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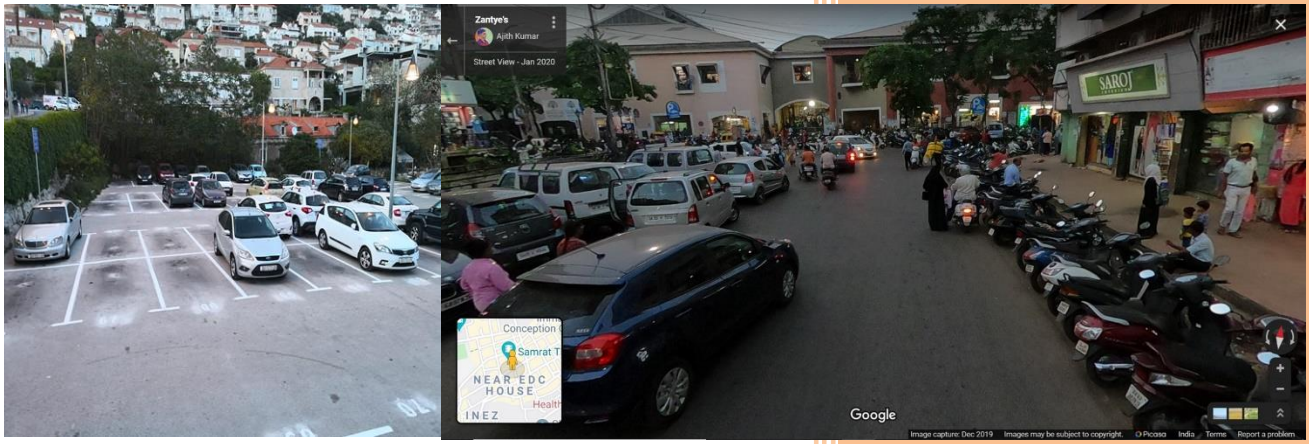

Smart Parking Solution at a Pilot Site in Panaji, Goa

Final Report

INTERNATIONAL URBAN COOPERATION
European Union

HANDS THAT CARE
CORPORATION OF THE CITY OF PANAJI

Prepared by - International Urban Cooperation (IUC- India)

For - City Corporation of Panaji

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Abbreviations

AMRUT	Atal Mission for Rejuvenation and Urban Transformation
AQI	Air Quality Index
CAGR	Compounded Annual Growth Rate
CAPEX	Capital expenditure
CBD	Central Business District
CCCC	City Command and Control Center
CCP	Corporation of the City of Panaji
CDP	City Development Plan
CMP	Comprehensive Mobility Plan
CO	Carbon Monoxide
ECS	Equivalent Car Space
EPC	Engineering, Procurement, and Construction
EU	European Union
GCoM	Global Covenant of Mayors for Climate and Energy
GHG	Green House Gases
GoI	Government of India
GSPCB	Goa State Pollution Control Board
HH	Household
IoT	Internet of Things
IPSCDL	Imagine Panaji Smart City Development Ltd.
IRR	Internal Rate of Return
IUC	International Urban Cooperation
JnNURM	Jawaharlal Nehru National Urban Renewal Mission
KTC	Kadamba Transport Corporation
UCAP	Urban Cooperation Action Plan
LEDS	Low Emission Development Strategies
LPWAN	Low-power WAN
LV	Land Value
NB-IOT	Narrow Band IoT
NMT	Non-motorized Transport
NPV	Net Present Value
OPEX	Operating expenditure
O&M	Operation and Maintenance
PoS	Point of Sell
PPP	Public Private Partnership
SCM	Smart City Mission
UN	United Nations
UPI	Unified Payment Interface

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Executive Summary

1. Background

Panaji, the capital of Goa State in India, has a total geographical area of 8.12 sq.km. and a population of 40,017 as per 2011 Census. The European Union's International Urban Cooperation (IUC-India) project is contributing to the Panaji – Dubrovnik city pairing through the development of a Urban Cooperation Action Plan (UCAP) for the city of Panaji. The key deliverable of the UCAP is a bankable project proposal developed by IUC India in cooperation with the City of Panaji for a 'Smart Parking Solution' pilot in the city.

2. Objectives

The objective of this proposal is to support Corporation of City of Panaji (CCP) in developing the Smart Parking Solution for a pilot site in Panaji. This report covers assessment of Panaji city and its current parking management system, review and comparison of different smart parking technology options, identification of a suitable option for Panaji city, brief on pilot site in Panaji, broad normative assessment of project costs and O&M costs, project structuring and risk management, and overall benefits of the Smart Parking Solution.

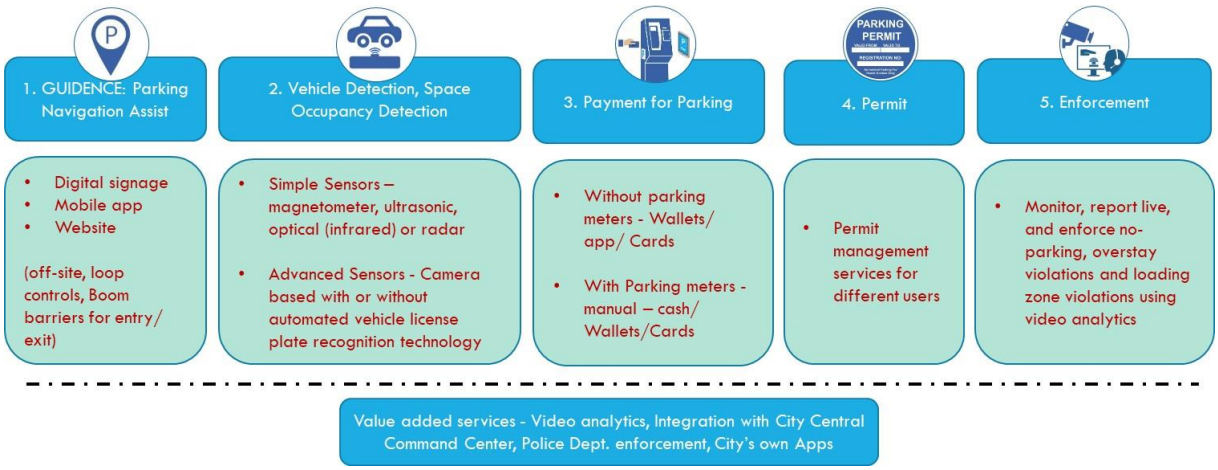
3. Parking management in Panaji – status

The current trend of increasing the number of vehicles in Panaji is creating pressure on the parking spaces, consuming the valuable urban land and streets. During the years 2010 to 2017, vehicle registration in Panaji has increased at a high Compounded Annual Growth Rate (CAGR) of 6%. On an average there are three personalised vehicles per household in Goa. As per the Parking Policy of Panaji city, the parking occupies 36% of the road area within the central business district of the city.

4. Smart Parking Solution - technology landscape and components

Smart Parking Solutions are a combination of various components and modules. Based on research on several global cities and their Smart Parking Solutions, it is observed that there are five critical components of a Smart Parking Solution. These are illustrated in the Exhibit E 1.

Exhibit E 1 Key components of Smart Parking Solution



Source: Secondary Research

5. Categorization of Smart Parking Solutions

As there is no definite classification of Smart Parking Solutions, they have been classified into three categories based on their key components:

- **BASIC SYSTEM:** Includes ground sensors, guidance through mobile app/ web & digital signages*, parking meter and / or payment app, provision for permit, enforcement and grievance redressal and CCTV for surveillance. In the case of off-street system - automatic boom barriers and looping system as additional components.
- **ADVANCED SYSTEM - I:** In addition to the Basic System it includes, CCTV surveillance & number plate recognition technology coupled with video analytics and data sharing with the ULB's system/ dashboard.
- **ADVANCED SYSTEM - II:** In addition to the Advance System-I, it includes integration with - City Command and Control Center (CCCC) and enforcement system of the police department. All the data generated by the vendor is pushed to the CCCC and integrated with the City's own app/ dashboard.

6. Learning from Indian cities' experience on Smart Parking Solutions

In Indian Cities, many of the Smart Parking Solutions have not been implemented even after the bidding phase for several reasons, such as too much focus on either technology or revenue to the ULBs, challenges in administrative and political acceptance, inadequate supporting IT infrastructure within cites, lack of citizen engagement and low levels of base tariffs. As seen in the case of Bangalore, Surat, Nashik, Jaipur, Vizag and other cities, the Indian cities prefer two types of project structures or contracts – Public Private Partnership (PPP) and Service provider through Bill of Quantity (BoQ).

7. Pilot Project

Corporation of the City of Panaji (CCP) has identified sites for Pay and Park. Currently, parking at some of these sites is managed by a private company but there is no adoption of Smart Parking Solution. CCP would like to incorporate smart parking elements to a specific pilot area near Central Business District (CBD), close to 'Our Lady of the Immaculate Conception Church'. The CBD area is visited by a lot of domestic and international tourists as it has many tourist sites including the famous church and casinos. The CBD area has following key characteristics:

- Total parking lots available for 4 wheelers are 123, which are marked by the yellow line in the Exhibit E 2.
- Currently there is a pay and park arrangement at the parking site managed by the local contractor. The contract is from 15 February 2020 to 14 February 2023.

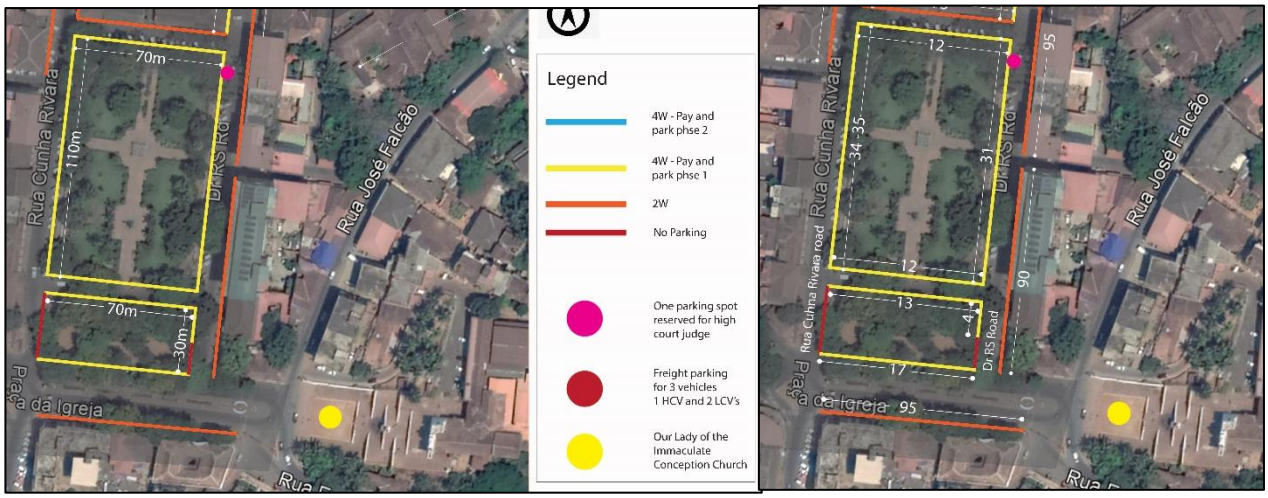
The proposed Smart Parking Solution pilot project at Panaji comprises of following components:

1. **Guidance:** Parking navigation assistance system will be a combination of mobile app, website, and digital display boards. Many tourists visit Panaji city, who may or may not have access to apps, hence there is a need for digital display boards placed at key locations to guide them.
2. **Sensors:** Magnetic ground-based sensors are recommended. But in case CCP wishes to bid out this project on PPP contract where the private player will be responsible for all risks associated with the technology, then CCP can allow use of any other inground sensor with provision for performance monitoring.
3. **Payment for parking:** shall be through app, website and through handheld PoS with various payment options such as e-wallet, credit & debit cards, and cash.

4. **Permitting and Grievance redressal system:** these components shall be integral part of the parking system.

5. **CCTV network** to be provided for surveillance.

Exhibit E 2 Panaji – Site for Pilot Parking Project, its length and number of parking lots



Source: CCP

8. Estimated Capital Expenditure (CAPEX) of the pilot project

The project CAPEX is estimated based on certain assumptions as given in the later part of this report. **As per the normative block cost estimates, the total estimated CAPEX is INR 8.14 million.** The costs may vary depending on the chosen components.

9. Estimated Operations and Maintenance Expenditure (OPEX)

The OPEX for the base year is estimated based on the various assumptions as given in the later part of the report. **The estimated OPEX for base year is INR 1.59 million for the year 2020.**

The OPEX for the base year is excluding debt servicing and taxes, and it is escalated at 5% per annum from the 2nd year onwards. In the base year, OPEX is 19.5% of the Total CAPEX. The replacement schedule of sensors is considered as: 35% of the sensors to be replaced in year six from the year of commencement of the project, additional 35% in the year seven and remaining 30% sensors to be replaced in the year 8.These estimates are based on the normative unit costs for a basket of components. The costs may vary if the CCP choses other components or makes.

10. Financial analysis

The financial analysis has been done for the base case and for various scenarios.

Base case analysis

In Base case analysis it is assumed that the average daily parking is for 9 hrs. per parking lot, average parking fee is INR 16.7 per hr. and average annual escalation of parking fees is 5%, average annual occupancy of parking lots is assumed at 60% of total capacity and estimated CAPEX is INR 8.14 mn. The replacement schedule of sensors is considered as: 35% of the sensors to be replaced in the year six from the year of commencement of the project, additional 35% in the year seven and remaining 30% to be replaced in the year 8. It is assumed that there is no revenue sharing by the private player with CCP.

Key findings are as follows -

- The project Internal Rate of Return (IRR) with seven years project duration, comes out to be 19% with a positive Net Present Value (NPV) of INR 500,000. This shows that the project is financially viable to be taken up on PPP mode with investment commitment by the private company.
- CCP has an option to choose between PPP and EPC plus O&M contract. If CCP choses to bid out this project on Public Private Partnership (PPP), it can consider the bid variable as – the annual revenue sharing by the private player with CCP and the bidder which is willing to share the highest revenue can be selected as a preferred bidder.
- If CCP decides to develop this project on Engineering Procurement and Construction (EPC) plus Operation and Maintenance (O&M) contract then, with the Base case scenario, it can earn a net revenue of INR 100,000 per annum. Net revenue is calculated based on the percentage (2.3%) of the total revenue at which the NPV becomes zero.
- However, if the project duration is 10 years, then both Net Present Value (NPV) and Internal Rate of Return (IRR) are negative indicating that it needs grant support for developing the project on PPP contract. To achieve a positive NPV, the minimum grant support required is 50% of the project cost, then the NPV for 10 years will be INR 220,000 and project IRR will be 12%.
- Hence, it is recommended to consider project duration as 7 years.

Scenario analysis

Further, it is observed from the scenario analysis that the finances of the pilot project are highly sensitive to revenue and operating expenditure. The sensitivity of the revenue depends on three factors – average base tariff, average annual escalation of tariff and occupancy of parking lots. Hence, it is recommended that CCP shall have a provision of 5% annual escalation in parking fees to make the pilot project financially viable. Additionally, the average occupancy of the parking lots can be maintained by proper communication and awareness among the users.

Exhibit E 3 IRR sensitivity to avg. parking fees, occupancy of parking lots and changes in OPEX

1. Project IRR vs Occupancy of parking lots			
Occupancy	55%	60%	65%
Project IRR	-ve	19%	37%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
Avg. parking fee INR per hr	16.7
CAPEX, INR mn	8.14

2. Project IRR vs Avg. parking fee			
Avg. parking fee	15.00	16.70	17.50
Project IRR	-ve	19%	30%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
CAPEX, INR mn	8.14
Occupancy	60%

3. Project IRR vs Changes in OPEX			
OPEX as % of CAPEX	17%	19.5%	22%
IRR	31%	19%	0%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
Avg. parking fee INR per hr	16.7
CAPEX, INR million	8.14
Occupancy	60%

11. Project structure

Pilot project's structuring and responsibility matrix depends upon the type of the contract. So, CCP has two choices based on the availability of the funds and financial viability of the project.

- **Option 1: Engineering Procurement and Construction (EPC) contract with O&M for 5-7 years**, in this type of contract, the responsibilities will be distributed among CCP and a private company. CCP will be responsible for investment for project CAPEX and OPEX. The revenue collected by the private player can be handed over to CCP. CCP can explore the option of implementing Smart Parking Solution on EPC plus O&M with the involvement of existing local player who is currently managing the Pay and Park in Panaji.
- **Option 2: CCP can adopt the Public Private Partnership (PPP) model**. If CCP does not have sufficient funds and grants to cover the entire CAPEX of the project. These types of PPP contracts can be for 5-7 years and if the viability gap funding upto 50% of the project CAPEX is provided then the project duration can be extended upto 10 years. In this case the private player will be responsible for almost all the key activities including bringing in investment for CAPEX. And CCP needs to make a commitment to set up a mechanism for annual tariff escalation. CCP can consider putting in viability gap funding upto 50% of project CAPEX and in lieu of that it can get fixed annual revenue share from the private player or concessionaire. CCP can explore the option of implementing Smart Parking Solution on PPP mode with the involvement of existing local player who is currently managing the Pay and Park in Panaji.

