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GIS BASED TRAFFIC PARKING MANAGEMENT PROTOTYPE: A CASE STUDY OF VARANASI

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CHAPTER 1

INTRODUCTION

1.1 General

The GIS is one of the most innovative advances in the study of geography. Since its development in the 1970s, GIS has had a major impact on geographic analysis and on business practice in government and the private sector. Most transportation agencies now use GIS and Geospatial Information Systems for Transportation (GIS-T) is one of the largest users of GIS technology. The significant innovation that GIS provides is the ability to manage data spatially in layers and then overlay these layers to perform spatial analyses. Therefore, a roads layer can be integrated with a land use layer enabling a buffer analysis of the land uses within a given distance of the road. The capabilities of GIS have improved over the past three decades, and GIS now provide a wide range of tools for data management and analysis. In the early 1990s, GIS added specific tools for linear data management of transportation data that has proved to be extremely successful among transportation organizations. These capabilities enable transit agencies to georeferenced their bus routes, stops, time points, and other features to a digital street centreline file, and keep all these data in synch.

The deployment of GIS has attracted the interest of transportation software vendors who provide scheduling, vehicle tracking, and trip itinerary planning programs. In some cases, these vendors have developed their own mapping interfaces with GIS-type functionality. In other cases, they provide import and export programs to convert data into compatible GIS formats. These developments reflect in part the demands from the customers for mapping inter-faces. Another interesting trend has been the convergence between geospatial technologies comprising GIS, GPS (global positioning system), and remote sensing technologies such as satellite images, LIDAR (Light Detection and Ranging), and products that orthorectify remote sensed data. This convergence is occurring in part because of IT compatibility and the overlap and

complementarities between the technologies. Many users prefer the term "geo-spatial" to "geographic" information systems for these reasons.

Population growth in urban areas and the deficiencies in the implementation plan cause problems in transportation planning. For modelling parking demand, the activities based on human behaviour should be determined and then identified at space and time. Due to complex nature of these activities, it is impossible to calculate certain demand and to relate land use Functions. Data sets that will be utilized to calculate spatial distribution of demand weights should be available and obtained easily for any residential area. Therefore, it is inevitable to make some assumptions.

An abstraction of the real world is required to model parking demand on GIS environment. In the most basic sense, almost all elements requiring parking demand are expressed in a "structure" having a certain volume. Digital representation of a structure producing par

King demand and supply can be defined with point geometry. All these supply and demand locations have to be defined with (X, Y) coordinate pairs in a common Projected Coordinate System. A geographic database should manage vector and related tabular data sets to calculate the demand. Then, network analysis and location-allocation techniques help to determine the best location for parking places or car parking.

1.2 Significance of Problem

Varanasi is the Cultural Capital of World which is popularly termed as City of Music by UNESCO. Varanasi is also known as Benares, Banaras, and Kashi. The city is known worldwide for Ghats, embankments along the river bank where pilgrims perform ritual ablutions- Dashashwamedh Ghat, the Panchganga Ghat, the Manikarnika Ghat and the Harishchandra Ghat, etc. Varanasi is considered the Spiritual Centre for Hinduism and Buddhism and Jainism. A few outlined demographics of Varanasi are:

1. Among the estimated 23,000 temples in Varanasi are Kashi Vishwanath Temple of Shiva, the Sankat Mochan Hanuman Temple, and the Durga Temple;
2. Banaras Hindu University (BHU) is One of Asia's largest residential universities;
3. Education Hub: Mahatama Gandhi Kashi Vidyapeeth, Sampooranand Sanskrit University and Tibetian University along with BHU
4. Climate: Varanasi experiences a humid subtropical climate;
5. Population: Varanasi urban agglomeration had a population of 16 lakhs;
6. Area: 82.10 km2; Elevation: 80.71 m (264.80 ft); Literacy: 80.12%. Varanasi is governed by a number of bodies, the most important being the Varanasi Nagar Nigam (Municipal Corporation) which is responsible for the master planning of the city

Before Prime Minister Narendra Modi's constituency turns into Kyoto in partnership with Japan, the Smart City plan of Varanasi submitted to the Centre this week has identified traffic congestion and encroachment menace in

Varanasi has cited an Ernst & Young study on a 'City Mobility Plan' to say that 50% of the carriageway capacity in the heart of Varanasi is occupied by irregular parking as no proper parking facilities exist.

1.3 Objectives

The paper examines the problem of car parking in cities and urban areas in order to set general principles and guidelines for parking solutions. To achieve the quality of citizens" life the concluded solutions should consider the aspects of planning, management, technology, environment, and aesthetics. The research objectives are:

i. To determine the different types of data that will model a parking solution.
ii. To assess the challenges encountered in accessing and managing parking.
iii. To review current tools and techniques used in managing urban parking.
iv. To develop a prototype for parking management.
v. To test and analyse the prototype.

1.4 Justification for the Study

This research is significantly paramount for planning transportation in the city, particularly the Varanasi. This is the area where most economic activities take place, thus the conditions should be made conducive for the activities to thrive. The fact that parking is quite dynamic in that, one minute the parking space is engaged and the next or so minutes it is vacant, it is vital that a solution should be developed to efficiently and effectively manage it. The county government will have a proper ground for structuring parking space utilization and traffic police will strain less in terms of controlling traffic and congestion on the roads. This research will shed more light in decision making for city engineers particularly on the use of spatial and non-spatial data in space management. The effect of this congestion has a spiral effect on all stakeholders therefore a GIS-based solution will be effective in alleviating drivers' pain of finding and reserving parking spaces.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

While evaluating the prerequisite so far portable GIS-based parking administration framework, this chapter of study audits an immeasurable archive of data which is secured under urban transportation studies. Much of the literature investigated in this chapter exhibits deviation from the old worldview that parking is continuously accessible and that it is not a subject of judicious administration. As per Rashid, et al(2012) shrewd parking administration frameworks and ITS techniques are investigated to impact parking request administration procedures to the city supervisors for enhanced administration conveyance, client relationship administration and income accumulation. In that case, the purpose of this chapter is to identify some of the previous studies on this topic and determine the ones that can give light to a more advanced finding that will address the research question and problems, and overall objectives in the use of GIS in urban transportation planning and management within the Varanasi. The literature gathered therefore investigates the advances and foundation in the management of parking in urban communities and their utilization for all classifications of clients.

2.2 The Parking Situation in Varanasi

Twenty-first century cities consume two-thirds of the world's energy, and emit 70% of global greenhouse gases. More than 800 million urban dwellers live in sprawling slums, in health compromised conditions. Many live in cities that are yet to lose their reputation for being crowded, unsafe, and environmentally irresponsible.

