in the study area*).

Graph: Time of arrival in the study area

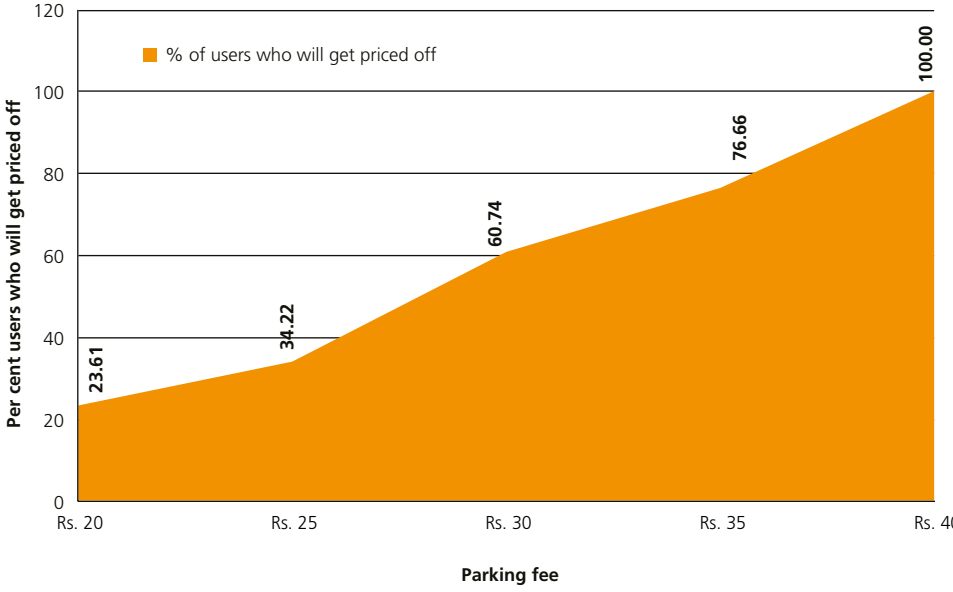


Source: CSE analysis

Almost one-fourth of the users will stop using the existing on-street parking if priced at more than Rs 20 per hour

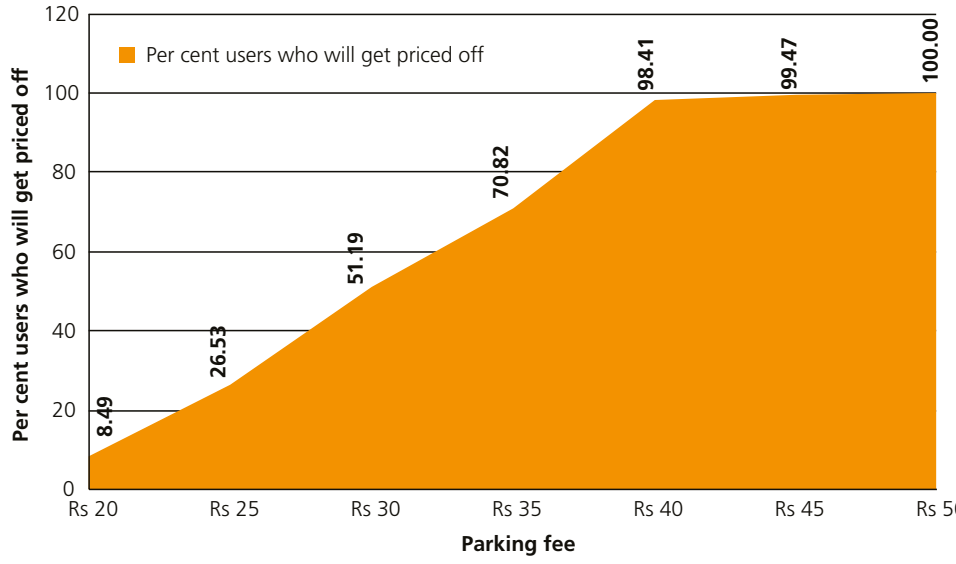
The maximum amount that users are willing to pay for existing on-street parking facilities in the study area is Rs 40. The willingness-to-pay parking survey found that 23.91 per cent (or about one-fourth) of users will pay a maximum of Rs 20 per hour for the existing on-street parking facilities. Similarly 34.22 per cent of users are willing to pay a maximum of Rs 25 per hour, and 60.74 per cent for Rs 30 (see *Graph: Percentage of users priced off at different parking charges in existing on-street parking facilities*).