12. Risk management

The risks are the potential or perceived events that will prohibit the efficient and effective implementation of proposed activities. Smart parking technology is still not widely implemented in Indian cities. The report looked at some of the good use cases in Indian and global cities. One of the key learning was to take up a pilot project and then based on its experience the city should scale it up to city level. So, in case of Panaji city a pilot project is taken up to demonstrate the technology application in smart parking space. Similarly, another major learning is to go for the basic solution rather than focusing on high tech and data intensive solutions. So, in case of Panaji city a basket of components is proposed which comprises the basic system.

13. Benefits of the smart parking system

The benefits for the city include improved traffic flow, less congestion, and better mobility and living conditions. It further helps in getting additional revenue through increased capture rates and pricing changes powered by analytics. It will give recognition to Panaji as a smart innovator in urban space.

Smart parking can significantly curb air and noise pollution levels through sustainable urban mobility, saving time and energy, reducing traffic problems, etc. Local business benefits with ease of parking, resulting in greater customer footfall. It will provide an opportunity to generate targeted offers and promotions for citizens, based on parking data. Citizens benefit by reduced circling, leading to savings in time and fuel. Less overall congestion and general improvement in quality of life.

The adoption of the Smart Parking Solution will result in **annual fuel savings of 97,112 liters for cars** considering car parking demand of 4,146 lots. This is equivalent to estimated annual **Green House Gas (GHG) emission reduction to the tune of 228 tonnes of CO2e**.

14. Benefits of partnership with Dubrovnik

Dubrovnik and Panaji were paired as part of the European Union's International Urban Cooperation (IUC-India) project. The city to city pairing agreement was signed on 26th July 2018 by Panaji city and

on 11th December 2019 by Dubrovnik city. The Panaji city officials visited Dubrovnik city during 9-14 December 2019, while the Dubrovnik delegation visited Panaji during 13-16 November 2018. Dubrovnik contributed with very valuable technical advice and financial information.

Both Dubrovnik, and Panaji, are similar sized cities in terms of their population. Both are coastal cities and are favourite destinations for tourists.

The IUC programme is an opportunity for both city governments to learn from each other, set ambitious targets, forge lasting partnerships, test new solutions, and boost their city's international profile. The progarmme's activities support the achievement of policy objectives as well as major international agreements on urban development and climate change, such as the EU Urban Agenda, the United Nations (UN) Sustainable Development Goals, and the Paris Agreement.

15. Conclusion[1]

Since this is a pilot project, it is recommended that CCP should adopt Basic Smart Parking System, comprising of (i) guidance system with a combination of mobile app, website, and digital display boards; (ii) magnetic ground-based sensors; (iii) payment facilities shall be through app, website and handheld PoS with digital and cash based payment options; (iv) permitting and grievance redressal system; and (v) CCTV network for surveillance.

CCP needs to decide which project structure they would like to adopt for this pilot project and accordingly carry out the bidding process. Exhibit E 4 provides a brief on recommended project structures.

Exhibit E 4 Recommended project structures

SN	Project structure	Key features	Requirements
1	EPC contract	• CAPEX and OPEX by CCP • Pvt. player will be responsible for implementation and O&M for stipulated period • O&M duration 5-7 years • Revenue to be collected by the private player with an option to share with CCP • CCP has option to make a provision for revenue sharing by private player to CCP • Pvt. player will be paid on execution of work and post that - annually for O&M	• CCP to bid out project on EPC + O&M for 5-7 years • Bid variable can be NPV of CAPEX, OPEX and revenue. • Preferred bidder will be the one with lowest NPV.
2	Public Private Partnership (PPP)	• CAPEX and OPEX by pvt. player • Pvt. player will be responsible for implementation and O&M for stipulated period • Contract period: 7 to 10 years • Revenue collected and retained by the pvt. player • CCP can consider putting in viability gap funding upto 25% of the project CAPEX and in lieu of that it can get fixed annual revenue share from the private player or concessionaire. • CCP to make commitment for setting up a mechanism for annual escalation of tariff • CCP may consider the current parking provider as the pilot project provider.	• CCP needs to develop a Concession Agreement to be entered between CCP and the successful private player • And carry out the bid process with a bid variable as – the annual revenue sharing by the private player with CCP. • The bidder who is willing to share the highest revenue can be selected as a preferred bidder.

[1] This report on Smart Parking Solution for Panaji was prepared by Mahesh Harhare, Urban Policy Expert for IUC India.

Currently a local private company is managing the pay and park at the pilot site. CCP can work out a mechanism to involve the current local private company in this pilot project.

This pilot project will be immensely helpful in gaining understanding of the smart parking system, implementation challenges and benefits. Based on the success of this pilot project, CCP can upscale it to cover all the pay and park sites identified by it.

1 Introduction and Project Objectives

1.1 Introduction

The European Union's International Urban Cooperation (IUC-India) project is supporting the Panaji – Dubrovnik city pairing, the development of a Urban Cooperation Plan (UCAP) and a Climate Action Plan (CAP) for the city of Panaji and the development of a bankable project proposal for a Smart Parking Pilot Solution. Corporation of the City of Panaji (CCP) has conveyed their interest to receive a technical and financial analysis from the IUC team for a smart parking pilot project in Panaji. CCP has identified sites for Pay and Park to be taken up in Phase -I and Phase-II. CCP would like to incorporate Smart Parking elements to a specific pilot area.

1.2 Brief on IUC- India partnership and Panaji Dubrovnik city pairing

The International Urban Cooperation (IUC) programme enables cities in different global regions to link up and share solutions to common problems. It is part of a long-term strategy by the European Union to foster sustainable urban development in cooperation with the public and private sectors, as well as representatives of research and innovation, community groups and citizens. Through engaging in the IUC, cities will have the chance to share and exchange knowledge with their international counterparts, building a greener, more prosperous future. The IUC programme is an opportunity for local governments to learn from each other, set ambitious targets, forge lasting partnerships, test new solutions, and boost their city's international profile. Its activities will support the achievement of policy objectives as well as major international agreements on urban development and climate change, such as the EU Urban Agenda, the UN Sustainable Development Goals, and the Paris Agreement Brief on IUC – India partnership – three offerings.

The City of Panaji has focused on international cooperation as a path to low-carbon and sustainable urban development. They have worked as part of a diversity of bi- and multilateral international partnerships, including as a signatory to the Global Covenant of Mayors for Climate and Energy (GCoM), as well as in a bilateral IUC city-to-city pairing with Dubrovnik (Croatia). Panaji joined the GCoM in October 2015 and have since expanded the number and types of international climate initiatives in which they are engaged.

The city to city pairing agreement was signed on 26th July 2018 by Panaji city and on 11th December 2019 by Dubrovnik city. The Panaji city officials visited Dubrovnik city during 9-14 December 2019, while the Dubrovnik delegation visited Panaji during 13-16 November 2018.

Corporation of the City of Panaji (CCP) showed interest in cooperating with Dubrovnik city on smart parking related solutions.

1.3 Project Objectives

The objective of this proposal is to support Corporation of City of Panaji (CCP) in developing the Smart Parking Solution for a pilot site in Panaji. This report covers assessment of Panaji city and its current parking management system, review and comparison of different smart parking technology options, identification of a suitable option for Panaji city, brief on pilot site in Panaji, broad normative assessment of project costs and O&M costs, project structuring and risk management, and overall benefits of the Smart Parking Solution.

2 Background - Panaji City

2.1 City Profile

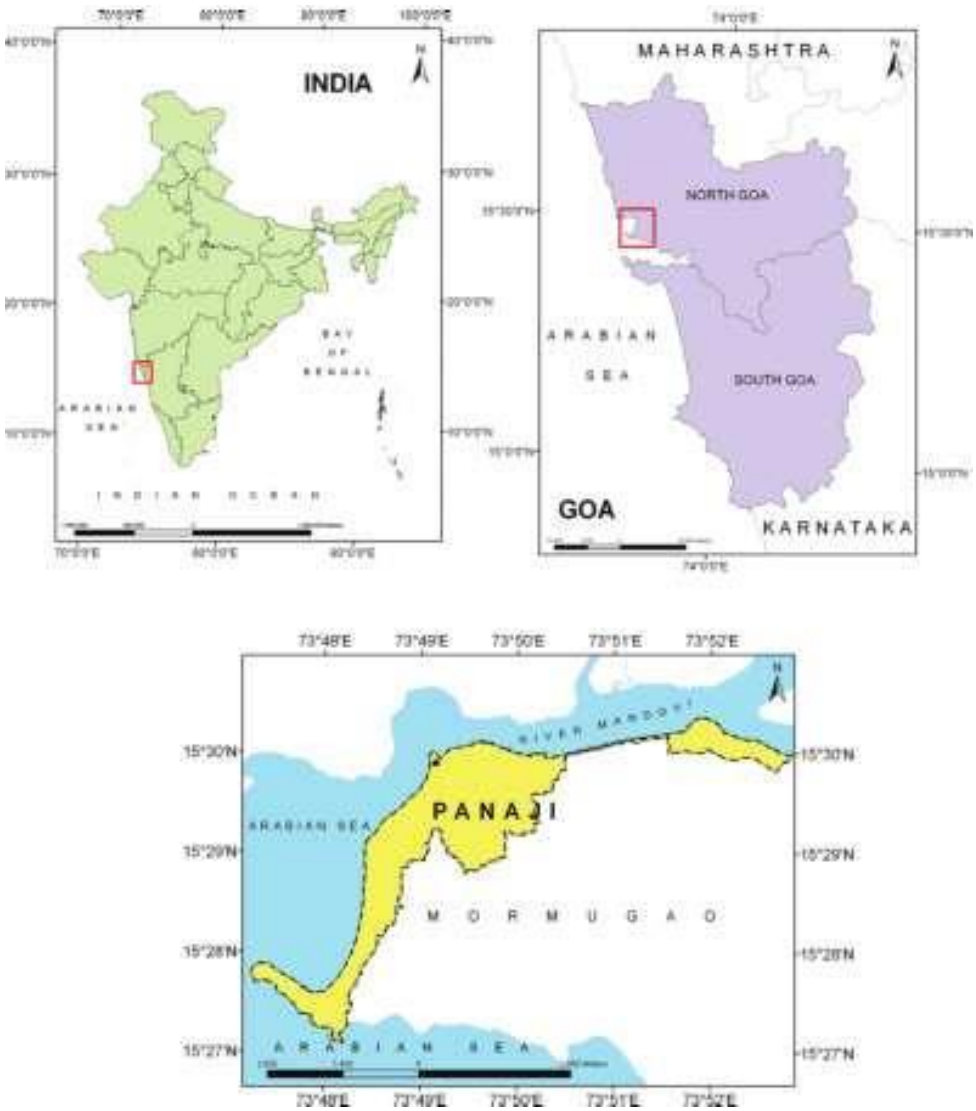
2.1.1 History, macroeconomic and topography

History

Panaji was annexed by India with the rest of Goa and the former Portuguese territories in 1961. Between 1961 and 1987, it was the capital of the Union Territory of Goa, Daman and Diu. Panaji became a state-capital on Goa's elevation to statehood in 1987. A new Legislative Assembly complex was inaugurated in March 2000, across the Mandovi River, in Alto Porvorim.

Panaji has been the administrative centre from the time of Portuguese rule. It is presently the state capital of Goa and the only urban centre in the state with the status of Municipal Corporation. Panaji is the third largest city of the state after Margao and Vasco. It has rich historical, political, commercial, educational, cultural and tourist importance. Panaji is a Municipal Corporation which is in Tiswadi taluk of North Goa district. It is the state capital of Goa and district head quarter of North Goa district.

Exhibit 2-1 Regional setting of Panaji



Source: Panaji City Development Plan, 2015

Economic activities

In recent years the city has emerged as a major tourist destination in the state due to its tourism resources, good connectivity, and availability of good tourist infrastructure facilities. The growing importance of the city as a tourist destination has increased the tourism based economic activities by many folds over the years. This has been supported by various trade and commerce establishments, hotels and restaurants, tours and travels and tourism-based art and artefacts. The city is also a major trading center for agricultural products and other commodities coming from the neighboring smaller towns and rural areas. The city also serves as the medical and education hub for urban and rural areas within the district as well as state.

The city of Panaji does not possess any industrial establishments; yet there are a number of industries at a range of 15 km from the city. The Corlim Industrial estate is one of the important industrial estates located near Panaji which has about 58 industrial units that enhances the economic prospects of the city. The city is an ecologically sensitive zone and not favourable for heavy and medium industries. Handicraft and cottage industries supporting tourism are prevalent in the city.

Topography

Physiographically the North Goa district can be broadly divided into four distinct morphological units from West to East.

- Coastal plain with marine landforms on the West (coastal area), vast stretch of plains adjoining the coastal plain (coastal area),
- Low dissected denudational hills & tablelands towards the East, (mid lands) and
- Deeply dissected high Western Ghats denudational hills along the Eastern most part of the district. (ghats)

Saline soil in the district occurs in the flood plains of Zuari and Mandovi rivers in Tiswadi, Bardez, Pernem and Ponda taluks which includes Panaji city also. The soil in this region is deep, poorly drained and less permeable. It is saline, high in pH and contains humus and organic matter. The major crops grown are paddy, cereals, millets, pulses & oil seeds, sugarcane, coconut, arecanut and cashewnut.

2.1.2 Climate

Temperature

Due to maritime influence, the diurnal range of temperature during the day is not large. The diurnal range is the least being 4 to 6° C during monsoon season and increases to the maximum of 10 to 20°C during December & January. May is the hottest month where the mean daily temperature increases to 30°C. January is the coolest with mean daily temperature of about 23°C. It is noted that the day temperature is the lowest in the monsoon months of July and August and not in the cool winter months of December and January. The temperature is highest (around 33°C) in pre – monsoon months of April & May and again in post monsoon months of November & January.

Humidity

Due to proximity to the Arabian Sea, humidity throughout the year in Panaji is more than 60% with a range from 80 to 90% during monsoon period. The relative humidity is higher during the months of July to September. During the months of December and January the difference between the Relative Humidity (RH) recorded at 08:30 hours and 17:30 hours is quite significant, as winter sets during these months. The weather is mostly foggy during dawn and at dusk during the rainy season.

Rainfall

Panaji receives rainfall from South-West monsoon between the months of June to September. As a result of orographic influence, rainfall increases towards the Western Ghats. Over 90% of annual rainfall occurs during monsoon months of June to September. About 32% of the annual rainfall is received during July. The average annual rainfall observed in the city is 3,124 mm which is higher than the district average of 2,932 mm.

Wind Directions

Throughout the year the wind flow in the morning is generally from East towards North – East direction during the months of October to April while it flows from West to North –East side in the month of May[2]. In the afternoons, the wind blows towards West or North West direction due to the influence of sea breeze along its coast. In the monsoon season wind direction is mostly westerly throughout the day. The winds are strong during monsoons while the moderate rest of the year.

City Corporation of Panaji (CCP)

CCP has a total geographical area of 8.12 sq.km. which is divided into 30 administrative wards. It has total population of 40,017 as per 2011 Census with a density of 4,928 persons per sq.km. The total population of the Panaji city along with the urban agglomeration areas is 1,14,759 as per 2011 Census and comprises a total area of 86 sq.km. The Panaji urban agglomeration area (PUA) consists of CCP area as well as adjoining urban pockets which includes seven outgrowth areas and four census towns (CTs). The seven out-growth areas are Panelim, Morambi-o-Grande, Renovadi, Morambi-o-Pequeino, Cujira, Taleigao, Durgawado; and four CT are Chimbel, Murda, Calapor and Bambolim.

2.1.3 Demographics

Historical Population

The city population growth has been fluctuating over the past five decades mostly due to the changes in the area under jurisdiction of CCP. As per Census 2011, the total population of Panaji city is 40,017 which is a decline from 2001 Census population of 59,066. This is due to exclusion of Taleigao and Durgawado, which were part of Panaji Municipal Council in Census 2001 and were made outgrowths in Census 2011. In 2002, when Panaji gained the status of Municipal Corporation by incorporation of the Corporation of City of Panaji Act 2002, these areas were excluded from the jurisdiction of Panaji resulting in reduction of population. Exhibit 2-1 presents the population growth trend in the last five decades.

Exhibit 2-2 Historical population and decadal growth rate

Year	Population, No.	Decadal growth rate, %
1971	34,953	-
1981	43,165	23.49
1991	43,349	0.43
2001	59,066	36.26
2011	70,991 (CCP+ outgrowth)	20.19
2011	40,017	N.A.

Source: City Development Plan for Panaji, 2015

[2] Source: CDP for Panaji, 2015

Projected Population

As per CDP 2015, the projected population of Panaji city is estimated to be 100,012 in 2021 and 173,756 in 2041. Refer Exhibit 2-3.

Exhibit 2-3 Projected population of Panaji city

	2014 esti.	2021	2031	2041	Growth (2021-31)	Growth (2031-41)
Base population (CCP+ Outgrowth)	75,945	88,892	115,684	1,51,367	30.14%	30.85%
Floating population (daily)	6,468	7,430	9,059	11,043	21.92%	21.90%
Tourist population (Daily)	2,480	3,690	6,458	11,346	75.01%	75.69%
Total population	**84,893**	**1,00,012**	**1,31,201**	**1,73,756**		

Source: City Development Plan for Panaji, 2015

As per the research paper published by The Energy and Resources Institute (TERI), formerly Tata Energy Research Institute. Every year, two million visitors land on Goa. North Goa district is a major tourist destination and commonly termed as a "hub of a variety of tourism-related activities". The researchers point out that over 500,000 tourists visit the beaches and other coastal places of this district each year. Currently, tourism officials estimated a total of two million tourists visit the province of Goa each year, of which nearly a 250,000 are foreigners[3].