Surprisingly, these inefficiencies have not deterred the demand for urban land. By 2050, two out of three people in the world will live in such cities. In a business-as-usual scenario, they will withstand the worst of climate change, even as they contribute upward of 80% to global GDP.

In the years to come, as their due, urban dwellers will demand intelligent urban planning that creates safe, affordable and resilient cities with green, and culturally inspiring, living conditions. Goal 11 of the UN Sustainable Development Goals has anticipated this demand by calling for sustainable cities and communities. India is attempting to deliver on this commitment through her ambitious Smart Cities Mission. The Mission promotes an area-based development strategy that focuses on city improvement (retrofitting), city renewal (redevelopment) and city extension (green field development). In addition, a pan city initiative will attempt to integrate the city using smart technological solutions.

Identified smart cities will innovate replicable ICT solutions to resolve basic infrastructure issues, enhance the quality of life, and strive for a clean and sustainable environment. The goal is to learn from one another;

among the identified 100 Smart Cities, a 20-20 concept pairs up the laggards with the frontrunners. Thus, the Mission promotes and innovatively uses smart solutions that all Indian cities can learn from, replicate, and model to their unique context.

Nadav Levy, Itzhak Benenson(2016) every car trip ends with a parking search and parking. However, current transportation research still lacks practical tools and methodologies to analyze parking needs and dynamics, which cannot be adequately performed at an aggregate level. This paper presents PARKFIT, a novel algorithm for estimating city parking patterns that is based on a spatially explicit high-resolution view of the inherently heterogeneous urban parking demand and supply. Using high-resolution data obtainable from most municipal GIS, we apply PARKFIT to evaluate the fit between overnight parking demand and parking capacity in the city of Bat Yam, both currently and within the framework of the Bat Yam2030 transportation master plan. We then analyze PARKFIT's capabilities and limitations, and supply PARKFIT as a free ArcGIS-based software.

Hsiao-Kuang, et al. (2014) with 2000 of which in important cars and trucks, measures typical pace, in addition to picking up the rocks or normal water while travelling. These people find vehicles using disturbances within earth's magnet niche as a result of vehicles. People examine diverse approaches to depend on new or used cars. Most are in-road inductive loops, probe vehicles within site visitors, entry to permanent magnetic devices, us going for wise streets studs, some machine eye sight solutions (with problems) and using info because of mobile or portable mobile phone network. The job objectives are solving the efficient potential customers' operations and road safe practices obstacle by providing some assembly to get customer info. Hsiao-Kuang, et al. (2014) proposed WSN-based traveling facts range along with communication process. These people engineered in addition to prototype hardware in addition to applications WSN themes. Additionally, they establish you are the different parts of ITS for the reason that security sub-system, approach sub-system, execution subsystem in addition to communication sub-system. That they produced some nodes choices: vehicle machine (mobile nodes), roadside equipment (static nodes) along with intersection item (sink). One's own success targets solving that successful supervision and additionally road safety practices struggle by giving the composition to collect traffic knowledge.

Qing, et al, (2014) studied a good VANET that includes roadside entrance nodes. Their particular inter-vehicle conversation (IVC) process offers a couple of categories of connection; routine together with aware primarily based. Their specific purpose should be to improve safe practices. They were proven their specific criteria working with Matlab simulators and lastly accomplished concerning appliance applying smallish rural autos. Additionally, they highlight several other VANET implementations. You succeed targets curing the successful potential customers operations together with highway safe practices challenge by giving a good structural part to recover traffic data.

Venkateswaran et. al, (2014) provide some traffic monitoring process implemented as a result of WSN using the essence some bendable, efficient, low-cost in addition to low-maintenance Wi-Fi solution concerning choosing traffic related info to get generating safety warnings for black colour sites down the road mobile phone network. One's own WSN is made of a particular Entrance Node (GN) together with n Sensor Nodes (SNs) implemented on the roadside as per some close to linear topology.

Chen, Na, et al. (2016) Data within the SNs is usually collected from the GN in addition to delivered to Road Side Equipment (RSU) to blame for fusing the idea by means of traffic-related data files produced just by free options. Their system has become tested using quite a few serious use-case circumstances. Their report comprises addition particulars by using TelosB. The work marks solving the useful traffic organization test by giving a good framework to get traffic data. As per study by Chen, Na, et al. (2016) the necessities for a successful WSN construction designed for ITSs. These people surveyed WSN architectures and additionally stated a principal amount of HER projects. They've already labelled all of them straight into monitoring parking lots, traffic supervision in addition to influence, and traffic evaluation. They will talk about the main element aspects that will generate the model of WSN because of its. They are particular succeed targets solving this effective traffic organization obstacle together with improving upon buyer working experience by providing a competent WSN engineering.

Srinu, M. Venkata, and B. Shiva Shankar (2016) concentrate on detailed analysis of the mobile phone network topology, energy conserving and additionally stability in addition to integrity. These people seal the deal electronic style and design associated with multilevel sensor node and additionally mobile phone network methods suited to urban open take strategy via the internet travel and leisure buses, could be administered with real-time, to achieve the purpose of intelligent operations. It offers higher cost performance look when placed against today's Navigation Systems applied to general public transit strategy. People present their particular answer, however, certainly no comparison created from by using prevailing treatments. Their work objectives curing this powerful traffic organization concern by providing an assembly to accumulate traffic facts.

Merriman et. al, (2016) studies show a powerful construction to enhance the safe practices from road travel around applying WSN and Wireless Bluetooth. Most people additionally discuss an ad-hoc mobile phone network creation relating to vehicles in addition to facts trading sensed as a result of detectors. Their simulation effects demonstrate which Wireless Bluetooth along with sensor systems ISSN 2229-5518 IJSER © 2016 http://www.ijser.org can be used collaboratively to increase wellbeing with streets travel around. Additionally, they highlight a lot of pattern factors for its. You will get the job done targets at curing the street welfare challenge by giving some knowledge selection structural part determined by WSN in addition to Bluetooth.

Zips, Patrik, Martin Böck, and Andreas Kugi (2016) they describe various hardware tools which might be utilized since mobile cooperating toys within the prototype functions. Some functions from each hierarchical stage along with an inter-hierarchical stage practical application have with results from those tests around researching the feasibility of using middleware inside actual take program applications. Inside their proxy newspaper, Xiaohong, et al, provide a fantastic comparison associated with mobile technologies and some more ITS jobs on their extension daily news. Both of their functions aim at helping you out with the useful traffic direction struggle by providing a good assembly to accumulate traffic data files choosing heterogeneous WSN. additional analyse the number of choices associated with exploitation the technological know-how from WSN within A. In-depth detailed description from sensor node developed for sensing the intensity of magnetic discipline in addition to velocity is commonly given. By way of example, an offered sensor is needed to help sense the acceleration involving moving vehicles so to classify the vehicles' corresponding their predicted proportions.