Graph: Percentage of users priced off at different parking charges in existing on-street parking facilities



Source: CSE analysis

Graph: Percentage of users priced off at different parking charges in existing on-street parking with information systems, meter and digital payment



Source: CSE analysis

Maximum amount users are willing to pay for on-street parking with information systems, meters and digital payment is Rs 50 per hour

The willingness-to-pay parking survey found that the maximum hourly charge people are willing if they are provided on-street parking with information systems, meters and digital payment is Rs 50. More than half of the users, i.e., 51.19 per cent are willing to pay a maximum of Rs 30, beyond which they will stop using the parking. The important thing noticed here is that after the addition of parking information systems, meters and digital payment to the existing on-street parking facilities, the share of people willing to pay a maximum of only Rs 20 dropped from 23.61 per cent to 8.49 per cent (see *Graph: Percentage of users priced off at different parking charges in existing on-street parking facility with information systems, meter and digital payment*).

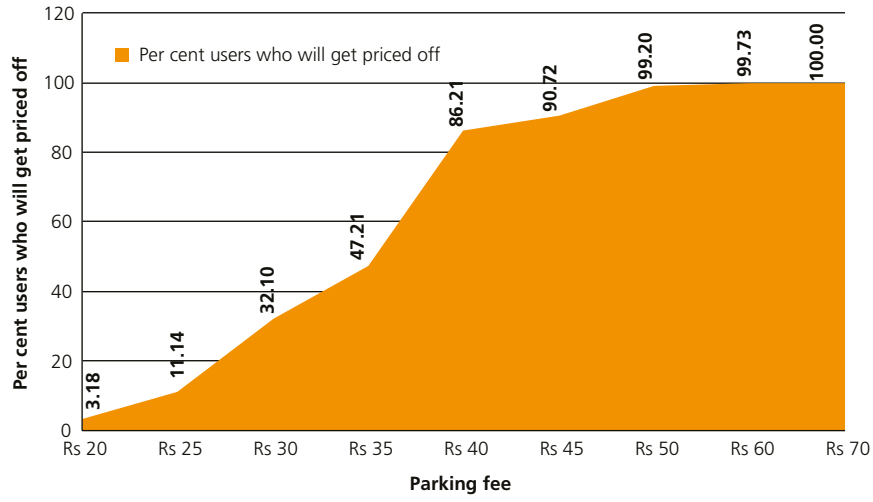
People are willing to pay more for multi-level parking

The maximum amount people are willing to pay for multi-level parking facility with parking information systems, meters and digital payment is Rs 70 per hour, which is Rs 20 more than they are willing to pay for on-street parking with the same facilities. One more important fact is that only a small share (3.18 per cent) are not willing to pay more than Rs 20 for an hour for such facilities (see *Graph: Percentage of users priced off at different parking charges in existing on-street parking with information systems, meter and digital payment*).