Average Household Size

The total number of households in the Panaji CCP and its outgrowth areas is 17,807 and the average household size is 3.9 persons per household. It is lower than the taluk average of 4.2 persons per household and district average of 4.3 persons per household.

Literacy Rate

The literacy rate in Panaji city has increased gradually from 79% in 1991 to 87% in 2011. The average literacy rate in the Panaji city region is 85%. Thus, the average literacy rate of the city as well as the city region is higher than the taluk average of 82% and district average of 81%. The city is a major educational centre with educational facilities like pre-primary, primary, secondary, higher secondary schools and degree colleges.

Sex Ratio

The average sex ratio (number of female population per 1000 males) of the CCP has increased considerably from 882 in 1971 to 981 in 2011. The average sex ration in the city region is 973 as per 2011 census. The average sex ratio in CCP as well as city region is lower than the district average of 1,038 and taluk average of 1,035. Hence the city shows a healthy increase in sex ratio from 1971-2011 decade.

2.2 Urban Planning and Development initiatives

Following are list of urban planning and development initiatives and similar plans taken up by CCP for improvement of the urban mobility and parking system within Panaji city.

2.2.1 City Master Plan

In relation to the parking strategy, as laid down in the Master Plan for Holistic Development of Panaji City, the target was to reduce the number of the parked cars on street, and hence the public space can

[3] Source: CDP for Panaji city

be used by pedestrians. The next goal related to parking in the Holistic Development Plan is to maintain or slightly increase the total number of parking spaces.

2.2.2 City Development Plan (CDP)

The City Development Plan (CDP) was prepared under the government of Indian scheme - JnNURM[4]. The CDP proposal for Panaji has taken into consideration various studies and the project proposals under Traffic and Transportation were formulated based on the components proposed in these study reports.

One of the major proposals was the Decongestion Model for the city centre of Panaji. The decongestion model for Panaji predominantly addresses three main issues, apart from the change in traffic directions: a. Bus Rapid Transit, b. Parking strategies, and c. Pedestrian Environment.

Under the Parking Strategies - various parking sites have been identified to ensure proper working of the decongestion model. It recommends formulation of appropriate parking policies, including parking hours and rates, for all residential areas around the city to discourage haphazard parking around the proposed parking sites. The identified parking locations are mainly divided into three different categories:

- Off-site multi storey parking in the periphery – Multistory parking facilities in the peripheral areas for the population, which is commuting from the peripheral areas of Margao, Vasco, Porvorim, etc., to the North-East or from Miramar, Dona Paula to the South-West. To be located at interchange transit point e.g. Kadamba Bus stand where the hop on hop off buses can be easily accessible.
- On-site parking in the CBD – Dilapidated government structures like P.W.D. garage and other government buildings with the possibility of providing enough parking spots, like Junta House and Municipal Market, have also been considered as on-site parking areas. Multi-level parking would be the best option to tap the fullest parking potential of these spots/ parking space in the CBD wherever possible.
- On street parking in the CBD - All designated parking streets in the CBD will have on street parking along them, Typical road widths have been proposed for four-wheeler and two-wheeler parking as shown in Exhibit 2-4.

[4] JnNURM: Jawaharlal Nehru Urban Renewal Mission

Exhibit 2-4 Proposed on site and on street parking facility in the core city under CDP

2.2.3 City Comprehensive Mobility Plan

City Mobility Plan (CMP) for Panaji (2008)

The city of Panaji prepared the first Comprehensive Mobility Plan (CMP) in the year 2008. The CMP emphasizes on improving eco-friendly public transportation such as trams, pedestrianisation, and promotion of Non-motorized Transport (NMT).

The City Mobility Plan for Panaji (2008) discusses components such as NMT, ferries and waterways. CMP talks about introduction of an eco-friendly public transport system such as trams and promoting pedestrianisation and the use of non-motorized vehicles. CMP proposes to encourage NMV and pedestrians by introduction of dedicated cycle tracks, walkways, foot-over bridges, zebra crossings, footpath up gradation and pedestrian precincts. CMP included proposals to make major heritage, tourist, and retail destinations as pedestrian friendly zones. There are also proposals to strengthen the ferry system to allow cross movement of people as well as vehicles along with a cruise terminal near Fort Aguda, regulated by Panaji Port.

Comprehensive Mobility Plan for The State of Goa (2017-18)

Imagine Panaji Smart City Development Ltd. (IPSCDL) has prepared a Low Carbon Mobility plan for sustainable regional transport over a 20-year planning horizon, known as the Comprehensive Mobility Plan (CMP) for the State of Goa. Some of the key recommendations of this Plan with respect to parking management are as follows –

- Facilitate organized parking for various types of vehicles
- Adopt smart parking technologies by delineation and numbering of parking space along with parking sensors, providing parking information via internet and phone, and provision of parking meters.
- Provide parking spaces at the Jetties: parking spaces should be provided near the jetties for parking of two wheelers and cars because some of these vehicles are transported by ferries.

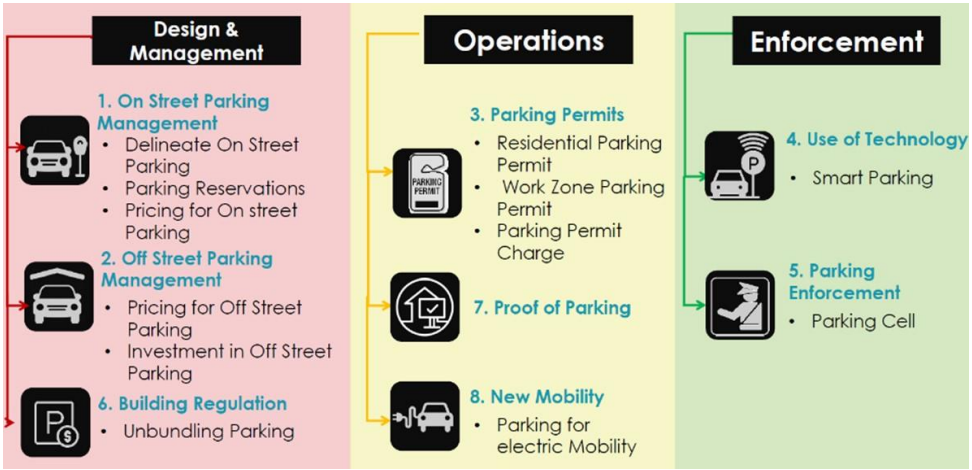
- Allocate parking bays for auto rickshaws at crucial nodes such as bus terminals, busy commercial areas, shopping malls, theatres etc., with proper signages and way findings. (average of 3 Equivalent Car Space (ECS) at a spacing of 600 m is suggested)
- Make all on-street and off-street parking as pay and park
- Keep a provision for reducing parking charges during off-peak hours and discounted parking rates for the off-street parking
- Encourage short term parking by adopting telescoping parking charges which increase with the duration of parking
- Make a provision for displaying parking charges for an off-street parking facility
- Make a provision to allow free usage of the off-street parking spaces against bulk payments during special events

2.2.4 Panaji Parking Policy

Draft Parking Policy for Panaji city was prepared in November 2018. The purpose of this policy for Panaji is to provide guiding principles and policies for the management and supply of parking in Panaji city. The policy enables in approaching all the parking issues in a consistent manner considering the sustainable transport approach. Salient features of the policy are as follows –

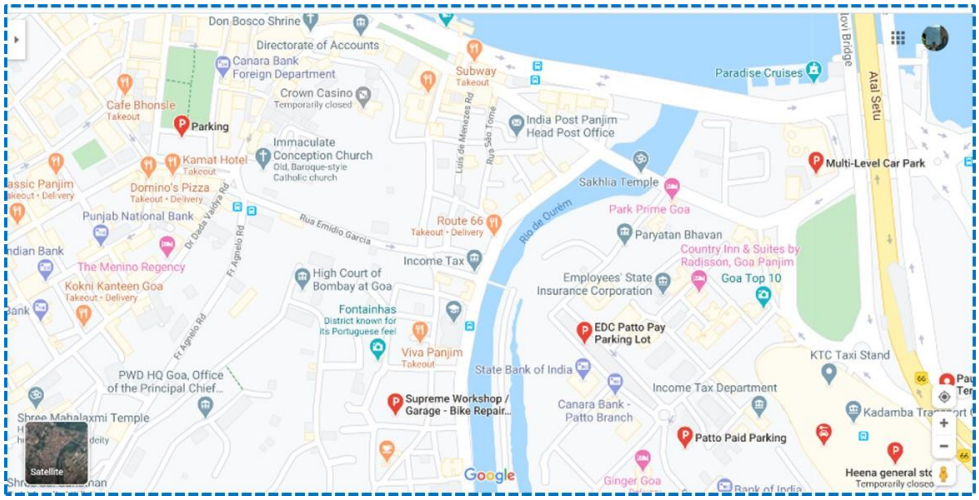
- Street surveys have been carried out to identify demand and supply of parking
- Key streets, junctions, and places are delineated for parking delineation
- One of the key recommendations is to adopt smart technology for parking management
- The Policy further recommends setting the parking charges or the tariff based on the set formula. The criteria for parking charges shall include Land Value (LV), Vehicle Type and Duration of Parking, Parking District, Existing Demand in the parking. City has been divided into different parking zones and a factor has been allotted to each zone.

Exhibit 2-5 Key pillars of Panaji Parking Policy



Source: Panaji Parking Policy

Exhibit 2-6 Selective parking lots identified under Parking Policy of Panaji



Source: Panaji Parking Policy and Google maps

2.2.5 Panaji Smart City Plan

Panaji city is selected among 100 smart cities in India under the Smart City Mission of Government of India. Under this mission, Panaji city has prepared the Smart City Proposal (SCP). In SCP, Panaji city identifies following key issues

- Inadequate amenities for the increasing tourist population: mobility, parking facilities, sanitation, solid waste management and tourist accommodation
- Higher concentration of commercial activities in the city causes traffic congestion, problems due to on street parking, loss of pedestrian space, air and noise pollution

To comprehensively address the parking management issue, it further identifies key actions as given below –

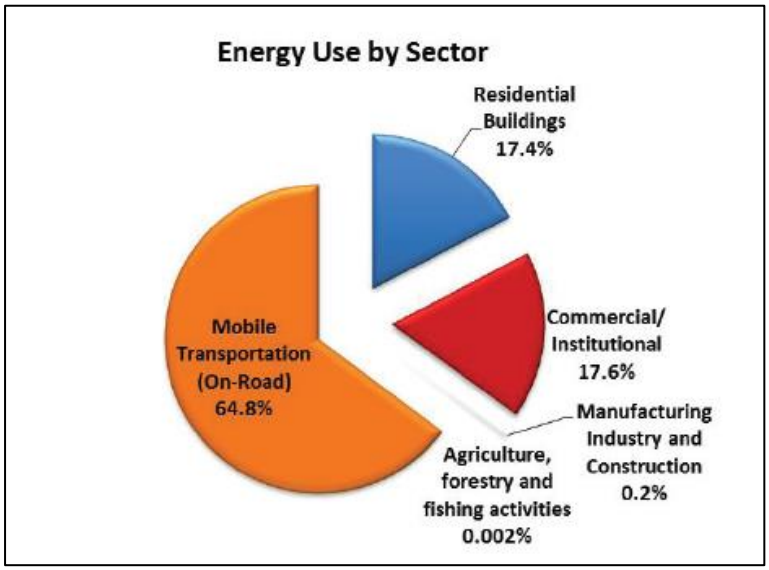
- Opening of underutilized Patto area and Patto parking after office hours for the city as a vibrant area for event-based tourism (Patto Cultural zone), with Creek side cafes and waterfront promenades.
- Designated parking free roads with citizen participation in Mala Heritage Zone to enhance the image of the area and pay parking for commercial and tourist vehicles around Church square.
- Smart Parking Solution - City wide parking management system that includes locators and automated fare collection
- fees from parking and market facilities: Multi-level parking facilities and development of Bus Terminal would be on PPP mode of development. However, on-street parking shall be leased to third party and lease proceeds from the same would be collected on a periodic basis.

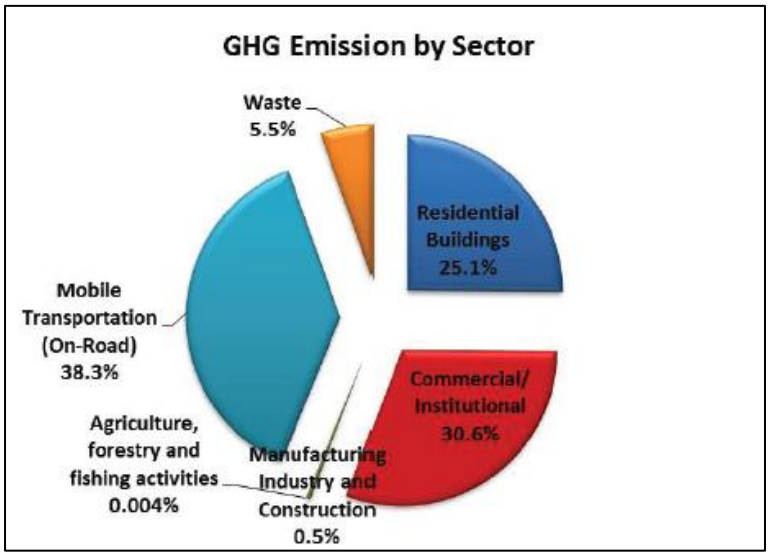
2.2.6 Panaji Climate Action Plan

The Low Emission Development Strategies (LEDS) for Panaji City was prepared in November 2015. ICLEI South Asia, with financial assistance from the European Commission and in partnership with UN-HABITAT, is supporting the Corporation of The City of Panaji (CCP) in implementing the project - Promoting Low Emission Urban Development Strategies in Emerging Economy Countries (Urban-LEDS). The strategies have been recommended based on the local priorities and plans and will inform the proposals being developed for Panaji under the Government of India's Smart Cities Mission. The

per capita GHG emission of Panaji city at 3.04 tonnes of CO2e is substantially high compared to the national per capita average of 1.43 tonnes of CO2e due to considerable tourist influx.

Exhibit 2-7 Snapshot of energy consumption and resultant GHG emissions by sector in Panaji





Source: Low Emission Development Strategies (LEDS) for Panaji City, 2015, by ICLEI South Asia

As per the LEDS assessment, Total Community scale Energy use in 2013-14 was1,195,018 Giga Joules. And the largest energy consumers are Transport Sector (64.8%), Commercial and Institutional Buildings/Facilities Sector (17.6%); Residential Buildings Sector (17.4%). The largest GHG emitters are Transport Sector (38.3%) followed by the Commercial and Institutional Buildings/Facilities Sector (30.6%).

The prominently used energy sources are petrol (37.8%), electricity (27.7%) and diesel (27%). And their corresponding share of GHG emissions are Petrol (23%), Electricity (55.3%) and Diesel (17.5%) respectively.

The measures and specific actions proposed under the low emission development strategy for Panaji city build upon the city's priorities and sustainable initiatives already identified across sectors under various plans.

The recommended structural and non-structural measures for the transportation sector are:

1. Structural measures related to parking management:
    - Implement intelligent parking management system and provide multilevel parking spaces within the core city area with connection to bus, railway or ferry lines (public transport).
    - Implement Intelligent Traffic Management Systems using technology to optimize vehicle movement, reduce congestion, improve safety.
2. Non-structural measures related to parking management:
    - Enforce motorized vehicle free zones in core city area
    - Develop and implement parking strategies such as demarcation of paid parking zones, dynamic parking pricing based on time and locations

It further estimates that the potential GHG emission reduction by adoption of the Intelligent Parking Management System will result in annual fuel savings of 97,112 liters for cars considering car parking demand of 4,146 lots. This is equivalent to estimated annual GHG emission reduction to the tune of 228 tonnes of CO2e.

3 Urban Transport and Parking in Panaji - Status & Challenges

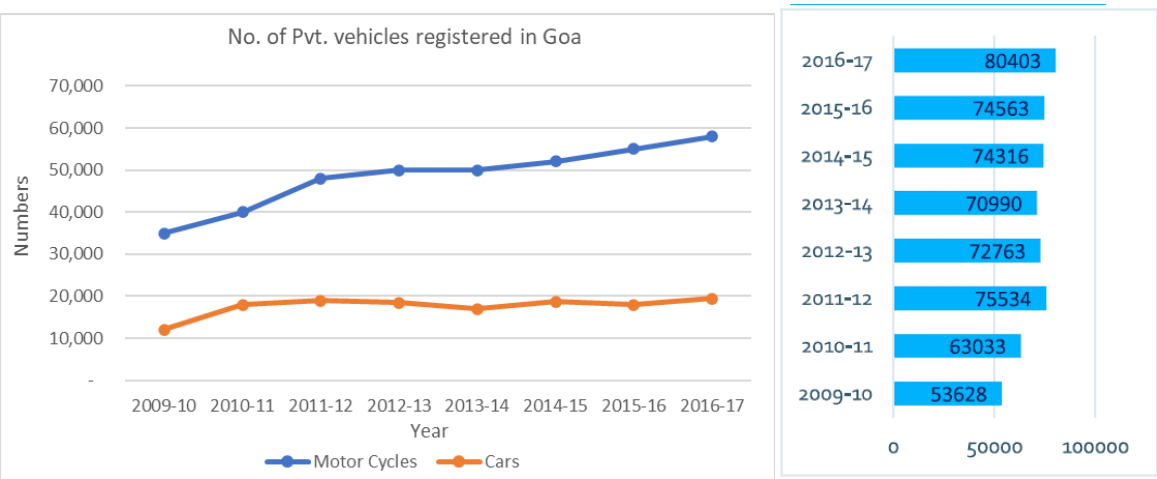
3.1 Status of Urban Transportation in Panaji

3.1.1 Personalised transport

Panaji city, like other Indian cities, is undergoing rapid urbanisation since the last few years. Rapid urbanisation and increase in per capita income have resulted in substantial increase in private vehicle ownership. At the same time, the public transportation system has not improved much, which led to further increase in private vehicle ownership. During the year 2010 to 2017, vehicle registration has increased at a high CAGR of 6%. The average vehicle ownership per HH in goa is 3 for a HH size of 4.2 persons per HH.