Gallo et al. (2011) explicitly represent road network and parking facilities to study the effects of drivers' parking preferences and cruising on the traffic in the area. Their model estimates the correlation between the increase in the parking occupation rate and the level of road congestion.

Li et al. (2007) present a conceptually similar model that includes public transport in addition to private cars, demonstrating that the relation between parking supply and the level of road congestion is more complex and in some cases the increase in parking supply can induce increased congestion. Recently, we proposed tackling the problem of predicting parking dynamics in a city with PARKAGENT, a spatially explicit, high-resolution simulation model of parking search.

Thompson and Richardson (1998) spatially explicit simulation models aim at understanding the dynamics of parking patterns. Thompson and Richardson ssimulate a driver's choice between on- and off-street parking within a neighborhood of two-way streets, and demonstrate that the driver's decisions while searching for parking, result in non-optimal search behavior.

Willson,(2013) Increasing parking fees over wide areas causes, usually, strong public criticism, while local changes just encourage drivers to search for parking further away from the desired destination, thus shifting parking congestion to areas where the parking situation was considered balanced. Therefore, assessing the influence of existing or planned constraints and regulations on parking availability demands accounting for the high-resolution heterogeneity of the urban parking space. This heterogeneity is often ignored by planners and their manuals that are still based on aggregate measures of demand and supply .

CHAPTER 3

METHODOLOGY

3.1 Introduction

This chapter introduces the general research strategy in terms of data gathering and the precise techniques that will be used to achieve the overall research objectives. As from the previous parts, the purpose of this study is to examine the perceptions of GIS regarding the quality and condition, maintenance, improvement, utilization and renovation of existing urban plans within the city of Varanasi. In that case, this chapter defines the scope and extent of the research design as well as the methods that are implemented to acquire the necessary and diversified data to answer the main research questions.

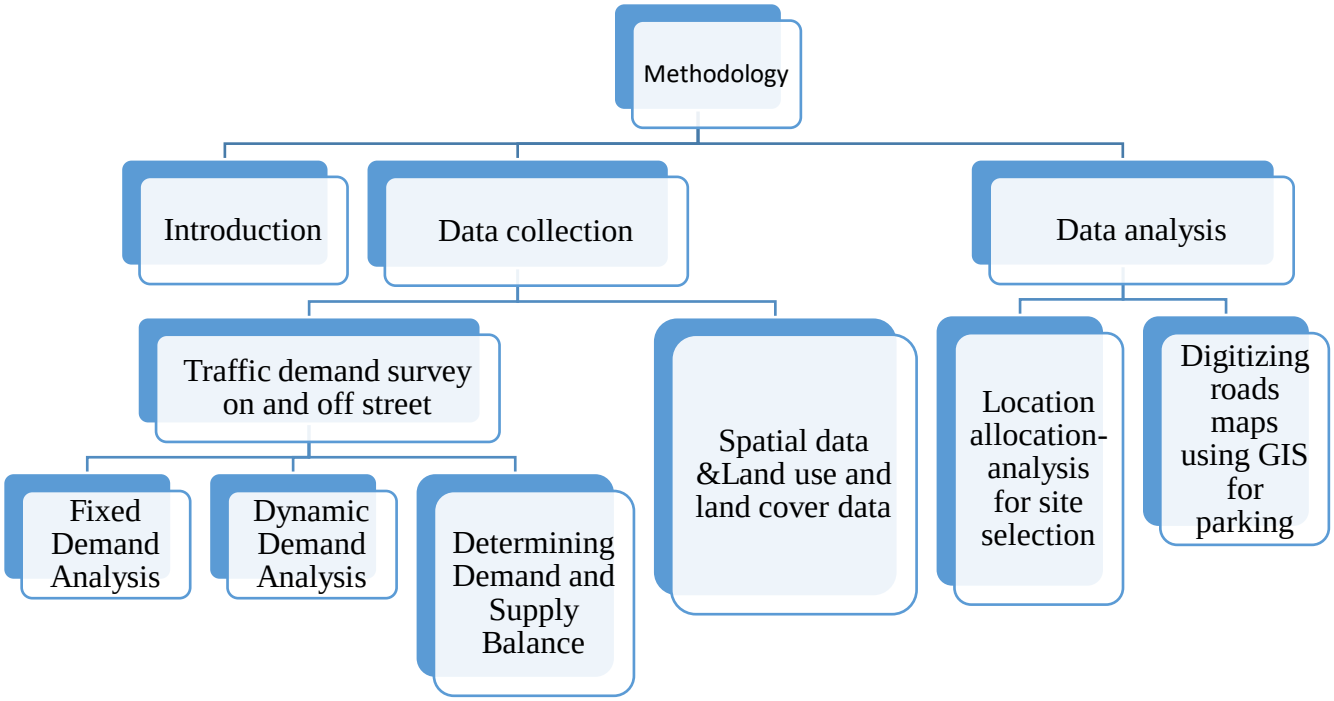

Figure 3.1: Flow chart of research Methodology

The above figure describes the research methodology process and shows how the relevant data could be collected both on street and off street parking location. Case study of this research is located at CBD of Varanasi City. Where the number of vehicles were counted according to the selected parking location. In this flow chart figure also shows the GIS software application and the production of map. Finally the results from the data collection were analysed by using

graphics and creating the parking software application which can guide the drivers in order to find the free parking location easily.