Users willing to pay more for off-street parking facilities

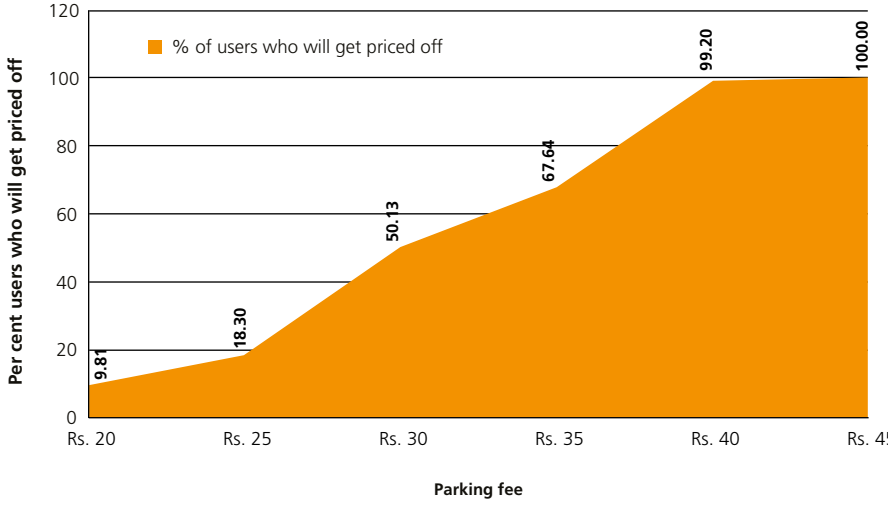
The maximum amount users are willing to pay for existing off-street parking facilities (Rs 50 per hour) is more than what they are willing to pay for existing on-street parking (Rs 40 per hour). Almost half of the users are not willing to pay more than Rs 30 per hour for existing off-street parking facilities. Also, the share of people willing to pay the minimum of Rs 20 per hour is much lower for off-street parking than on-street parking. Nearly 10 per cent will stop using off-street parking if the charge per hour increase to Rs 20, whereas 23.61 per cent will stop using on-street parking if charged as much (see *Graph: Percentage of users priced off at different parking charges in existing off-street parking*).

Graph: Percentage of users priced off at different parking charges in multi-level parking with information systems, meter and digital payment



Source: CSE

Graph: Percentage of users priced off at different parking charges in existing off-street parking

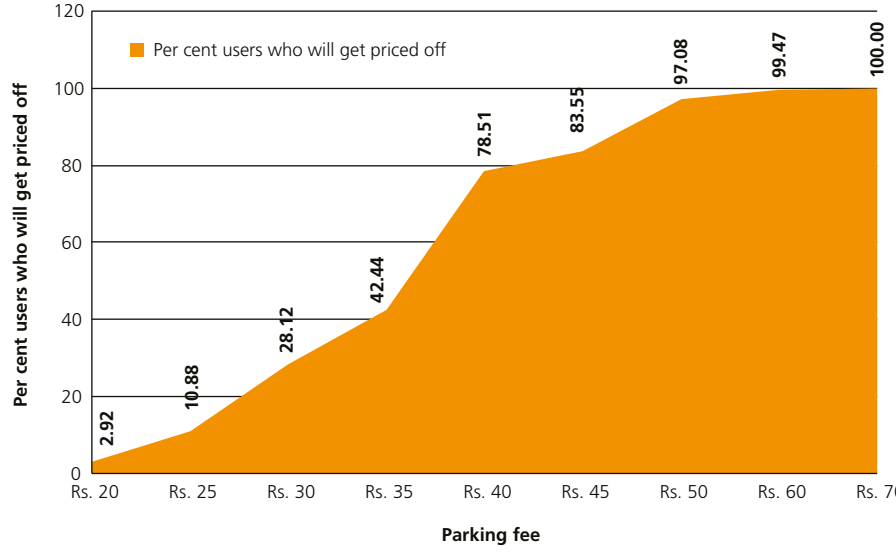


Source: CSE analysis

Dedicated bus or metro services in the area have a positive impact on parking prices

If dedicated bus and metro service is available in the area, the area becomes less congested and the overall public infrastructure improves. The survey found that these improvements are not lost of private vehicle owners, who are willing to pay more for parking in such a scenario. Also, the share of people willing to pay not more than Rs 20 for on-street parking is lowest with the share of 2.92 per cent (see *Graph 30: Percentage of users priced off at different parking charges in existing on-street parking facility if dedicated bus or metro services are available to Jasola district centre from their origin*).