Being the most preferred mode of transport, the increasing number of private two wheelers and four wheelers in the city over the years has elevated the traffic congestion and parking issues. The average road width in the core city of Panaji was planned during the Portuguese period which does not allow for continuous flow.

Exhibit 3-1 No. of private vehicles registered annually in Goa



Source: Draft Parking Policy of Goa

3.1.2 Public Transport

The public transport system in Goa predominantly includes bus transport system. Currently the Kadamba Transport Corporation (KTC) has been assigned the power to operate and maintain the public transport system in Panaji. KTC operates buses in and outside Goa state. Traffic management is assigned to the traffic police department. Operation, maintenance, and asset management is also delegated to the traffic police department. The Smart City Proposal for Panaji city highlights lack of adequate and reliable public transport facilities, both within Panaji and for connecting outgrowth areas to Panaji as a key challenge.

Apart from this motor cabs, autorickshaws and pilots (motorcycles) also serve the purpose of passenger transport in the state which form the major mode of transportation in Goa.

One of the biggest issues in Panaji is the inadequacy of the public transport system. The details on modal share of public transport in Panaji city is not available, however in case of Goa state the share

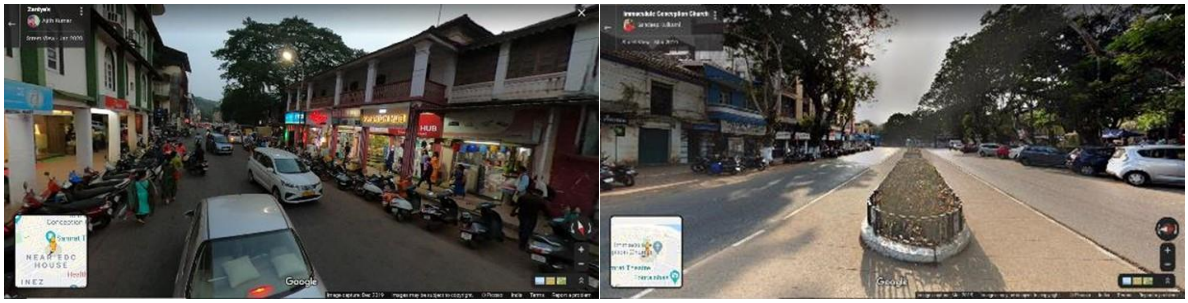
of public transport is 11.4%[5] of the total trips in Goa. Public transport routes are not comprehensive and do not cover all areas of the city. The existing bus services in the city are insufficient and inadequate.

3.1.3 Status of parking infrastructure

The current trend of increasing vehicle numbers in Panaji is creating pressure on the parking spaces, consuming the valuable urban land and streets. As per the Parking Policy of Panaji city, parking occupies 36% of the road area within the central business district of the city.

Exhibit 3-2 Key features of parking system in Panaji

Source: Draft Parking Policy for Panaji city



Source: Google Images of Panaji city

Pay and park at Patto Plaza, Panaji

EDC Limited (A Government of Goa Financial & Investment Corporation) had appointed a private operator to manage the pay and park system at Patto Plaza, Panaji. As per the tender document the contract was till 31 March 2019. The parking fees were collected by the licensee from vehicles parked in the parking lots of Patto Plaza as per the schedule of fees fixed by EDC for different categories of vehicles. The parking lots are fixed at Patto Plaza, for different categories of vehicles, as marked on the road.

The licensee was responsible for issuing monthly passes for persons who have offices at Patto Plaza or who work at Patto Plaza or who regularly visit Patto Plaza for work, without giving any assurance or guarantee of Parking space to such pass holders.

[5] Source: CMP for Goa State, March 2019

3.1.4 Pay and Park sites identified by CCP

The District Magistrate of North Goa and CCP have notified[6] Nine sites in Phase- I for the Pay and Park for parking of two wheelers and 4 wheelers in the City of Panaji. It further identifies nine more sites to be taken up in Phase- II. List of Nine Pay and Park sites identified in Phase-I are given in Exhibit 3-3 and Exhibit 3-4. The lengths are worked out based on the google map.

Exhibit 3-3 Pay and Park sites identified in Panaji in Phase -I

Source: CCP and google map

Exhibit 3-4 Pay and Park sites identified in Panaji in Phase -I

S.N	Location	Length (approx.)
S1	18th June road commencing from junction of A.B.Road, Elvina Britto Road and Cunha Riveira road to D.B. Marg via Pharmacy College.	815 mts
S2	A.B Road commencing from John Paul building to Caritas Complex	862 mts
S3	Dom Joao de Castro road commencing from Old Patto Bridge to Old Secretariat	392 mts
A1	Elvina Britto road (Church Square)	1,741 Sq.m
S4	Roque Souza road commencing from Elvina Britto road to M.G. road via Velhos Filhos building.	200 mts
S5	Cunha Riveira road commencing from 18 th June road to M.G. road Via Hindu Pharmacy.	200 mts
S6	Link road between Cunha Riveira road and Roque Souza road.	Link road 1 -75 mts Link road 2 – 75 mts
S7	Messias Gomes road commencing from road between Cunha Riveira road and Roque Souza road	80 mts
A2	Campal Heritage Precinct.	800 mts

*Source: CCP; * S indicates Street ** A indicates Area*

List of Nine Pay and Park sites identified in Phase- II[7] are given in Exhibit 3-5 and Exhibit 3-6 The lengths are worked out based on the google map.

[6] Source: Notification by Office of The District Magistrate, North Goa, dated 31/12/2019 and Corrigendum dated 10/01/2020
[7] Source: Notification by Office of The District Magistrate, North Goa, dated 20/08/2020

Exhibit 3-5 Pay and Park sites identified in Panaji in Phase -II

Source: CCP and google map

Exhibit 3-6 Pay and Park sites identified in Panaji in Phase -II

S.N	Location	Length (approx.)
S1	Patto Plaza Panaji and road leading from Old Patto bridge to Vrindavan Building (Opp. Govt quarters, Patto Panaji) and road leading from Sapna building to Cardozo building Patto Panaji.	450 mts
S2	M.G Road (Mhamai Kamat House to Caculo Island)	Couldn't find this location on Google Map
A1	Along roadside from Betim Ferry to Sulabh Toilet on D.B. Road Panaji.	850 Sq.m
S3	From Keni Petrol pump, near Old PWD office (Corina Bar & Restaurant) to Old Patto Bridge and Largo da Estanico (Tobacco Square) Opp. to Head Post Office, Panaji behind Postmaster General Office to Predio Abilio Coelho – Pereira Building on D.B. Marg Panaji.	100 mts, 125 mts
S4	From Menezes Braganza Road i.e road leading from Median Opp. Café Bhonsle to Cedmar Apartment via Neptune Hotel.	302 mts
S5	Back side of State Bank of India i.e from Hotel Mandovi to Custom House Gen. Assa Road behind Custom House and infront of GST Comissioner Office, M.G. Road	250 mts
S6	Vinanti Hotel and side of Custom House touching D.B. Marg Panaji.	45 mts
S7	Road between 18th June Road and Menezes Braganza Road (Neptune Hotel) up to Frank Chamber.	70 mts
S8	"General Bernardo Guedes Road" (from Inox to Geeta Bakery to Govt. printing Press building)	565 mts

*Source: CCP; * S indicates Street ** A indicates Area*

Pay and Park is allowed for 24 hrs on all days and all government vehicles will be exempted from Pay parking. The tariff set for Pay and Park is given in Exhibit 3-7.

Exhibit 3-7 Tariff structure for Pay and Park in Panaji

Parking Duration	Amount, INR
For Two Wheelers	
Up to 4 hrs	INR 4
4-12 hrs	INR 8
12-24 hrs	INR 15
For Four Wheelers	
First hr	INR 20
Every extra hr or part after first hrs	INR 15

Source: CCP

3.2 Key issues and challenges

Key issues and challenges faced by various stakeholders due to inadequate parking management system are highlighted below -

Traffic congestion

Parking can be a challenging issue, especially in urban areas where 30 percent of all traffic congestion is caused by drivers circling to find a space. Add to that the amount of time wasted and the limited data available to guide motorists' decision making, can be frustrating. Cities are also losing out. Aside from the damaging environmental effects, they often lose revenue due to inadequate meter enforcement and no-parking, standing, and loading zone violations. Income for shops and local businesses is also heavily affected by the availability of parking.

Air and noise pollution

In its annual report 2017-18, the Goa State Pollution Control Board (GSPCB) has underlined that pollution levels in cities like Panaji, Ponda, Mapusa, and Margaon are higher than the permissible limits. As per a study conducted by the GSPCB, levels of PM10 (particulate matter of 10 microns diameter) and PM2.5 are found to be much above the permissible limits in these cities. The PM10, which needs to be at 40 pg/m3 (per gram cubic metre) is more than double at 81 pg/m3 in Vasco. Ponda stood second where PM10 levels were nearly double than the permissible limit at 78.8pg/m3. Similar levels for other cities like Panaji are 75.2 pg/m3, Mapusa (73pg/m3) and Margao(68.7pg/m3). GSPCB has attributed the high level of air pollution to increasing vehicular movement in Panaji, Mapusa, Vasco, and Margao and subsequent rise in resultant population[8].

As per the Central Pollution Control Board and State Pollution Control Board in Panaji the levels of CO (Carbon Monoxide) in air is ranging between Poor and Very Poor Categories as shown in Exhibit 3-8. The concentration of CO in air has harmful effects on both the environment and human body, by causing extreme weather changes and breathlessness & serious health risks (if long exposure) respectively. The levels of CO in the air can be reduced by less usage of fossil fuels.

Exhibit 3-8 The Air Quality Index in Panaji as of September 2020

IST 12:00 am – 7:00 am	PM2.5	3.0 µg/m³, AQI 3	Good
	PM10	25.87 µg/m³, AQI 25	Good

[8] Source: https://timesofindia.indiatimes.com/home/environment/pollution/pollution-level-in-major-cities-in-goa-above-normal-govt/articleshow/64479190.cms

	CO	250.0 µg/m³, AQI 12	Poor
IST 9:00 am – 01:00 pm	PM2.5	10.0 µg/m³, AQI 10	Good
	PM10	37.0 µg/m³, AQI 37	Good
	CO	350.0 µg/m³, AQI 17	Poor
IST 02:00 pm – 7:00pm	PM2.5	1.0 µg/m³, AQI 1	Good
	PM10	40.0 µg/m³, AQI 40	Good
	CO	420.0 µg/m³, AQI 21	Very poor
IST 7:00pm – 11:00pm	PM2.5	3.0 µg/m³, AQI 3	Good
	PM10	38.0 µg/m³, AQI 38	Good
	CO	360.0 µg/m³, AQI 18	Poor
Poor (201-300)	May cause breathing discomfort to people on prolonged exposure, and discomfort to people with heart disease.		
Very poor (301-400)	May cause respiratory illness to the people on prolonged exposure. Effect may be more pronounced in people with lung and heart diseases.		

Source: https://airpollutionapi.com/aqi/india/goa/panaji-santainez-panaji-north-goa

Inconvenience to the commuters and tourists

A recent global study of parking in big cities across the world suggests that the average city driver spends an average of 18 to 20 minutes per trip searching for a parking space, resulting in stress, wastage of fuel, increased emissions, congestion on streets, and decrease in productivity. Panaji is a tourist place and attracts a large number of domestic as well as international tourists. So, there is a sizable loss of time and economy due to time spent on locating parking lots. This causes a lot of inconvenience to commuters and tourists.

3.3 Summary of key findings

Pricing of parking should be based on 'user pay' principle, reflecting the cost of the public good – the precious urban space. CCP has taken a step towards that by notifying areas for pay and park and setting tariffs. Further, it has taken several initiatives for improving the parking management system including preparation of CMP and Parking Policy etc. Now, to improve the system further and to reduce the traffic congestion and improve air quality, there is a need to adopt ICT and technology in the form of Smart Parking System. The Smart Parking Management System will help in not only addressing some of the challenges highlighted earlier but also improve the revenues for CCP and bring more transparency in the parking management.

The levels of CO in the air can be reduced by less usage of fossil fuels. Through innovative and efficient Smart Parking systems the search time for parking will be faster and easy, making less fuel consumption. As per the LEDS estimates, the potential GHG emission reduction by adoption of the Intelligent Parking Management System will result in estimated annual GHG emission reduction to the tune of 228 tonnes of CO2e[9].

[9] Considering car parking demand of 4,146 lots.

4 Smart Parking Solution – Technologies and Case Studies

4.1 Smart Parking Solution

It is imperative to use Smart Parking Technology to address various challenges related to unorganised parking management. The complete end to end smart parking solution comprises a combination of various components and levels such as vehicle detection sensors, cameras with automated vehicle license plate recognition technology, smart meters, smart payment for parking, and parking assistance by digital signage and navigation apps.

It can often involve low-cost sensors and smartphone-enabled app-based navigation system and payment systems that allow drivers to identify the available spaces and reserve their spot in advance. Parking system can be broadly categorised as on-street and off-street. The off-street parking can be a gated plot-based system or a multilevel car parking system.

In this section, evaluation of several smart parking technologies and few global case studies is undertaken. In the next section some of the Indian case studies are reviewed and key learning are captured.

4.2 Smart Parking Solution – components and sub-components

The assessment of Smart Parking Systems is carried out through secondary research covering several global cities and smart parking solution providers. These cities are Dubrovnik, Barcelona, Los Angeles, Jerusalem, Linz and Nice etc.

There is no specific categorization of smart parking technologies. It is a basket of various solutions and modules. Based on the research on several global cities and their smart parking solutions, it is observed that there are five critical components of the smart parking solution. These are -

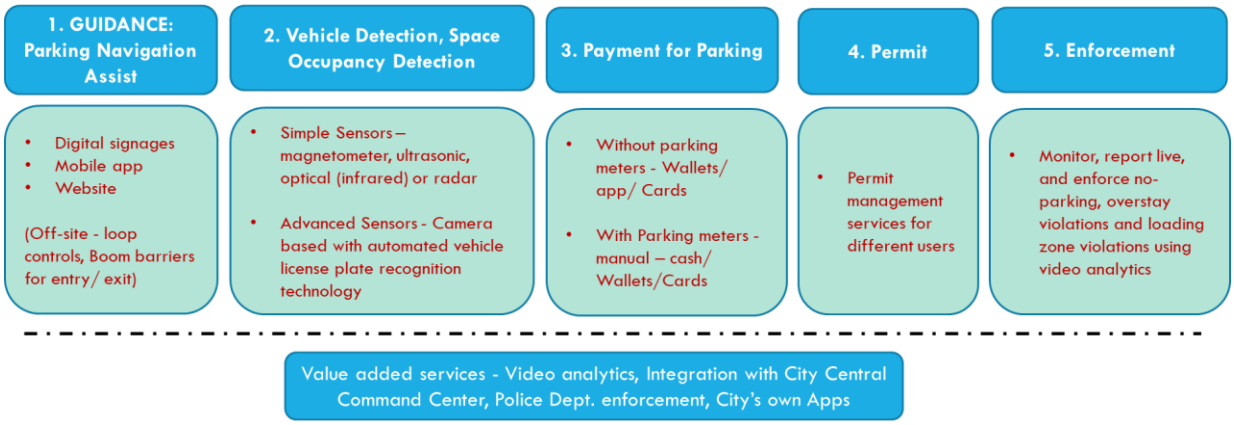
1. Guidance: Parking Navigation Assist
2. Vehicle Detection, Space Occupancy Detection
3. Payment for Parking, fines etc.
4. Permits Management
5. Enforcement

And each of these components have several sub-components as illustrated in Exhibit 4-1.

So, the Smart Parking System can be a combination of subs- components across these five functions. For Example – A system can include Digital Signage + Magnetometer sensors + digital wallet-based payment+ permit management system linked to meters/ app.

Another Example is that of an advanced system that can include mobile app-based navigation, magnetometer sensors, digital payment via wallet and cards, and permit management system linked to parking meters/ app.