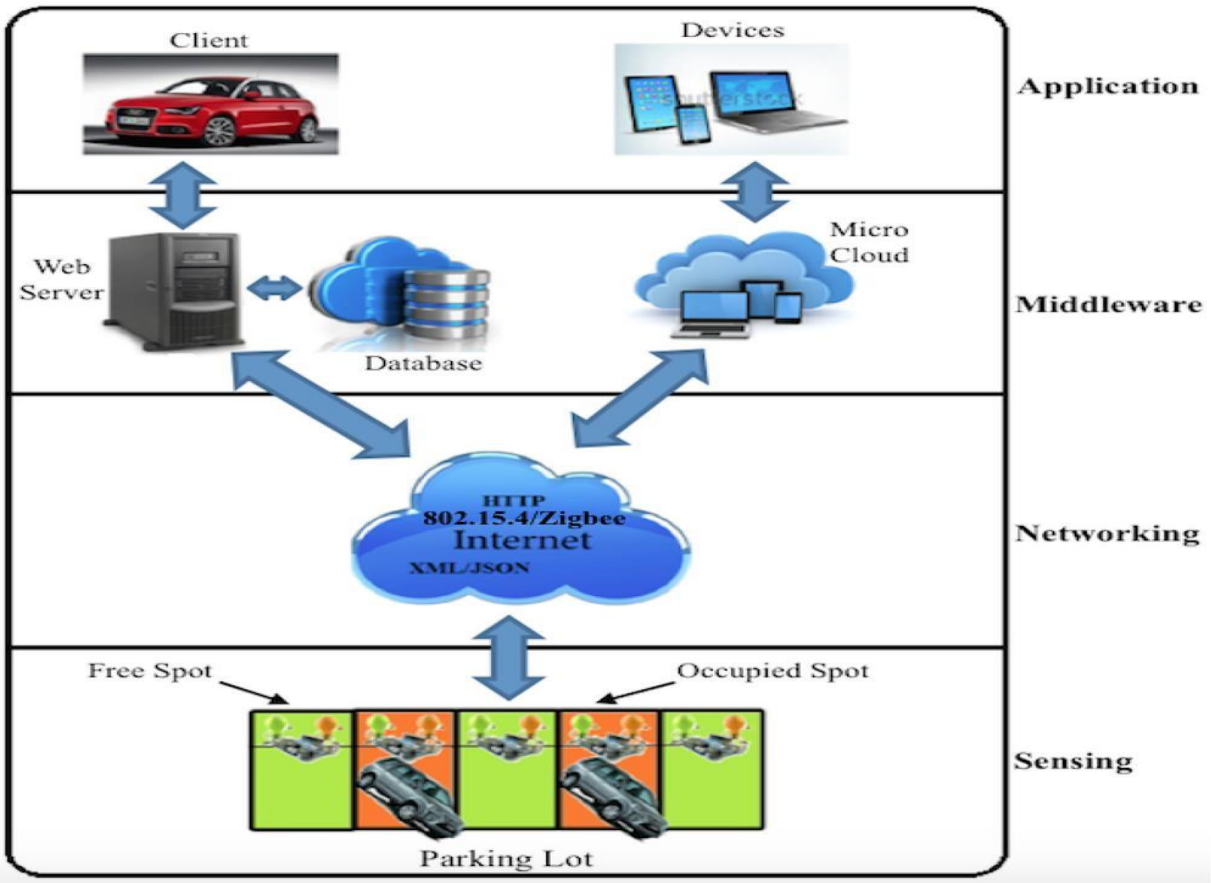

Figure3.2:The Conceptual Framework

3.2 PARKING DEMAND - SUPPLY ANALYSIS

The scope of the parking problem can be examined in two sections as Demand and Supply.

- Demand means parking demand that existing houses and workplaces causes and determined in view of parking behaviour on land use.
- Supply includes all available parking space such as indoor roadside parking, private parking, and functional parking.

Demand and supply balance can be calculated with network analysis techniques or raster-based map algebra techniques on GIS program. As seen on Figure 1, parking demand weights(blue) and parking supply weights (red) are calculated for each object. These are added algebraically in minimum area or pixelby using GIS presentation techniques.

3.2.1 Fixed Demand Analysis

Fixed demand concrete and predictable is determined in priority because it is concrete and predictable. It can be calculated with the accumulation of housing (night) and workplace (day) demands;

- If there is a housing, there is parking demand for housing as fixed demand. Time cycle of this demand is generally from18: 00 evening to 06:00 morning as a daily event.
- If there is a workplace, there is parking demand for workers as fixed demand. Time zone of this demand is from 06:00morning to 18:00 evening as a daily event.

Housing and workplace parking demands are integrated to determine fixed parking demand. Housing and workplace demands should be considered in complementary time cycles (Figure 2).

3.2.2 Dynamic Demand Analysis

Dynamic demand covers daily business and all movements other than fixed demand. People visit workplaces for business, public services, education, shopping, entertainment, sport, and health. It includes continuously changing demands according totime and space. These demands have behaviours at five cycles(Figure 3.3).

- First cycle from 06:00 morning to 18:00 evening is the dynamic demand of the workplaces where people go for business and public services.
- Second cycle from 08:00 morning to 24:00 evening is the dynamic demand of the workplaces where people go for social and recreational purposes.
- Third cycle is the dynamic demand of the workplaces where people go all day for purposes like health.
- Periodic cycle represents workplaces where people go at certain time of the month and the week.
- Special time is for exceptional events causing very much parking demands.

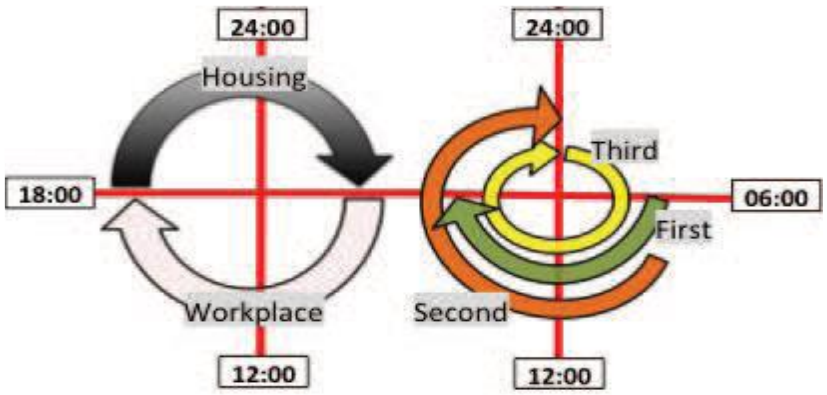

Figure 3.3 Fixed (left) and Dynamic (right) time cycle

3.3.3 Determining Demand and Supply Balance

If a parking supply was linked to a building, demand and supply balance would have been calculated easily for each building. However parking demands can be calculated spatially if the level and quality of available data sets is sufficient.

Parking demand is equal to the sum of fixed demand and dynamic demand for each building. Parking supply is especially situated inside the building or on the roadside. Private parking supply especially meets parking demands in commercial and mixed land use areas.

Demand i = Fixed Demand i + Dynamic Demand i - Supply j

Demand i = the total demand of any building/structure.

To determine demand and supply balance, parking demand subtracts parking supply after removing constraint. This can be calculated by pixel or location-based map algebra techniques of GIS. Then, parking demands can be generalized to district/neighbourhood and traffic zone (TAZ) level if necessary, depending on application needs (Figure3.4).