Graph: Percentage of users priced off at different parking charges in existing on-street parking if dedicated bus or metro services are available to Jasola district centre from their origin

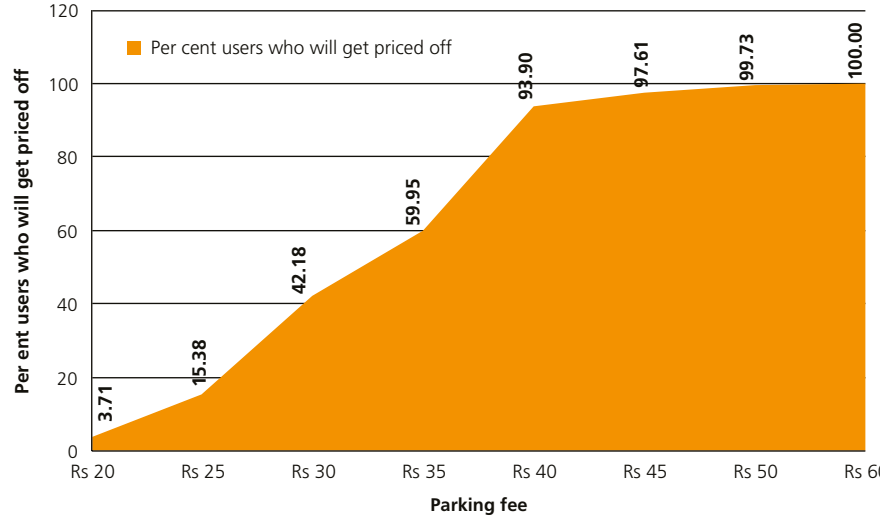


Source: CSE analysis

Maximum amount users are willing to pay for off-street parking is Rs 60 per hour

From the willingness-to-pay parking survey, it was clear that the maximum hourly charge users are willing to pay is Rs 60, if they are provided on-street parking with information systems, meters and digital payment. 93.9 per cent are willing to pay a maximum of Rs 40 beyond which they will stop using the parking. In this scenario, people willing to pay a maximum of Rs 20 drops from 9.81 per cent to 3.71 per cent (see *Graph: Percentage of users priced off at different parking charges for existing off-street parking facility with information systems, meters and digital payment*).

Graph: Percentage of users priced off at different parking charges for existing off-street parking facility with information systems, meters and digital payment



Source: CSE analysis

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9 Ibid

10 2017, Todd Litman, *Parking Management: Comprehensive Implementation Guide*, Victoria Transport Policy Institute. Available at http://www.vtpi.org/park_man_comp.pdf, as accessed on 20 August 2017

Box: Why do cities need parking area management plans?

1 2016, *Master Plan for Delhi—2021*, Delhi Development Authority, New Delhi. Available at http://dda.org.in/tendernotices_docs/may1/MPD-2021%20March2016BW190516.pdf, as accessed on 3 December 2016

Box: Some principles for capping parking supply

1. 2006, *Parking Spaces / Community Places: Finding the Balance through Smart Growth Solutions*, Development, Community, and Environment Division (1807 T) U.S. Environmental Protection Agency Washington, DC 20460. Available at http://pipta.org/wp-content/uploads/2014/04/Smart-Growth-Parking-Solutions.pdf, as accessed on 11 September 2017

2. 2015, Fei Lia and Zhan Guob, *Do Parking Standards Matter? Evaluating the London Parking Reform with a Matched-Pair Approach*. Available at https://www.london.gov.uk/sites/default/files/gla_migrate_files_destination/Li%20%20Guo_Do%20Parking%20Standards%20Matter.pdf, as accessed on 19 September 2017

With exploding motorization parking demand has become insatiable. Conventional urban planning has focussed on solving this problem by providing limitless and free or very cheap parking. Sprawling and infinite parking areas have become an iconic symbol of urbanity. This has not only incited more vehicle usage and ownership that chokes cities, it has also diverted valuable and scarce urban land from housing, basic services, and commercial and livelihood requirements of people. But no more. It is time to get out of this Malthusian trap.

The emerging good practice is to implement comprehensive area wide parking management plans that identify legal parking areas, penalize illegal parking, introduce variable pricing, allow neighbourhood-scale sharing of parking, protect local greens and parks, provide for night-time parking of public transport vehicles and commercial vehicles, ensure unhindered lanes for passage of emergency vehicles, and enable overall street improvement for all road users for safe access.

The underlying principle is that while organizing and modernizing parking management in and infrastructure of a city, regulatory and pricing tools need to reduce overall demand for parking and encourage shift to sustainable modes of transport. How to do this? Devil is in the detail. This case study of 'Parking Area Management Plan', therefore, highlights the key steps and principles that can help find a method in the madness.

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