Exhibit 4-1 Smart parking solution – components and sub-components



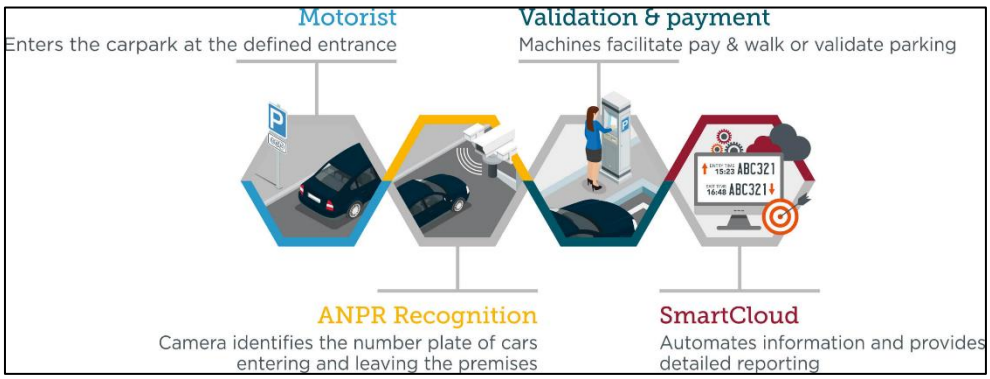
Source: Secondary Research

Sensors

The choice and combination of sub- components depend upon the procurement agency, different offerings available in the market, inter component compatibility, costing and maintenance related aspects etc. For example – there are two main types of the Sensors based on technology and application - Simple sensors and the advanced sensors. Within simple sensors, further there are different options available like magnetometer sensors, ultrasonic sensors, optical or infra-red sensors or radars. The radar approach is unique. Siemens has installed radar above street parking spaces which scans the parking space below to detect if the space is occupied by a vehicle.

Depending upon the positioning of the sensors, it can be classified in three types i.e. side-mounted, in-ground, and radar. For parking building retrofitting, side-mount units will be the easiest. But this type of sensor would be much more difficult for street parking. On the other hand, in-ground sensors can be installed for both parking structures and street parking, but it requires that the ground is dug up for installation[10]. For example, in the case of smart parking, magnetometers are best suited for outdoor smart parking environments as they are resistant to weather interferences and lighting conditions. On the other hand, video camera sensors are well suited for off-street parking locations such as garages and parking lots – as they are easy to deploy and their performance is affected by lighting and weather conditions. Magnetometers and video camera sensors are just two options for Smart Parking Solutions.

Exhibit 4-2 Automatic Number Plate Recognition



Source: https://www.smartparking.com/latest/case-studies

[10] Source: https://enterpriseiotinsights.com/20180901/fundamentals/sensor-applications-smart-parking

Exhibit 4-3 Comparison of different types of smart parking sensors

Sensors type	Description	Detection Accuracy	Battery/ power Consumption	Cost	Ease of Installation & Mgmt.	Area required/ footprint	Other
1. Ground Sensors							
Magnetometers	Measures magnetic field intensity	Moderate	Moderate	Low	Easy	Medium	Modern electric vehicles don't have ferromagnetic parts at all.
Infrared ranging sensors	Two types of infrared (IR) ranging sensors: Reflected Intensity, Time-of-Flight (ToF).	Moderate	High	High - 3 x of magnetometer	Moderate	Large	Sensitive to any optical obstruction
Ultrasonic Sensors	Through emission and echo of ultrasonic waves.	High	High	Low	Easy	Large	Don't operate well under a cover plate. Preferred for overhead sensors.
Radar ranging sensors	Radars have the same adv. and disadv. as IR/ ToF	High	High	High	Difficult	Medium	More expensive and may require special high-frequency circuit design knowledge.
2. Overhead Radars/ LIDARs							
Overhead radars/ LIDARs	Use radio signals and laser light reflections. The system provides accurate results within 7 metres	Moderate, sensor fixed on lamp post can cover only 4-5 parking spots	Moderate	Medium	Moderate	---	At a greater distance (>7 m) and sharper reflection angles its accuracy decreases
3. Camera based							
Video Camera and Image Processing	Using video cameras & image proce. algo: Cloud-based/server processing & On-board processing	Moderate Possible to cover a great area with only one device, resulting in a convenient solution.	High	High	Difficult Can become a complicated process for training and detection	---	Large open space lots like those in supermarkets or airports, well-lit at evening time

Source: Secondary research and analysis

Connectivity

Depending upon the solution that needs to be deployed the choice of the right form of connectivity is decided. For example, if the solution requires video monitoring of parking spaces or streets through

surveillance systems on lighting poles, the connectivity option should offer the necessary bandwidth. In that case, cellular technologies (4G and the coming 5G) are the most appropriate connectivity solution[11].

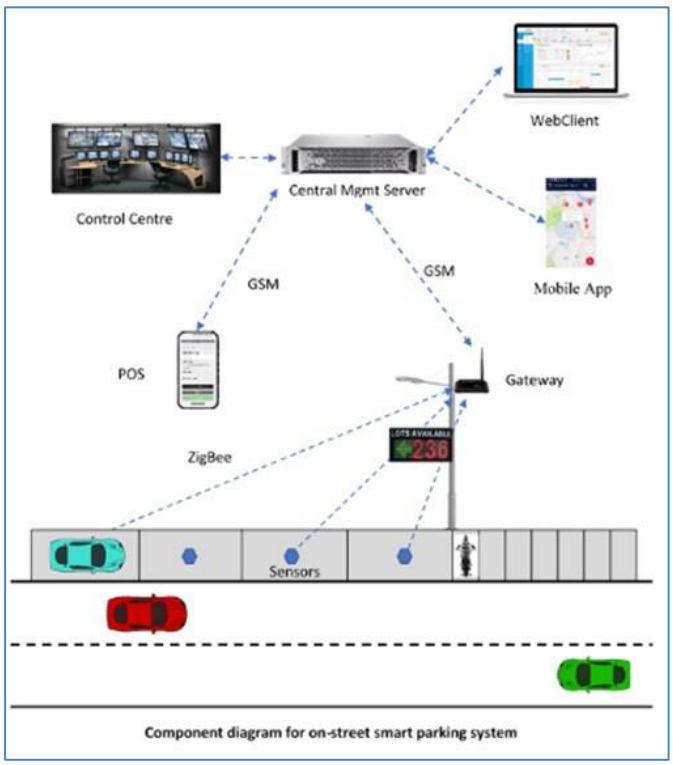
IoT-Analytics' recent research on LPWANs reveals that smart parking and connected street lighting are the most adopted smart city applications using LPWAN – while smart metering is the largest adopter of LPWAN in all sectors.

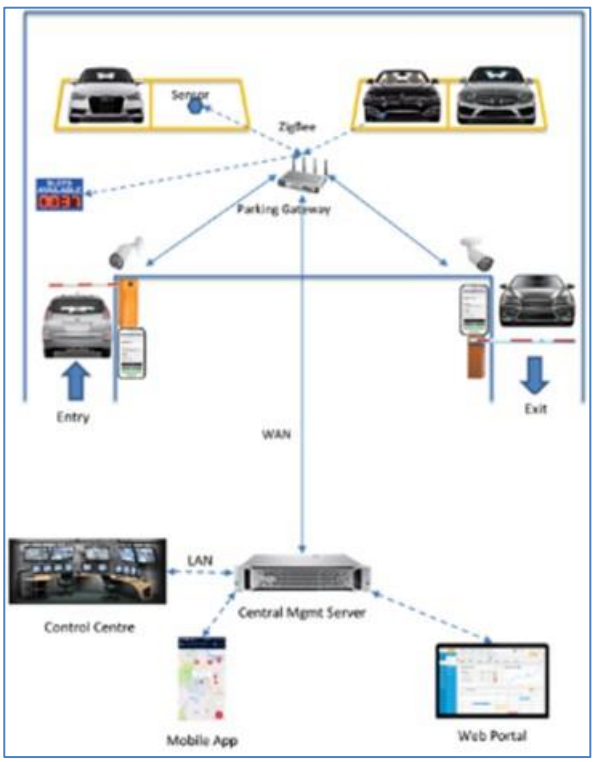
Availability of power to the IoT devices is a key, hence, nowadays Low-power WAN (LPWA) such as LoRaWAN is used. It transmits data periodically to the LoRaWAN or a cell tower indicating if a parking space is occupied. Additionally, the low-power technology enables a battery life of multiple years[12]. This is important because changing batteries in the sensors is a very labor-intensive endeavor. NWave, a UK-based company has developed its own wireless technology and is said to consume even lower power and boasts a longer wireless communication distance than LoRaWAN[13].

Narrow Band IoT (NB-IoT) is a low power wide area network (LPWAN) technology. NB-IoT has been developed to enable efficient communication, long battery life for mass distributed devices and lower costs for wide geographical footprints or deep within urban infrastructure.

Few illustrations of the architecture of the Smart On- street and off-street parking is given in Exhibit 4-4.

Exhibit 4-4 Illustrations of the Smart Parking Solution Architecture





Source: Google images

[11] Source: iot-analytics.com/5-key-insights-from-350-smart-city-iot-projects/
[12]Source: https://enterpriseiotinsights.com/20180901/fundamentals/sensor-applications-smart-parking
[13] Source: https://enterpriseiotinsights.com/20180901/fundamentals/sensor-applications-smart-parking

4.3 Snapshot of global case studies on Smart Parking System

4.3.1 Dubrovnik, Croatia – Smart Parking Solution

4.3.1.1 Smart Parking Solution

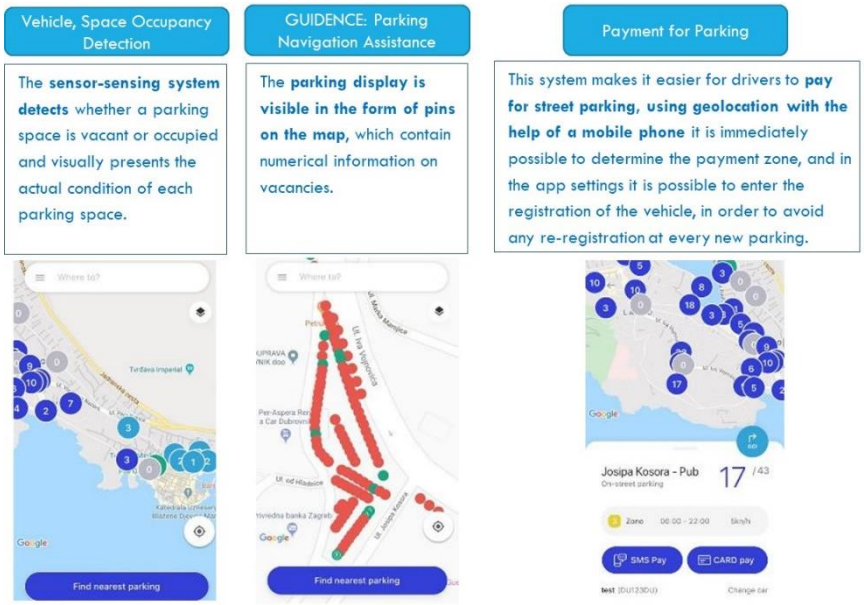
The Dubrovnik project is one of the largest integrated solutions for smart parking on the Narrowband IoT (NB-IoT) network in the world and the largest project in the segment of smart cities in Croatia.

Sensors are installed at each of the city's parking spaces allowing the system to accurately detect when a space is free or not, the data is sent to a central location and drivers are able to access the information through a free app.

In the city's parking hot spots, a system of twenty public information displays was set up to allow drivers who don't use the app to see real-time parking spaces.

The NB-IoT network from Hrvatski Telekom allowed the project's sensors to be more efficient and cost-effective, and as a result, increase the project's sustainability and futureproofing. This network is based on the global industry standard for mobile networks and enables the connection of an extremely high number of connected IoT devices. It features excellent coverage, low cost, high signal quality, and a high level of security and reliability in line with global telecommunications standards in mobile networks.

Exhibit 4-5 Dubrovnik – Smart Parking System – components



Source: Dubrovnik city

4.3.1.2 IUC: Panaji – Dubrovnik partnership

Benefits of the partnership

The city of Dubrovnik is in the southern Adriatic, on the eastern coast of the Adriatic Sea, where the open sea begins. The geographical location of this area is typically Mediterranean, with mild and humid winters and hot and steamy summers.

Both Dubrovnik, and Panaji, are similar sized cities in terms of their population. Both are coastal cities and are favourite destinations for tourists.

The IUC programme is an opportunity for both city governments to learn from each other, set ambitious targets, forge lasting partnerships, test new solutions, and boost their city's international profile. Its activities will support the achievement of policy objectives as well as major international agreements on urban development and climate change, such as the EU Urban Agenda, the UN Sustainable Development Goals, and the Paris Agreement.

Dubrovnik experience with smart parking

Regarding the Smart Parking Solution and its implementation, the aim was to resolve one of the crucial problems of Dubrovnik - traffic especially parking. This problem was constant but highlighted during the summer season when the number of vehicles in the town grew by 100 %. Thus, the aim was to reduce traffic congestion and increase the quality of parking on city streets. A total of 2,010 sensors connected to the NB-IoT network were installed.

For the citizens of Dubrovnik, the project has made it easier to find a vacancy through the mobile app. It has also allowed the users to navigate to a vacant location, find an alternative vacancy and pay for a parking ticket with the preferred mode of payment. In addition to the built-in sensors and the built-in mobile app, public display indicators were also set up to allow citizens and tourists who do not use the app to have an insight into vacancies and several streets earlier.

Considering the number of sensors as well as the fact that they are installed all over Dubrovnik, this is one of the largest integrated smart parking solutions implemented on the Narrowband IoT (NB-IoT) network worldwide and the largest project in the smart cities segment in Croatia and the region. This project is part of a series of activities under the umbrella project "Dubrovnik Smart City".

4.3.2 Barcelona, Spain – Smart Parking System

The solution for Park and Ride was installed in 10 areas of Barcelona. The data captured by the installed sensors is transformed into useful information which transmits the availability of free spaces to the users through the app. This way, drivers are informed about the availability of spaces in these parking areas so that they can go directly to the areas with free spaces.

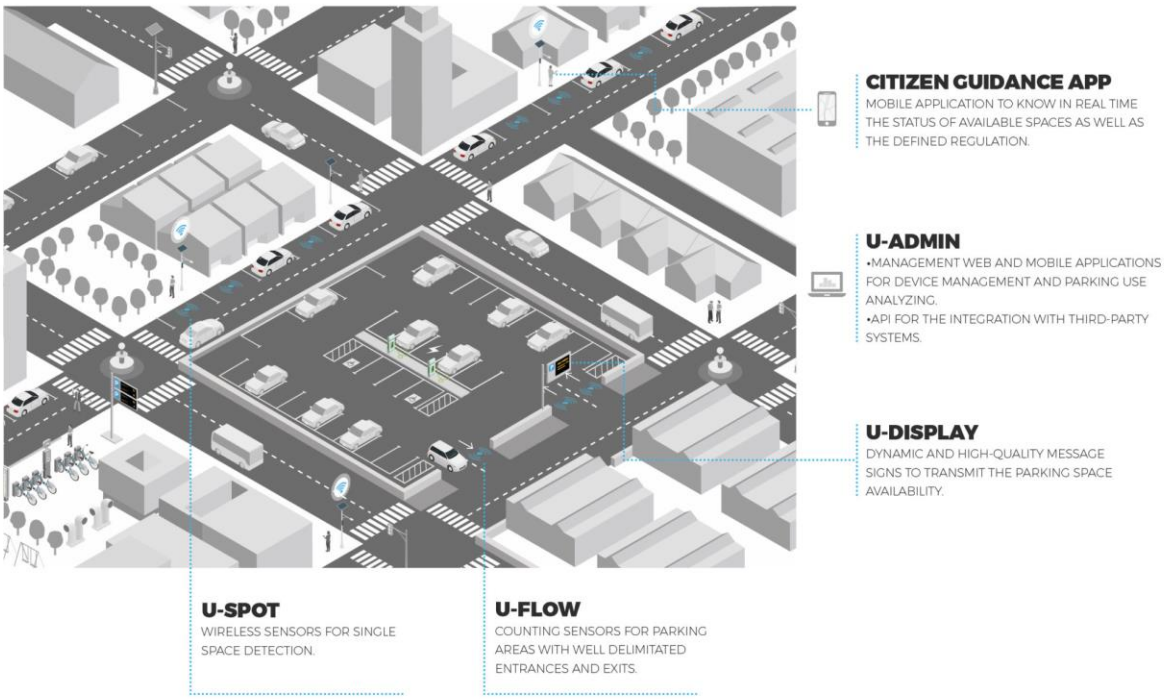
The solution is a win-win since it satisfies both the needs of citizens and those of public administrations.

Details of the installed system:

- U-Flow[14] counting sensors to inform about the availability of free spaces.
- U-Spot[15] single space sensors to inform about the availability of reserved spaces (electric vehicles, taxis, etc.)
- Integration with multimodal platforms and user information app for the citizens to know the status of available parking spaces in real time.
- Management web and mobile applications for device management and parking use analyzing.

[14] U-Flow Parking is a wireless and autonomous sensor of vehicle counting designed to detect in real time any vehicle passing through the entrances and the exits of a parking zone. This is a product of urbiotica company.
[15] U-Spot is a sensor installed in the parking space that uses magnetic technology to detect in real-time the entry and exit of vehicles in the parking spaces as well as the duration of the session. This is a product of urbiotica company.

Exhibit 4-6 Barcelona – Smart Parking System



Source: https://www.urbiotica.com/en/smart-solutions-2-en/urban-parking-guidance-system-2/

How it works?[16]

- The driver goes to a parking area and accesses it through a well-defined entrance. The U-Flow sensor installed at this entrance detects that the vehicle drives over it and sends the information to the platform.
- The platform collects the data and recalculates the availability based on the total capacity of the parking vs this new access and sends the updated data to the dynamic message signs and/or the user apps, indicating one less free space in this case.
- When the vehicle exits the area and passes over the U-Flow sensor installed in the exit lane, the process takes place in reverse. The system transmits the updated data indicating one more free space to the total available in the parking area.
- When reserved parking spaces are monitored with U-Spot sensors, they detect vehicles parking over and send the information to the platform. It can be deduced from normal space availability and information is given to the users according to the defined space category.
- At the U-Admin platform, the manager can handle the published information, as well as configure, supervise, and consult all the system's activity.