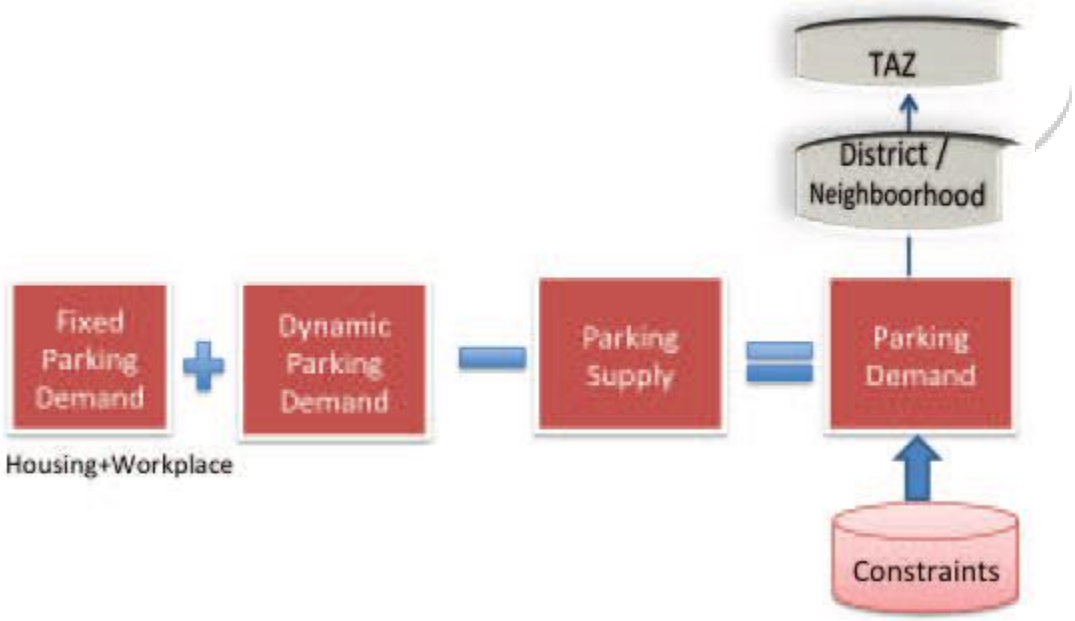

Figure 3.4 Parking Demand and Supply balance

3.4 Data analysis and mapping

To include your data in a map, it must be available online. To make it available online, publish your data as hosted feature layers or as an ArcGIS Server service. See Publish hosted feature layers in ArcGIS Online, Publish hosted feature layers in ArcGIS Enterprise, or About publishing services for ArcGIS Server. When you create a map that includes your layer or service, the map can be opened with Explorer.

CHAPTER 4

STUDY AREA & DATA COLLECTION

4.1 Study Area

4.1.1 Introduction of study area

This chapter introduces the general research strategy in terms of data gathering and the precise techniques that will be used to achieve the overall research objectives. As from the previous parts, the purpose of this study is to examine the perceptions of GIS regarding the quality and condition, maintenance, improvement, utilization and renovation of existing urban plans within the city of Varanasi. In that case, this chapter defines the scope and extent of the research design as well as the methods that are implemented to acquire the necessary and diversified data to answer the main research questions**.**

4.1.2 Location and Topography

Varanasi city lies between the 25°14’ to 25°23.5’ N latitude and 82°56’ to 83°03’ E longitude (Figure 4.1). The environment of the town is tropical with temperature ranging from 5 °C in winter to 45 °C in summer. The mean annual rainfall lies between 680 mm to 1500 mm with a large proportion of its occurring during the months of July to September. The site selected for the survey was made to ensure coverage to the entire city, uniform spatial coverage and key locations from the point of view of commercial importance. The selected sites were: Lanka, Godowlia, Lahurabeer, and Cantonment. These are the important points of Varanasi and the problem of traffic congestion is prevalent at these points.

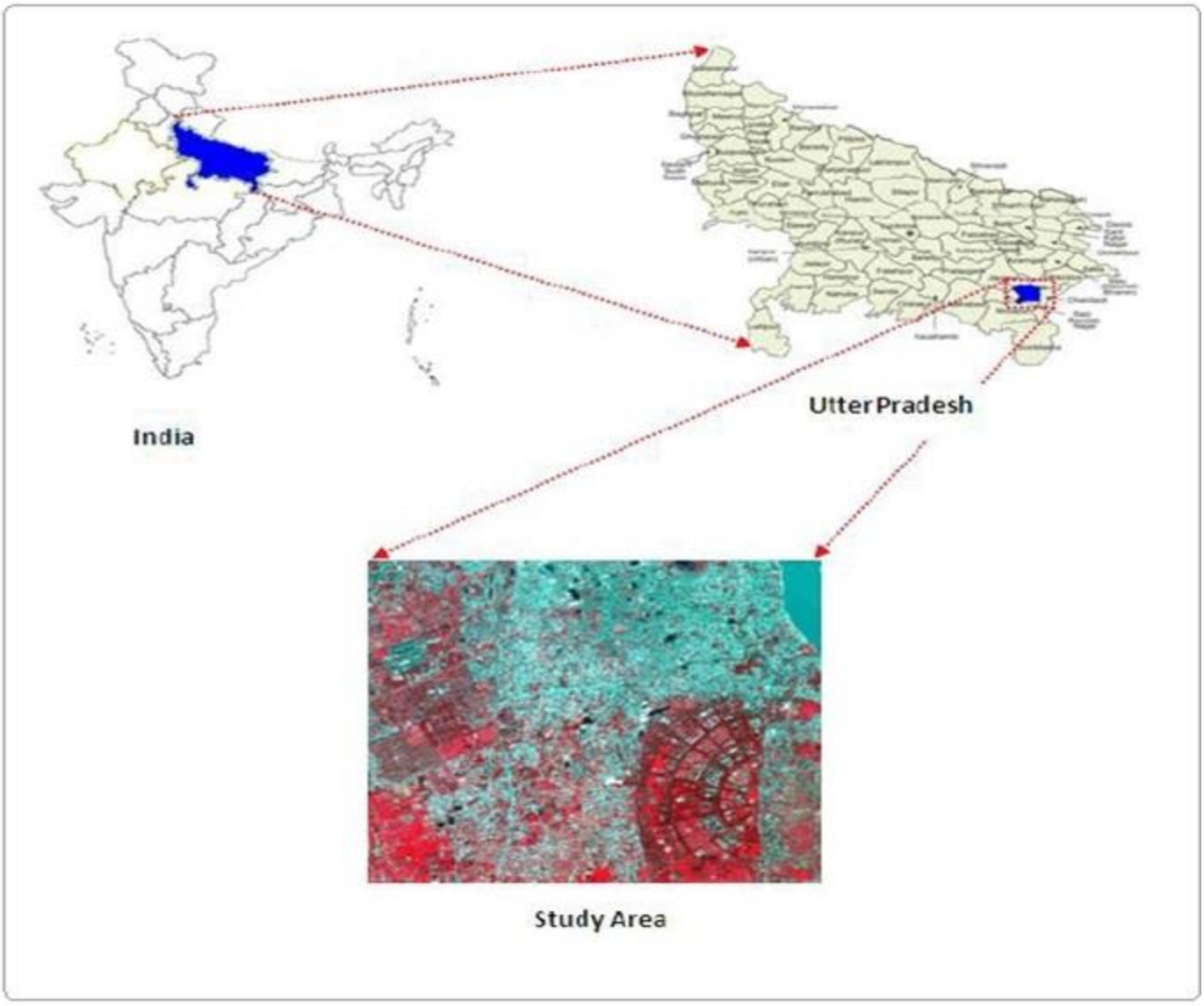

Fig. 4.1: Study Area

4.1.3 Transportation in study area

GIS is progressively more important in customizing and integrating a broad range of exploratory data. There are three national highways i.e. NH-2, NH-56 and NH-29 and four state highways i.e. SH-82, SH-21, SH-24 and SH-98 passing through the heart of the city. These National Highways and state highways have high passenger traffic as these roads provide a good connectivity to the surrounding areas in the Uttar Pradeshstate as well as two metropolitan cities that are Delhi and Kolkata. Transportation and road map were shown in Fig.2.

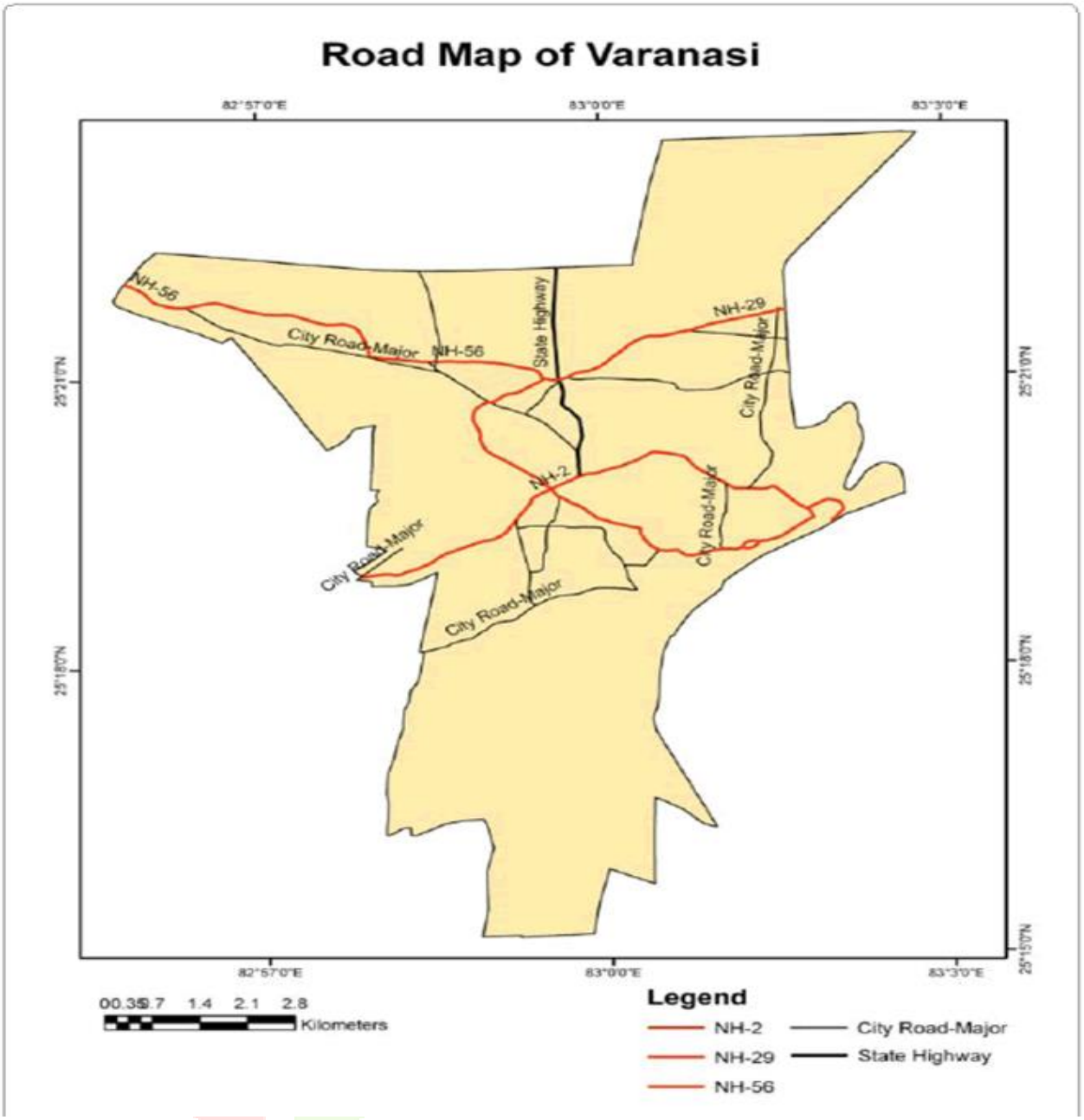

Fig 4.2: Transportation map of Varanasi city

4.2Data collection

4.2.1 Spatial data

LANDSAT satellite images of the study area were acquired in the year 2020. These were obtained from the Global land cover Facility (GLCF), an Earth Science Data Interface. Details of the data

have been presented in Table 4.1. The spatial data consisting of Survey of India toposheet and satellite imagery were used after pre-processing. Digital image-processing techniques were applied to obtain relevant information including identification of classes and features.

Particulates	
Satellite	LANDSAT
Sensor	MSS/TM
Band combination	4,3,2
Spatial Resolution	30 m
Year	2020

Table 4.1: Description of satellite data used data.

The first step was to design the geodatabase according to the information. After the geodatabase design, we started to get all the datasets. The raw data sets were put through the different analysis tools in Arc Toolbox for the required data. After the geodatabase creation, different tools in ArcMap were used to optimize the information. Digital image analysis was carried out using ERDAS IMAGINE 11 and ArcGIS 10 software package. All the spatial data in the form of maps were transformed into computer readable digital maps.These digital maps were imported into PCI Geomatics 10 to perform optimum enhancement and then into ERDAS IMAGINE 2011 for further analysis. Based on the brief reconnaissance survey with additional information from previous research in the study area, a classification scheme was developed for the study area.