4.4 Experiences (Pros and Cons) from other smart parking solutions in India

The assessment of planned or ongoing adoption of Smart Parking System in several cities in India is carried out through secondary research and further validated through interaction with few private solution providers (private players). These cities include Bangalore, Nashik, Surat, Jaipur, Delhi, Vizag etc. and various Request for Proposals (RfPs) available on Smartnet under Smart City Mission of India.

[16] Source: https://www.urbiotica.com/en/smart-solutions-2-en/smart-parking-solutions/parking-guidance-for-park-ride-facilities/

4.4.1 Snapshot of Indian case studies on Smart Parking System

4.4.1.1 Bangalore Smart Parking Solution

In Bangalore, the government is implementing a 'smart parking' system that helps drivers find parking slots using a smartphone app. In its first phase, it will convert parking stretches on about 85 roads into smart ones. A central server will connect the management of all parking lots. CCTVs will be installed from where employees and municipal officials can check the live status of the parking situation in a bay and oversee all the activities. This step will help make multilevel parking a success. Key features of Bangalore Smart Parking Solution -

- Bengaluru Municipal Corporation has bid out Smart Parking Solution 85 roads in Bangalore (pop. 8.5 mn) on PPP mode to a private company Central Parking Services (CPS) Ltd. The pilot has been implemented on Kasturba Road (~ 800 m stretch) for 100 cars, 300 two wheelers
- IoT device-based smart parking system with Namma Bengaluru smart parking app, along with parking meters connected to a central command and control centre.
- CCTV surveillance to prevent theft or damage to vehicles
- 13,600 slots with capacity 3,600 cars and 10,000 two wheelers.
- CPS will invest INR 85 crore i.e. INR 850 mn (~ USD 9.7 mn)
- CPS will pay a fixed annual payment for 10 yrs to BBMP
- Bengaluru is divided the city into A, B and C zones and fixed zone wise parking fees
- Tariff: Cars: INR 30, 20 & 15 per hr in zone A, B & C
- Tariff: Two wheelers: INR 15, 10 & 5 in zone A, B & C
- CPS has also provided the facility of sending an SMS of the payment receipt. The payment can be done by cash or any Unified Payment Interface (UPI) service.

Exhibit 4-7 Bangalore Smart Parking Solution -pilot site at Kasturba Road

Source:https://www.thehindu.com/news/cities/bangalore/kasturba-road-gets-smart-parkingsystem/article

4.4.1.2 Surat – proposed Smart Parking Solution[17]

Surat Municipal Corporation (SMC) has prepared the RfP for appointment of an agency for iPARK - Intelligent Parking Management System for Multilevel Parking & Open Parking Lot in ABD area of Surat City. The RfP document has been prepared and kept on hold due to COVID -19 situation.

Salient features of the project are -

- The selected bidder will be required to Design, Develop, Supply, Install, Implement and Maintain iPARK - Intelligent Parking Management System which is intended for implementation at identified Multi Level Parking Facilities across Surat along with two Open Parking Lots in the ABD area for Surat City.
- The selected Bidder will be required to implement the solution in two different releases Request Order 1 and Request Order 2. Both the request orders will be part of the same work order.
- Request Order (RO) 1: RO 1 will comprise of one multilevel parking and one off-street parking.
- Request Order (RO) 2: RO 2 will be issued on successful completion of the POC. RO 2 will also incorporate the enhancements and the customization required by Surat Smart City Ltd. Or SMC.
- Revenue collection and associated operations with manpower is awarded to different vendors by SMC through a separate tendering process and is not part of the RfP.

Surat smart city has prepared proposal for iPARK - Intelligent Parking Management System

- Multilevel smart parking at 9 locations and off-street parking at 2 locations
- Integration of the parking management System to Central Control Center (SMAC) and give citizens and SMC officials, live status of parking occupancy.
- 6 months implementation + 5 years O&M
- Its Design, Development, Implementation, Maintenance and Management contract with provision for Service Level Agreement (SLA) linked penalties – it resembles with Bill of Quantities (BOQ) with performance-based service contract
- The Bidder needs to quote against all the items of the BOQ (supply, installation & implementation) including 5 years comprehensive part replacement onsite warranty.
- Payment: Installation milestones, then 5% each year for five years support

Multi-Level Parking System comprise of -

- Multi-level parking system consists of all indoor / covered / underground parking areas
- It includes entry and exit parking equipment and automatic barriers, sensors for recognition of each parking slot, loop sensors, slot availability information, advanced slot booking facility and map-based guidance system, LED signages and CCTV at entry and exit.

Off-Street Pay and Park comprise of -

- This consists of a demarcated area for parking near a street or road.

[17] Source: RfP floated by SMC

It will include, entry and exit parking equipment, automatic barriers, handheld devices, advance booking of parking facility and map-based guidance system, LED signages and CCTV at entry and exit.

Exhibit 4-8 Surat iPark Project – functional and non-functional requirements

Functional requirements of Parking Management System

- Parking Guidance and Management System (PGMS)
- Parking Information/Guidance
- Parking Access Control / Management
- Parking Pricing and Payment
- Audit, Performance MIS Reports and Alerts
- Breakdown/Off-Line / Manual mode
- Maintenance Mode
- Central System
- Monitoring & Control Dashboard
- System Data Requirements
- Citizen/ Operator / Authority Interface
- Integration with other Systems

Non-functional requirements of Parking Management System

- Ticket Dispenser
- Barrier Gate
- Parking Occupancy Controller
- Parking Occupancy Sensors
- Public Information Signs (PIS)
- QR Code Reader
- Local Server Cum Operating Console for MLCP/Off-street
- Central PGMS Management Server
- Fixed CCTV Camera
- Thermal Receipt Printer
- User fare Display
- Handheld POS

4.4.1.3 New Delhi Municipal Council (NDMC)

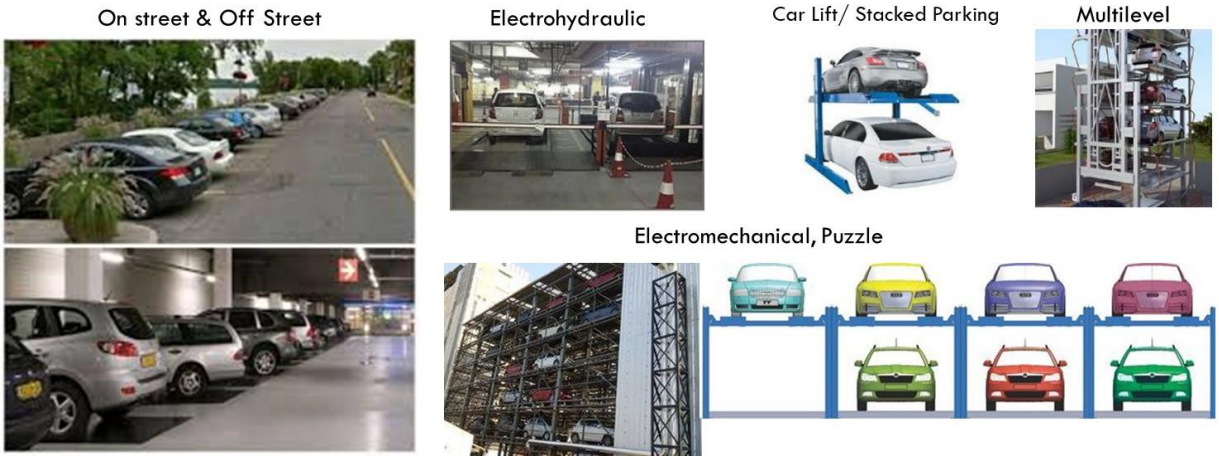
New Delhi Municipal Council (NDMC) has proposed to appoint a concessionaire for a period of 5-7 years for managing and upgrading all parking lots in its areas with sensors and installation of cameras on public-private partnership (PPP) basis. With the proposed sensor-based parking management system, citizens can get online information about the availability of the parking space, its usage charges and route map on their smart phones.

4.4.2 Observations on parking management in Indian Cities

Key general findings on Parking Management and adoption of Smart Parking System in Indian cities is given below:

- Most of the Indian cities do not have an organized Parking Management System due to several reasons including lack of experience, inadequate capacity of ULBs, unorganized nature of the sector, lack of tariff rationalisation, and practice of free on street parking etc.
- The Smart Parking System is even rare, although few cities like Jaipur, Surat, Chandigarh and Chennai have taken some initiatives under the Smart City Mission of the Government of India.
- Some of the types of parking systems adopted in Indian cities are illustrated in Exhibit 4-9.

Exhibit 4-9 Types of Parking Systems adopted in Indian cities



Source: google search, images are for representation purpose only

- Many Indian cities are now adopting Multi Level Car Parking (MLCP), especially near prominent public places like bus terminus, CBD areas and centralised government offices etc. E.g. Car park at Vegetable Market and Railways Station area in Pune, Mumbai Airport
- MLCPs with or without automation, are coming up at Shopping districts, metro stations, large residential projects etc.
- During the last 3-4 years, cities have started adopting Smart Parking System, especially for off-street parking. And MLCP with commercial development is a preferred option to monetise land value, transfer risks to pvt. player through PPP model and reduce CAPEX commitment of ULBs. E.g. Bangalore, Vizag, Surat.
- The Smart City Mission is encouraging cities to adopt Smart Parking solutions for on street and off-street parking. E.g. Surat, Bangalore, Nashik, Delhi, Jaipur, Dehradun, Kanpur etc.

4.4.3 Categorization of Smart Parking Solutions

As there is no definite classification of Smart Parking Solutions, they have been classified into three following categories based on their key components:

- **BASIC SYSTEM:** it includes Ground sensors, guidance through mobile app/ web & digital signages*, parking meter and / or payment app, provision for permit, enforcement and grievance redressal, CCTV for surveillance. In case of off-site system - automatic boom barriers and looping system as additional components.
- **ADVANCED SYSTEM - I:** it includes Basic system plus CCTV surveillance & number plate recognition technology coupled with Video analytics, data shared with ULB system/ dashboard.
- **ADVANCED SYSTEM - II:** it includes Advance System-I which is integration with - City Command and Control Center (CCCC) and enforcement system of the police department plus all data pushed to CCCC and Integration with the City's own app/ dashboard.

A large no. of tourists visits Panaji city who may or may not have access to the app or website created for the guidance or parking navigation system. Therefore, a combination of various modes of guidance such as mobile app, web and digital signages is required.

4.4.4 Recommendation to CCP on adoption of the system

CCP can adopt the Basic System for its pilot project because of the following reasons -

- Its limited experience and low penetration of IT systems to manage voluminous data and smart IoT components
- Unavailability of IT and allied infrastructure like CCTVs, Video analytics system and comprehensive GIS mapping linked to various services etc.
- Payment for parking, especially for on-street parking, is still a new initiative at Panaji coupled with low levels of Tariffs and citizen/political/local vendor reluctance to adopt new system
- CCP's challenges to support large CAPEX upfront and the legacy system of revenue sharing from pvt. Player for parking management

4.4.5 Learning on project structuring from Indian experience

In Indian Cities, many of the Smart Parking Solutions have not been implemented even after bidding because of the following reasons -

- Too much focus on either technology or quantum of revenue shared with ULB
- Challenges in administrative and political acceptance
- Inadequate supporting IT infrastructure within cites, lack of citizen engagement, low levels of base tariffs etc.

As seen in case of Bangalore, Surat, Nashik, Jaipur, VIzag and other cities, the Indian cities prefer two types of project structures or contracts – Public Private Partnership (PPP) and Service provider through Bill of Quantity (BoQ). Among these PPP models are preferred by many cities because -

- CAPEX, Technology risk and demand risk can be Pvt. Operator's responsibility
- ULB's lack of experience and low penetration of IT systems to manage voluminous data and smart IoT components
- Inadequate IT and allied infrastructure in cities, like availability of CCTVs, Video analytics system and GIS mapping etc.
- In some cases, there is land monetization component as well, e.g. in Surat and Vizag, it's MLCP and commercial complex together.

Exhibit 4-10 Project Structuring – comparison

Key parameters/enablers	PPP Model	As tech provider: BoQ + SLA
Investment responsibility - CAPEX & OPEX	Its Pvt. Player's responsibility with possibility of Gap Funding from ULB	Its ULB's responsibility
Fluctuating demand for parking	Its Pvt. Player's responsibility and he can build demand risk in his financial model	Its ULB's responsibility
Technology related risk	Its Pvt. Player's responsibility (Installation & support)	Its Pvt. Player's responsibility (Installation & support)
Revenue collection efficiency related risk	Since Pvt. Player is responsible for collection of revenue, its his responsibility	Since ULB or third party is responsible for collection of revenue, its ULB's responsibility

Key parameters/enablers	PPP Model	As tech provider: BoQ + SLA
Responsibility of Parking tariff regulation	Its ULB's responsibility with provision for annual escalation	Its ULB's responsibility
Revenue to the operator	Revenue through Parking charges and/ or land development	On Bill of Quantities (BoQ) + annual payment for support
Revenue sharing with CCP	Depends on financial viability	No
Project duration	Installation :6 moths – 1 yr & Support for > 7yrs	Installation: 6 moths – 1 yr & Support for 5-10 yrs

5 Panaji - Smart Parking Pilot Project

5.1 Project description

The District Magistrate of North Goa and CCP have notified[18] Nine sites in Phase- I for the Pay and Park for parking of two wheelers and 4 wheelers in the City of Panaji. It further identified nine more sites to be taken up in Phase- II. The pilot site identified by CCP for adoption of Smart Parking Solution is near the Central Business District (CBD) area, which is visited by many tourists. This area has many tourist attractions including the famous church and many casinos. It is a very important area for the city's economic activities and is always crowded. Many drivers spend a lot of time finding parking spaces in and around this area. Hence, to reduce the congestion and create a better environment for citizens and tourists, a Smart Parking Solution is proposed to effectively manage the parking system at this site.

5.2 Project objectives

The objective of this pilot project is to develop and implement a Smart Parking Solution at a pilot site in Panaji city in Goa. The pilot site has been identified at the CBD area. The objectives envisaged by implementing Smart Parking Solution are to:

- Integrate on-street parking with advanced real-time parking availability information on-demand through mobile application to its users.
- Optimize parking space usage
- Reduce congestion through improved capacity of arterial & collector streets through regulated parking that does not block smooth movement of through traffic
- Reduce leakages in parking revenues through utilization of digital payment methods for paying parking charges
- Enable enforcement of penalties on parking violations
- Provide users with advanced information and guidance on mobile handsets for availability of parking spaces in and around their destinations.
- Use the learnings to implement and smart parking solution for the rest of the city

5.3 Site and key components

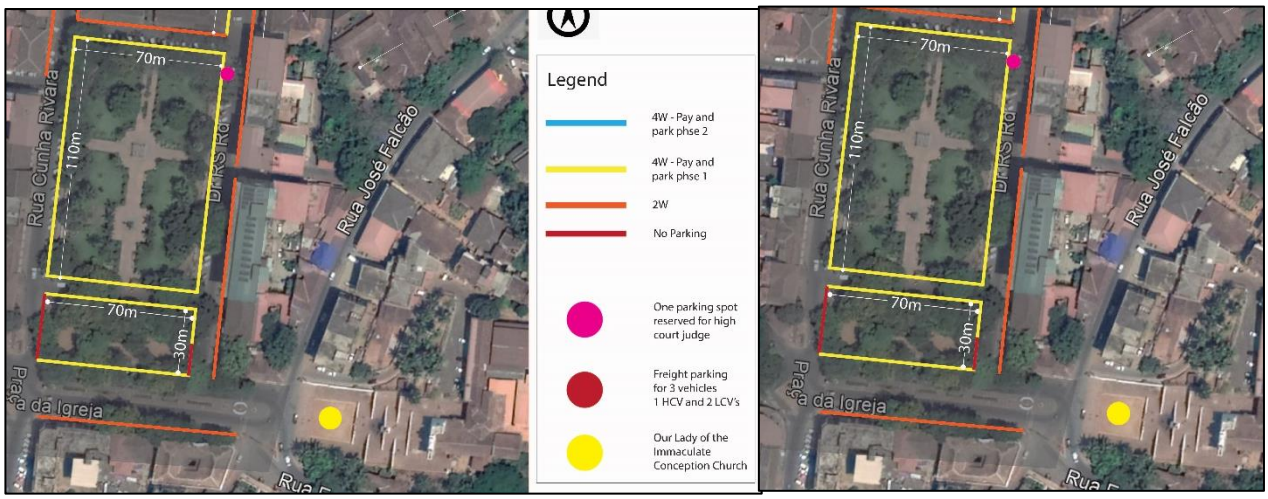
5.3.1 Pilot project – description of the site

The CCP has recommended taking the area near CBD as a pilot site. The area is near 'Our Lady of the Immaculate Conception Church'. This is a CBD area where a lot of tourists visit as it has many Tourist sites including the famous church and casinos. Key features of the site are as follows –

- Total parking lots available at a pilot site for 4 wheelers are 123, which are marked by the yellow line in the Exhibit 5-1.
- Currently there is a pay and park arrangement at the parking site managed by the local contractor. The contract is from 15 February 2020 to 14 February Feb 2023.