4.2.2 Land use and land cover data

The classification scheme developed gives a broad classification where the land use land cover was identified by a single digit. Various supervised classification algorithms were used to assign an unknown pixel to one of a number of classes. Supervised classification was carried out for generating land use and land cover map of study area. The classified LU/LC map of the study area is shown in Fig.3. All of these different land use types influences the parking and traffic movements conditions in this location. Herebelow is the map showing those land use types identified in the case study area.

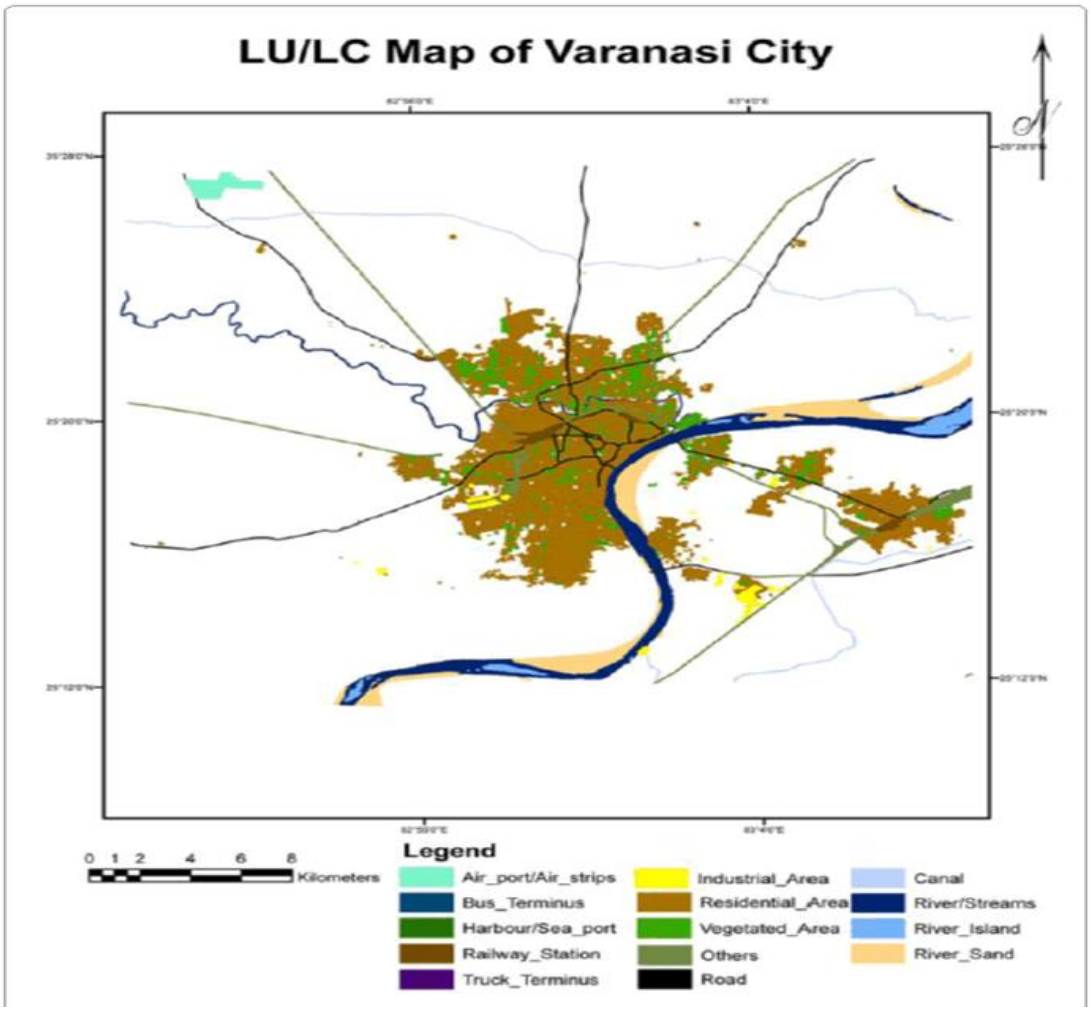

Fig4.3: LU/LC map of Varanasi city

4.3 Population and sampling

The study involves the collection of data from the city's central business district, which has a population of 36, 76,841. To come up with the correct data, the best sample size has to be established. This was determined using the Krejcie and Morgan (1970) formula:

Sample Size= X2NP(1−P)d2(N−1)+X2P(1−P)

Population:150; Accuracy:90%; Marginoferror:5%

Note: This sample size calculator uses a normal distribution of (50%) to calculate the optimum sample size.

The sample size stands for the number of the completed responses from the participants. The term samples originated from the fact that the figure only represents a portion of the total population within the area of research. The total population of the Varanasi CBD is around36, 76,841. 150 participants are used to produce relevant information, which address all the research questions. From

the 150 respondents, 50% are male and 50% female all aged between 25 to 55years. 20% will be from the county and national government offices, 30 percent from other business offices,35%will be activists and clergy communities and25% the unemployed common citizens within the CBD. The reason for selecting a diverse sample is that the study aims to collect diverse information regarding the entire GIS of Varanasi city and then narrow down to the area of study.

4.4 Data collection instruments

The study involves a number of data collections instruments. Geographic information system (GIS) captures, saves, analyses, manipulates and manages any form of geographical statistical data. GIS is mainly used to study the geographical systems of a certain area or environment. In this study, the GIS are used to describe the information system that stores, integrates, edits, analyses and displays graphic information regarding the Varanasi CBD. By using the tools of GIS, the researcher gets a chance to come with effective and interactive queries, conduct a spatial information analysis, edit some data in map, and present the results in a clearer manner thus making the entire study a success. The main data utilized in this study include that involving; tax files, parking preference, transport methods, number of garages, the years of construction, owners' information, private tenants and social housing proportions. Due to its complexity, the data to be used in this GIS study is collected through both primary and secondary methods such as observations, document reviewing, surveying, and questionnaire methods.

4.7 Surveying

Surveying is the other method, which will be used in this particular study. Surveying research is one of the crucial measurements employed across study disciplines, such as socialresearch. This method will involve an approach that collects data from the respondent by asking some questions. The main survey approaches will include questionnaires and interviews where by the respondents are required to answer some questions as directed by the researcher.