[18] Source: Notification by Office of The District Magistrate, North Goa, dated 31/12/2019 and Corrigendum dated 10/01/2020

Exhibit 5-1 Panaji – Site for Pilot Parking Project, its length and number of parking lots



Source: CCP

5.3.2 Key components and features

The proposed Smart Parking Solution for a pilot project at Panaji shall comprise of the following components:

1. **Guidance:** Parking navigation assistance system will be a combination of mobile app, website, and digital display boards. Many tourists visit Panaji city, who may or may not have access to apps, hence there is a need for digital display boards placed at key locations to guide them.
2. **Sensors:** Magnetic ground-based sensors are recommended. But in case CCP wishes to bid out this project on PPP contract where the private player will be responsible for all risks associated with the technology, then CCP can allow use of any other inground sensor with provision for performance monitoring.
3. **Payment for parking:** shall be through app, website and through handheld PoS with various payment options such as e-wallet, Credit & Debit Cards, and cash.
4. **Permitting and Grievance redressal system:** these components shall be integral part of the parking system.
5. **Enforcement:** This is an optional component which CCP can decide to include based on consultations with the Traffic Police Department.
6. **CCTV network** to be provided for surveillance.

Key features of these components are presented below -

Sensors for vehicle detection

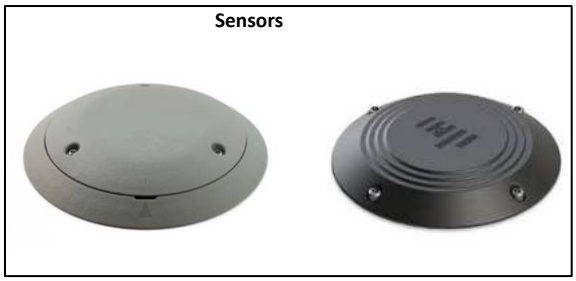
- The sensor shall be intelligent and accurately detect if the car space is vacant or occupied.
- Appropriate sensors shall be chosen based on the type of the parking spot and its external conditions.
- The sensor shall be able to detect a vehicle irrespective of the depth or height of sensor installation.
- Each sensor shall have an accurate and real time feedback mechanism to be detected automatically by the system in case of faults.

- It shall be placed appropriately per parking spot.

Informative digital display panels

- The display panels units shall indicate available spaces for each parking aisle, total parking spaces and parking availability and shall be able to be customized by software.
- The display panel shall be easy to understand.
- The contents to be displayed shall be in English language

Exhibit 5-2 Images of sensors, digital board for illustration purpose



Source: Google images

Mobile Application and Web Portal for Smart Parking:

- A Citizen App and Web Portal are required as a part of Smart Parking Solution.
- The app should detect the current GPS location of the user.
- Based on the final destination entered by the user, the nearest available parking spaces are shown using maps in decreasing order of distance and if user decides to reserve it, reservation is done with payment done from e-wallet/Credit or Debit Cards or after physically going there in which case the parking lot might or might not be available.
- Number of vacant parking slots in a parking on map should also be shown to user
- Users shall be able to locate alternate routes and parking lots after seeing the traffic congestion feed.
- Limit set on the advance time to reserve (six hours) except premium and periodic paid parking
- Cancellation for the spot shall also be provided in case of reservation. For this appropriate concession time for cancellation without penalty fee shall be configurable as per the requirements of CCP.
- Queuing facility as soon as spot fails vacant

Payment facility

- The payment facility shall be available through app, website and through handheld PoS with various payment options - e-wallet, Credit & Debit Cards, and cash.

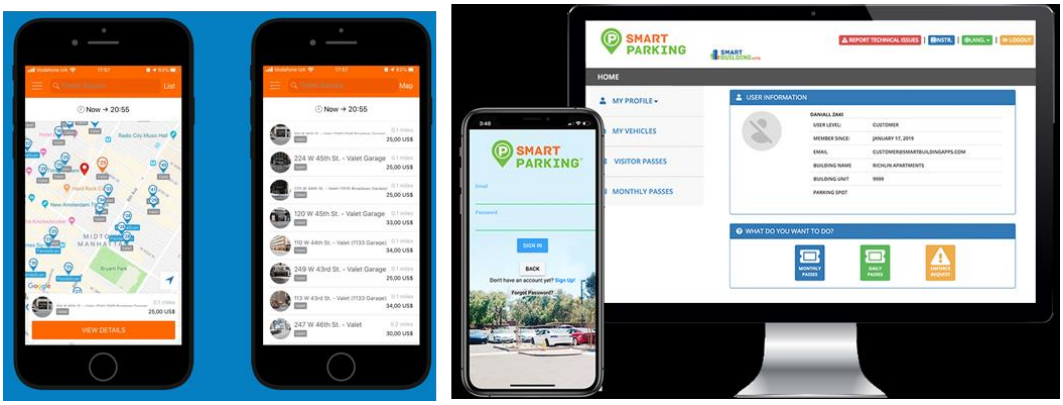
Permitting

i. Permit-seekers can review rates and availability of spaces, apply for a permit, upload verification documents, and purchase permits online in real time.

ii. Customer Convenience

- Easy online registration, permit ordering and renewal
- Instant email notification
- Temporary permits available immediately
- Permit status updates via email or text message

Exhibit 5-3 Images of mobile app and website for illustration purpose



Source: Google images

Hosting and Connectivity

- The vendor has to set-up the data center at an identified location or host in a cloud data center.
- The vendor must determine the appropriate technology for establishing connectivity from the field locations to the data center.
- The vendor must ensure that all applicable security standards as defined by Govt. of India regarding hosting and applications are met
- The vendor must undertake a security audit of software and hardware components once before Go-Live and thereafter on an annual basis.

Grievance redressal system

The grievance redressal system should be an integral part of the website and mobile app where people can lodge a complaint about issues related to the parking system and their queries need to be resolved in a timely manner. There shall be monthly/ bi-monthly reporting to CCP capturing occupancy of lots, grievances and issues resolved.

Enforcement

This is an optional component which CCP can decide to include based on consultations with the Traffic Police Department.

The parking enforcement component helps to monitor, report live, and enforce no-parking, overstay violations and loading zone violations using video analytics. CCP needs to decide on a revenue sharing mechanism with the parking enforcement agency like Traffic Police for parking violation fines.

CCTV network to be provided for surveillance.

5.4 Project Financial

5.4.1 Assumptions

Key assumptions used in estimating the project cost on normative basis.

1. Based on the assessment of the pilot site, the proposed Smart Parking Solution has been designed to have a capacity of 123 ECS.
2. This is a normative cost estimation of Smart Parking Solution for Pilot a Project at Panaji. The cost assumptions taken in this study are based on stakeholder interactions, assessment of similar studies, and secondary research. Since there are hardly any similar projects in India, some costs are based on market prices of individual components.
3. The cost estimates assume that the inground sensors based on the LoRAWAN or NB IOT with minimum 5 years battery life will be used. The unit cost of sensor is considered based on market cost of sensor- for instance, Bosch sensors cost (for a bulk order of more than 50 pieces) INR 17,000 per sensor[19] including the cost of dispenser and glue. It has a battery life of 5 years. The installation cost of a sensor is considered as 25% of the cost of a sensor and the cost of sensor activation and calibration is considered as 13% of the cost of a sensor. These percentages are based on component wise cost of smart parking project at Dubrovnik.
4. Replacement cost of sensors: The replacement schedule of sensors is considered as: 35% of the sensors to be replaced in year six from the year of commencement of the project, additional 35% in year seven and remaining 30% sensors to be replaced in the year 8.
5. It is assumed that the CCTV cameras will be deployed for surveillance and its configuration is 2 MP day & night, number plate reader camera, Hikvision-ANPR-Camera-IDS-TCM203-A, CMOS, Camera Range: 20 to 25 m. The cost of CCTV cameras is referred from the IndiaMart website comparing costs from a few vendors from Maharashtra and Karnataka states.
6. The financial assessment is done for 7 years and 10 years, starting from the year 2021. The NPV and IRR is calculated for seven and ten years. The discounting rate of 12% is considered for NPV calculation.
7. A parking lot will be occupied for an average 9 hrs per day and each vehicle will be parked for an average 3 hrs. Panaji is a tourist place, which has October to January end as its peak season. All parking lots will not be occupied on all days throughout the year. This is termed as 'Occupancy of parking lot'. The report estimates average parking lot occupancy as 65% in base case scenario.
8. The O&M cost is estimated based on the stakeholder interactions, assessment of similar studies, and secondary research. It is estimated for the base year and further escalated at 5% per annum from second year onwards to factor in inflation. The O&M cost estimates do not include the debt

[19] Source: https://connectedthings.store/gb/lorawan-sensors/bosch-parking-lot-sensors.html

servicing component and taxes. The O&M cost is worked out based on reference costs available from Dubrovnik smart parking project.

9. The operating cost of sensors is assumed at 20% of the cost of the sensors. The manpower cost involves salary for four wardens deployed at the parking site.

10. The parking tariff is assumed as per the pay and park guidelines issued by CCP.

Exhibit 5-4 Tariff structure for Pay and Park in Panaji

Parking Duration	Amount, INR
For Four Wheelers	
First hour	INR 20
Every extra hr or part after first hr	INR 15

Source: CCP

11. The Average parking fee of INR 16.7 / hr is worked out based on the average parking period of 3 hrs per car.

12. The total estimated revenue at the base year is escalated at 5% per annum from second year onwards.

13. Details of unit costs of key items are given in Annexure 2 and 3.

5.4.2 Estimated Capital cost of the pilot project

The project CAPEX is estimated based on the above assumptions. These are normative block cost estimates.

Exhibit 5-5 Estimated CAPEX for Smart Parking Solution at Pilot site

SN	Head	Unit	Particulars
1	No. of Parking Sensors, 4 wheelers	No.	123
2	Cost of Sensors incl. installation, activation & calibration, spare sensors	INR	3,174,138
3	Cost of Warden Devices	INR	60,000
4	Cost of CCTVs for surveillance with support infra.	INR	144,000
5	Project Planning & management	INR	1,107,000
6	Cost of Mobile Applications with all backend system	INR	1,725,000
7	Website development	INR	250,000
8	Cost of Digital Signage Boards	INR	240,000
9	Miscellaneous	INR	200,000
Net CAPEX		**INR**	**6,900,138**
10	Taxes at 18% (GST) of net CAPEX	INR	1,242,025
TOTAL CAPEX		**INR**	**8,142,163**

These estimates are based on the normative unit costs for various components. The costs may vary if the CCP choses other components or makes.

5.4.3 Operations and Maintenance Expenditure (OPEX)

The OPEX for the base year is estimated based on various assumptions as given in the later part of the report. OPEX for the base year is excluding debt servicing and taxes, and it is escalated at 5% per annum from the 2nd year onwards. In the base year, OPEX is 19.5% of the Total CAPEX.

Exhibit 5-6 Estimated OPEX for base year for Smart Parking Solution at Pilot site in Panaji

SN	Head	Unit	Particulars
1	Operating cost of sensors	INR	418,200
2	Total Cost of Warden Devices and other devices	INR	36,000
3	Operating cost of CCTVs	INR	14,400
3	Op. cost incl.- internet connectivity, mobile app, website management, analytics, server etc.	INR	615,000
4	Power Supply to various units including digital display boards	INR	72,000
5	Manpower cost – salaries of wardens/ supervisors (4 people)	INR	432,000
	Total OPEX	INR	**1,587,600**

These estimates are based on the normative unit costs for a basket of components. The costs may vary if the CCP choses other components or makes.

5.5 Financial Analysis

Sensitivity analysis has been undertaken with respect to CAPEX, OPEX and revenue. Results of the same are given in this section. As per the feedback received from the private sector, the expected project IRR is between 16% to 18%.

Base Case

In the Base Case following inputs were made -

- Avg. daily hrs. of parking per parking lot is 9.
- Avg. parking fee is INR 16.7 / hr and avg. annual escalation of parking fee is 5%
- Since, the tourism business in Panaji is seasonal, therefore, the average occupancy of the parking lots over the year is estimated at 67%. In this base case assessment, average annual occupancy of parking lots at 60% of total capacity is considered.
- Estimated CAPEX is INR 8.14 mn.
- Replacement cost of sensors: The replacement schedule of sensors is considered as: 35% of the sensors to be replaced in year six from the year of commencement of the project, additional 35% in year seven and remaining 30% sensors to be replaced in the year 8.
- It is assumed that there is no revenue sharing by the private player with CCP.

With the above inputs and assuming project duration of seven years, the project IRR comes out to be 19% with a positive NPV of INR 500,000. This shows that the project is financially viable to be taken up on PPP mode with investment commitment by the private company.

CCP has an option to choose between PPP and EPC plus O&M contract. If CCP choses to bid out this pilot project on PPP mode, it can consider bid variable as – the annual revenue sharing by the private player with the CCP and the bidder which is willing to share the highest revenue can be selected as a preferred bidder.

If CCP decides to develop this project on EPC plus O&M contract then, with the Base case scenario, it can earn a net revenue of INR 100,000 per annum. Net revenue is calculated based on the percentage (2.3%) of the total revenue at which the NPV becomes zero.

However, if the project duration is 10 years, then both NPV and IRR are negative indicating that it needs grant support for developing the project on PPP contract. To achieve a positive NPV,

the minimum grant support required is 50% of the project cost, then the NPV for 10 years will be INR 220,000 and project IRR will be 12%.

Hence, it is recommended to consider project duration as 7 years.

Scenario analysis - use cases

Further, it is observed from the scenario analysis that the finances of the pilot project are highly sensitive to revenue and operating expenditure. The sensitivity of the revenue depends on three factors – average base tariff, average annual escalation of tariff and occupancy of parking lots. Hence, it is recommended that CCP shall have a provision of 5% annual escalation in parking fees to make the pilot project financially viable.

Additionally, the average occupancy of the parking lots can be maintained by proper communication and awareness among the users.

Exhibit 5-7 IRR sensitivity to avg. parking fees, occupancy of parking lots and changes in OPEX

1. Project IRR vs Occupancy of parking lots			
Occupancy	55%	60%	65%
Project IRR	- ve	19%	37%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
Avg. parking fee INR per hr	16.7
CAPEX, INR mn	8.14

2. Project IRR vs Avg. parking fee			
Avg. parking fee	15.00	16.70	17.50
Project IRR	- ve	19%	30%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
CAPEX, INR mn	8.14
Occupancy	60%

3. Project IRR vs Changes in OPEX			
OPEX as % of CAPEX	17%	19.5%	22%
IRR	31%	19%	0%

Fixed parameters	
Avg. annual escalation of parking fee	5%
Avg. daily hrs. of parking / parking lot	9
Avg. parking fee INR per hr	16.7
CAPEX, INR million	8.14
Occupancy	60%

The sensitivity to the grant available for the project is also analysed.

- With a grant of 10% of the CAPEX, the project IRR in base case scenario increases from 19% to 31%
- With a grant of 20% of the CAPEX, the project IRR will further increase to 45%.
- Hence if CCP intends to develop this project on PPP mode it can consider putting in viability gap funding upto 20% and in lieu of that it can get fixed annual revenue share from the private player or concessionaire.

5.6 Implementation plan

5.6.1 Project structure

The projects structuring and responsibility matrix depends upon the type of the contract. In the case of Public Private Partnership (PPP) contract, the private player is responsible for almost all the key activities including bringing in investment. Whereas in case of EPC contract with O&M for 5-7 years, the responsibilities will be distributed among CCP and the private player.

The details of the proposed project structures are covered in the next chapter.

5.6.2 Monitoring and Evaluation

CCP will be the project implementing authority; and it needs to appoint a nodal person to monitor the project. The parking tariff will be fixed by CCP and escalated annually. CCP can monitor based on a set of Service Level Agreements (SLAs) as listed in the contract to be signed between the private player and CCP for this pilot project.

Suitable reporting software should be available to generate standard report formats to measure/ verify various SLAs, for monitoring the performance, etc.

- SLA during Implementation: These SLAs shall be used to evaluate the timelines for completion of deliverables that are listed in the contract. These SLAs will be applicable for commissioning of the project (implementation of the complete project as per scope of the work defined in the contract). For delay of every week in completion & submission of the deliverable mentioned in the proposal, the private player would be charged with penalty.
- SLAs during operations stage: set list of SLAs and applicable penalties in the contract. It should cover - complaints of over-charging or collecting parking charges outside the parking area, the number of vehicles parked shall not exceed the designated capacity of the parking lot, No offline billing of parking charges will be allowed etc.

6 Operating framework and Risks Management

6.1 Project structure for pilot project

CCP has the following two choices based on the availability of the funds and financial viability. CCP can decide on one of the following options -

- **Option 1: in case of EPC contract with O&M for 5-7 years**, the responsibilities will be distributed among CCP and a private player. CCP will be responsible for investment in the project CAPEX and OPEX. The revenue collected by the private player can be handed over to CCP. CCP can explore the option of implementing Smart Parking Solution on EPC plus O&M with the involvement of existing local player who is currently managing the Pay and Park in Panaji.
- **Option 2: CCP can adopt the Public Private Partnership (PPP) model** if it does not have sufficient own funds and grants to cover the entire CAPEX of the project. These types of PPP contracts can be of 5-7 years and if the viability gap fund upto 50% of the project CAPEX is provided then the project duration can be extended upto 10 years. In this case the private player will be responsible for almost all the key activities including bringing in investment for CAPEX. And CCP needs to make a commitment to set up a mechanism for annual tariff escalation. CCP can consider putting in viability gap funding upto 50% of project CAPEX and in lieu of that it can get fixed annual revenue share from the private player or concessionaire. CCP can explore the option of implementing Smart Parking Solution on PPP mode with the involvement of existing local player who is currently managing the Pay and Park in Panaji.

These two structures are elaborated further.

1. **Option 1: EPC contract with O&M for 5-7 years**: The responsibilities among different agencies and stakeholders are given in Exhibit 6-1.

Exhibit 6-1 EPC with O&M contract structure - responsibility matrix

Head	Govt. agency involved	Role of Private Player
CAPEX - Grant or Loan	CCP/ Smart City Mission	-
CAPEX - Viability Gap Funding, if any	CCP/ Smart City Mission	-
OPEX	CCP - Limited role	Private player's responsibility except for major repair works which are previously identified
Tariff fixation	CCP – with provision for annual escalation	-
Demand variation Risk	CCP	-
Parking Fee Collection	-	Private player and it will hand over the revenue collected to CCP or it will pay fixed lumpsum amount annually to CCP
Revenue sharing with CCP	CCP	One time premium or annual revenue sharing by private player with the CCP
Permitting	CCP – guidelines and tariffs	Providing permits, subsidised parking and fee recovery as per CCP's tariffs

Head	Govt. agency involved	Role of Private Player
Enforcement	Traffic Police	Collects fine and transfer 50% to traffic police department and 50% to CCP

The bid variable can be the lowest NPV of the CAPEX, revenue and OPEX of the project. OR the maximum annual revenue shared by the private player with the CCP.

2. **Option 2: PPP contract**: The project can be developed on Design Build Finance Operate and Transfer (DBFOT) basis. The private player can bring in own investment, design the system, install the system, operate the system for 7 years and transfer it to CCP. The responsibilities among different agencies and stakeholders are given in Exhibit 6-2.

Exhibit 6-2 PPP contract structure - responsibility matrix

Head	Govt. agency involved	Role of Private Player
CAPEX	-	Private Player except for the land cost and major civil works if any
Viability Gap Funding, if any	CCP/ Smart City Mission/ IUC	-
OPEX	-	Private player's responsibility except for major repair works which are identified upfront
Tariff fixation	CCP – with provision for annual escalation which need to be defined in the contract	-
Demand variation Risk	-	Private Player
Parking Fee Collection	-	Private player and it will retain the revenue
Revenue sharing with CCP	One time premium or annual revenue sharing with CCP	One time premium or annual revenue sharing by pvt. Player with CCP
Permitting	CCP – guidelines and tariffs	Providing permits and fee recovery as per CCP's tariffs
Enforcement	Traffic Police	Collects fine and transfer 50% to traffic police department, 25% to CCP and retains 25% OR as per the formula decided by CCP during contracting stage

A bid variable can be annual revenue sharing by the private player with CCP. The bidder which is willing to share highest revenue can be selected as a preferred bidder. CCP can consider assigning the tasks for the pilot phase to the current parking contractor.

6.2 Risks identification and mitigation

The risks are the potential or perceived events that will prohibit the efficient and effective implementation of proposed activities. Smart parking technology is still not widely implemented in Indian cities. The assessment involved review of some important use cases in Indian and global cities. One of the key learning was to take up a pilot project and then based on its experience the city should scale it up to city level. So, in case of Panaji city a pilot project is proposed to demonstrate the technology application in smart parking space. Similarly, another major learning is to go for the basic solution rather than

focusing on high tech and data intensive solutions. So, in case of Panaji city a basket of components which comprises the basic system is recommended.

Still there are potential risks that require mitigation measures could include: delays in implementation at grant launch from procurement of consultants/firms and obtaining governmental clearances; potential disruptions from conflict or natural disasters; cost and market risks; inadequate coordination/participation among stakeholders or institutions; lack of political will to support the project to completion. The project specific risks, degree of impact and indicative mitigating measures for the projects are presented in the Exhibit 6-3.

Exhibit 6-3 Risk assessment and mitigation measures

Risk	Probability	Impact	Indicative Risk Mitigants	Risk Bearer
Pre-Commissioning Risk	**Medium**	**Low**	CCP to provide all clearances/ NOCs upfront and in timely manner	Private player and CCP
Time and Cost over-run	**Medium**	**Medium**	Depends on project structure/ contract adopted. • PPP: Private player to secure financing in time, identify good, reputed local vendor on good commercial terms. • Another structure: CCP to appoint nodal officer to closely monitor implementation work to avoid delays and cost overrun.	PPP: Private player Another project structure: CCP
Financing Risks	**Low**	**High**	This is a small pilot project hence financing risk is low.	PPP: Private player Another project structure: CCP
Technology Risk	**Medium**	**High**	Private plyer will be given responsibility of implementation and O&M. And there are many local vendors whom the private player can tie up for operations related issues.	Private Player
Operating Risk				
Demand Forecast	**Medium**	**High**	A pilot area which has substantial footfall is taken up. Also, the cost sensitivity vis-a-vis parking occupancy is analysed to understand the volatility.	Private player
Security of equipment/ items	**High**	**High**	Safety, security of the items installed by the vendor at site shall be responsibility of vendor at his risk and cost for the entire execution period and during Defect liability period. The contractor shall have to get insured all material installed by him against any damage, accident or theft.	Private Player
Parking charges/ willingness to pay	**Medium**	**High**	CCP has fixed tariffs for the base year, which has been shared upfront with the private player so that they can work out their own assessment.	CCP and Private Player
O&M risk	**Low**	**Medium**	Major component of the O&M cost is maintenance of sensors and connectivity cost. These are adequately factored while assessing the O&M cost.	Private Player
Force Majeure	**Low**	**Low**	The contract between the private player and CCP should address it.	CCP and Private Player

6.3 Benefits from the Smart Parking Solution

6.3.1 Benefits to CCP

The benefits for the city include improved traffic flow, less congestion, and better mobility and living conditions. It further helps in getting additional revenue through increased capture rates and pricing changes powered by analytics. It increases the success rate in parking ticket disputes. It further helps in reducing environmental impact with lower carbon emissions and greater efficiency of traffic monitoring and improved planning, driving better return on investment and savings.

Enforcement Officer Benefits - Real-time visibility into parking violations, improved workforce management capabilities and improved results through better use of time and effort.

6.3.2 Environmental Benefits

Smart parking can significantly curb air and noise pollution levels through sustainable urban mobility, saving time and energy, reducing traffic problems, and bringing air and noise pollution down.

It uses sensors to indicate the availability of a parking lot, eliminating the need for drivers to waste time searching for space. By directing drivers to open spaces quickly, smart parking can reduce congestion and resultant emissions. Smart parking systems do this by collecting data in real time, relaying it to drivers through a mobile application. The apps also come with an automated payment method that allows for space reservation, thus reducing the time spent on road polluting the environment.

Through parking data, smart parking systems also enable city administrations to access crucial data to pave the way for cleaner environments. However, such benefits are unlikely to occur with outdated infrastructure in place and disconnected systems that can't communicate with each other. By leveraging IoT, smart parking easily solves this problem. Additionally, by implementing dynamic pricing based on available space, smart parking can significantly reduce congestion and overuse of parking lots, thus impacting air and noise pollution.

As an approach towards India's Nationally Determined Commitments (NDCs), smart parking is one of the components for climate change impact. The smart parking system contributes a portion in climate change mitigation.

As per the LEDS assessment of Panaji city,

- Total Community scale Energy use in 2013-14: 1,195,018 Giga Joules. And the largest energy consumers are Transport Sector (64.8%), Commercial and Institutional Buildings/Facilities Sector (17.6%); Residential Buildings Sector (17.4%). The largest GHG emitters are Transport Sector (38.3%) followed by the Commercial and Institutional Buildings/Facilities Sector (30.6%).
- The prominently used Energy sources are - Petrol (37.8%), Electricity (27.7%) and Diesel (27%). And their corresponding share of GHG emissions are - Petrol (23%), Electricity (55.3%) and Diesel (17.5%).

It is further estimated that the potential GHG emission reduction by adoption of the Smart Parking Solution will result in annual fuel savings of 97,112 liters for cars considering the car parking demand of 4,146 lots. This is equivalent to estimated annual GHG emission reduction to the tune of 228 tonnes of CO2e.

6.3.3 Social Benefits

A good smart parking system has several social benefits as well. Some of the direct and indirect social benefits are – increase in personal safety at night, reduction in accidents and car damage, minimizes theft, increases safety for pedestrians, provides accessible parking for all users including disabled and parents with children, creates transparency in pricing among citizens and parking managers thus avoiding conflicts, reduces anxiety among the drivers thus reducing the stress levels and unnecessary vehicle speeding and honking etc.

Local Business Benefits with ease of parking, resulting in greater customer footfall. The ability to generate targeted offers and promotions for citizens, based on parking data.

Citizen Benefits by reduced circling, leading to savings in time and fuel. Less overall congestion and general improvement in quality of life.

6.4 Branding of City /International project

Once the pilot Smart Parking Solution is successfully implemented the CCP can think of scaling it to other parts of the city. Scaling from 123 car spaces to more than 2,000 car spaces covering both on street and off-street parking within the Panaji city. This will help in creating transparency and instilling belief among citizens about the congestion free and accessible parking system.

Panaji is a tourist hub witnessing more than 200,000 foreign tourists every year. Thus, the smart and sufficient parking system across the city not only helps in improving the image of the city but also helps in branding it through the IUC partnership. The city can showcase its successful pilot project and its scalability to city level at various international platforms and forums with help of IUC partnership. This will help in instilling confidence among various investors and private players due to city' ability to plan and implement technology-based projects.

7 Conclusion and way forward

The Smart Parking Solution is a very good initiative by CCP in partnership with IUC to adopt the technological intervention to improve the experience of commuters, reduce congestion, reduce air pollution and its commitment towards reduction of GHG emissions.

This pilot project will be immensely helpful in gaining understanding of the smart parking system, challenges in its implementation and its benefits. Based on the success of this pilot project, CCP can upscale it to cover all the pay and park sites identified by it.

Since this is a pilot project, it is recommended that CCP should adopt Basic Smart Parking System, comprising of (i) guidance system with a combination of mobile app, website, and digital display boards; (ii) magnetic ground-based sensors; (iii) payment facilities shall be through app, website and handheld PoS with digital and cash based payment options; (iv) permitting and grievance redressal system; and (v) CCTV network for surveillance.

Pilot project's structuring and responsibility matrix depends upon the type of the contract. So, CCP has two choices based on the availability of the funds and financial viability of the project. CCP can implement the pilot Smart Parking Solution either on EPC plus O&M contract or through PPP contract. If CCP has its own funds plus grants available, then it can opt for the EPC plus O&M contract. In case the own fund is not sufficient to fully cover the CAPEX of the project then CCP can adopt PPP model with some viability gap funding through its own sources, if required.

CCP needs to decide which project structure they would like to adopt for this pilot project and accordingly carry out the bidding process. In case of PPP contract, CCP needs to develop a Concession Agreement to be entered between CCP and the successful private player. In case of EPC plus O&M contract, CCP needs to decide on a bidding mechanism and develop a contract document.

Currently a local private company is managing the pay and park at the pilot site. CCP can work out a mechanism to involve the current local private company in this pilot project.

Annexures

Annexure 1 Output of the financial model for the base case

Tariff	Unit		Source/ brief
4 wheelers	*INR / hr*	20	As per tariff policy of CCP
4 wheelers	For Extra hr after first hr, INR / hr	15	As per tariff policy of CCP
Cells highlighted in yellow are input cells			
Total Lots for 4 wheelers		123	As per CCP
Esti. CAPEX Total	**INR mn**	**8.14**	Estimated
Grant	**INR mn**	**-**	For base case, no grant assumed

	Unit	Assumption	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
A. REVENUE – Assumptions												
Parking fees												
Avg. parking duration of a car	hrs	3										
Avg. daily parking hrs per parking lot	hrs	9										
Avg. Capacity Utilisation	%	60%										
Avg. parking fee per hr for CAR	INR/ hr	16.7										
Avg. Annual Escalation in tariff	%	5%										
REVENUE Estimation												
TOTAL REVENUE	**INR mn**		**4.05**	**4.25**	**4.46**	**4.69**	**4.92**	**5.17**	**5.43**	**5.70**	**5.98**	**6.28**
B. OPEX												
OPEX	% of CAPEX, INR mn	19.5%	1.59									

	Unit	Assumption	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Replacement cost of sensors	% of sensor cost: 35% at year 6, 35% at year 7, 30% at year 8							1.63[20]	1.76	1.62		
Escalation per year	% per year	5%										
Annual revenue sharing with CCP	% of total revenue	0%	-									
TOTAL OPEX	INR		**1.59**	**1.67**	**1.75**	**1.84**	**3.56**	**5.37**	**7.40**	**9.39**	**9.86**	**10.36**
CASH FLOW excluding Taxes and debt servicing												
CAPEX	INR mn		8.14									
Grant	INR Mn		-									
OPEX	INR Mn		1.59	1.67	1.75	1.84	3.56	5.37	7.40	9.39	9.86	10.36
Revenue	INR Mn		4.05	4.25	4.46	4.69	4.92	5.17	5.43	5.70	5.98	6.28
Net Cash Flow	**INR Mn**		**(5.68)**	**2.58**	**2.71**	**2.85**	**1.36**	**(0.21)**	**(1.98)**	**(3.70)**	**(3.88)**	**(4.07)**

NPV- 7 years from 2021 to 2027 discounting at 12%	**INR mn**	**0.5**
IRR 7 years from 2021 to 2027	**%**	**19%**

[20] The replacement schedule of sensors is considered as: 35% of the sensors to be replaced in year six from the year of commencement of the project, additional 35% in year seven and remaining 30% in year 8.

Annexure 2 Broad estimates of CAPEX

CAPEX ESTIMATES			
	Unit	**Particulars**	**ESTIMATED CAPEX, INR**
No. of Parking Sensors, 4 wheelers at the pilot parking site		123	
A. Sensors			
Sensor Cost per unit	INR	17,000[21]	
Installation cost per sensor	% of unit cost	25%	
Sensor activation and calibration	% of unit cost	13%	
Extra sensors for replacing damaged sensors	% of total sensors	10% of 123 sensors	
Total Cost of Sensors	**INR**		**3,174,138**
B. Warden Devices			
Number of Warden Devices/ handheld POS	No.	4.0	
Cost per Device[22]	INR	15,000	
Total Cost of Warden Devices			**60,000**
C. CCTVs for surveillance	No.	8	
CCTV cost	INR/ unit	12,000	
Total Cost of CCTVs	**INR**		**96,000**
D. Accessories and image processing	**% of CCTV cost**	**50%**	**48,000**
E. Planning, Project Management			
Total Cost of Planning, Project Management and Supervision (based on Dubrovnik smart parking project cost)	**INR/ sensor**	**9000 x 123 sensors**	**1,107,000**
F. Mobile App[23] with navigation assist, back end payment system, grievance redressal system, analytics etc.			
Number of Applications	No.	1	
Cost Per Application	INR	1,725,000	
Total Cost of Mobile APP + Analytics	**INR**		**1,725,000**
Website development/ customisation	**INR**	**250,000**	**250,000**
G. Digital - LED Display Unit	No.	6	
Digital - LED Display Unit cost (avg. cost worked out based on prices on IndiaMart for 6 ft x 4 ft LED board)	INR/ unit	40,000	
Total cost of Digital Signages incl. installation	**INR**		**240,000**
H. Miscellaneous			200,000
TOTAL CAPEX	**INR**		**6,900,138**
Taxes (GST)	**%**	**18%**	**1,242,025**
TOTAL ESTIMATED CAPEX	**INR**		**8,142,163**

[21] The unit cost of sensor is considered based on market cost of sensor- for instance, Bosch sensors cost (for a bulk order of more than 50 pieces) INR 17,000 per sensor including the cost of dispenser and glue. It has a battery life of 5 years. The installation cost of a sensor is considered as 25% of the cost of a sensor; and the cost of sensor activation and calibration is considered as 13% of the cost of a sensor. These percentages are based on component wise cost of smart parking project at Dubrovnik.

[22] Source: https://www.indiamart.com/proddetail/wep-bp-pro-connect-handheld-billing-terminal-20682800055.html

[23] Mobile App development cost based on interactions with some vendors and referring https://www.businessofapps.com/app-developers/india/

Annexure 3 Broad estimates of OPEX for the base year

OPEX Estimates - I	Unit	No. of Units	Amount in INR
No. of sensors	No.	123	
Op. cost per sensor	% of Sensor cost	20%	
Op. cost of sensors	**INR**		**418,200**
Warden Devices and CCTVs			
Number of Warden Devices	No.	4.0	
Op. cost per Device	INR/ unit	9,000	
Op. Cost of Warden Devices	**INR**		**36,000**
Op. cost of CCTVs	**INR/ unit**	**1,800 x 8 units**	**14,400**
Internet Connectivity, Mobile App, Website management, Analytics, server			
No. of sensors to be connected	No.	123	
Connectivity, Mobile App, Web etc. management	INR/ year	5,000	
Op. cost incl.- Internet Connectivity, Mobile App, Website management, Analytics, server etc.	**INR**		**615,000**
Power Supply	**INR**	**6000**	**72,000**
Manpower - wardens plus other support – salary of 4 wardens at INR 9,000 per month	**INR**	**36,000**	**432,000**
Total estimated OPEX for base year	**INR**		**1,587,600**