In this study, applied survey method will be deployed to obtain data on parking capacity in the CBD by parking type (on-street, off-street and buildings). The data collected in this case entailed demand, demand and supply and parking duration by type of car, this was done in twelve car parks including off-street parking, on-street parking and car parking in the buildings. The output of the survey was as follows:

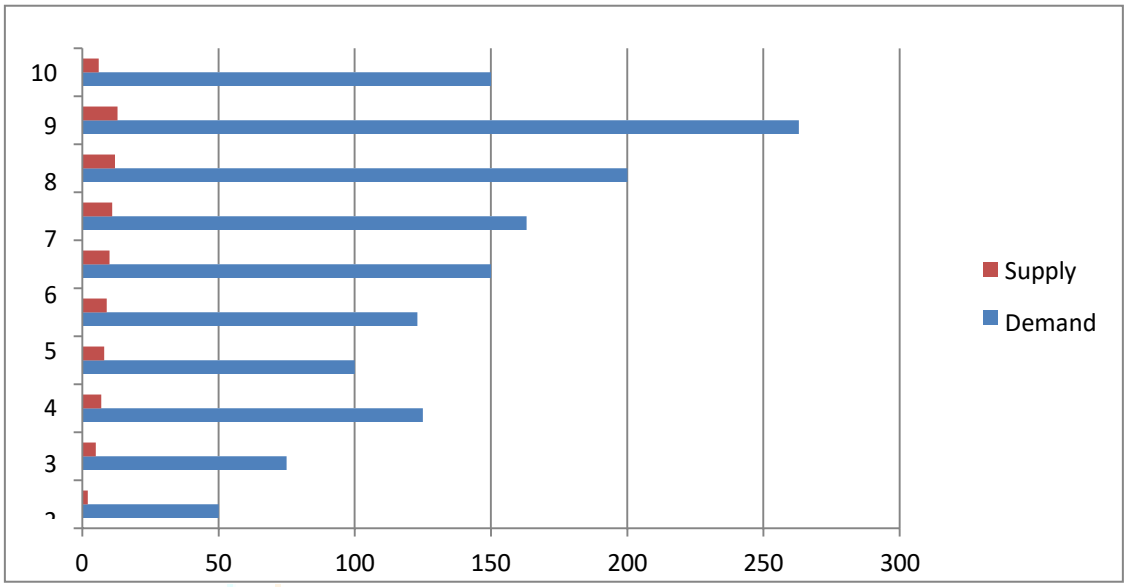

Figure 4.4: Study area and car parking demand and supply at Varanasi

4.8 Average Parking Time

The number plate matching for cars was carried out which was to determine the average time of parking which was as follows:

Total cars recorded revealed to be taking approximately 3 and half hours. Off-street parking and parking in the buildings takes more than 5 hours. For on-street parking, the average parking time is 1 hour and 45 minutes, this is quite a shorter time compared to the other types of parking. This is summarized in the table 4.1:

Table 4.1: Parking Place and Average Parking

Parking Place	Off-street	On -street	Building
Average Parking Time (min)	250.6	150.00	300.1

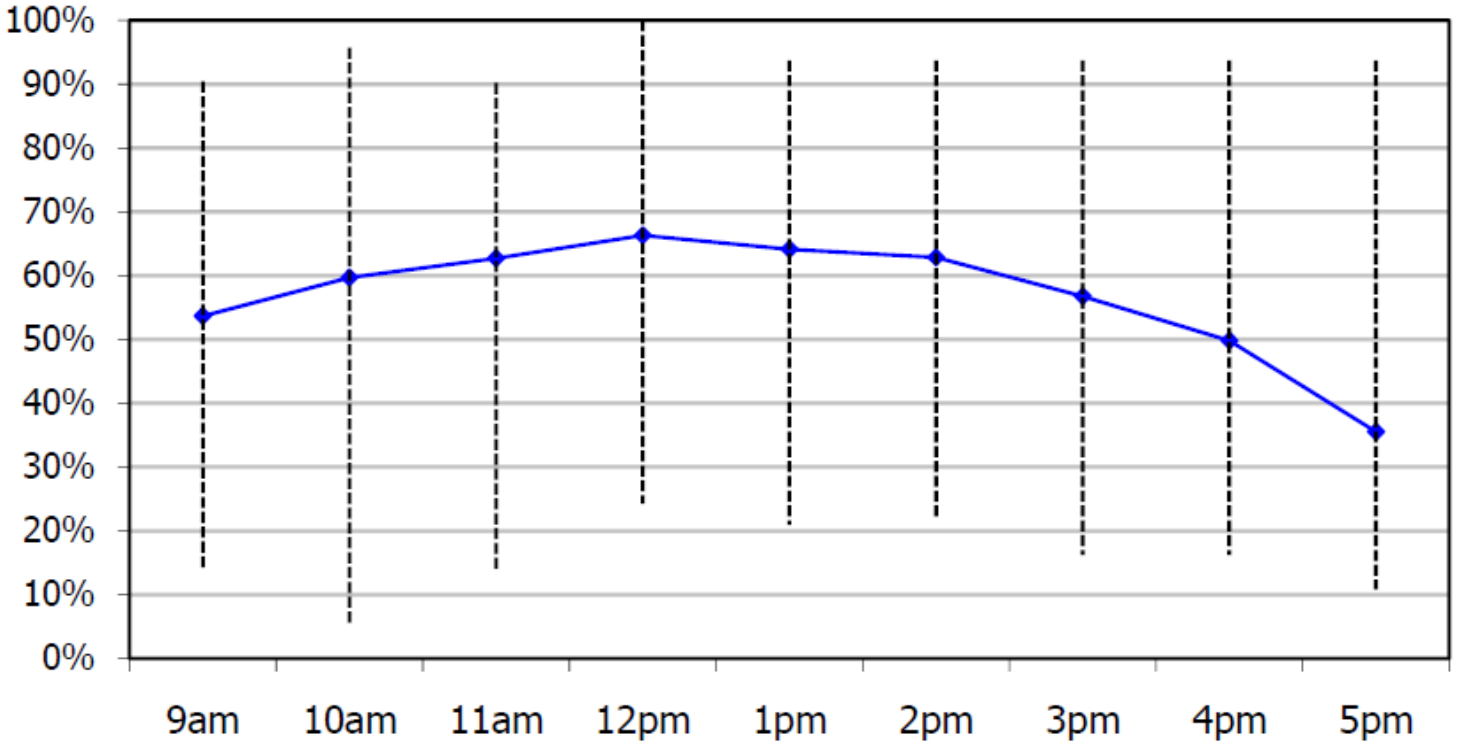

Figure 4.5 On Street parking demand in Varanasi city

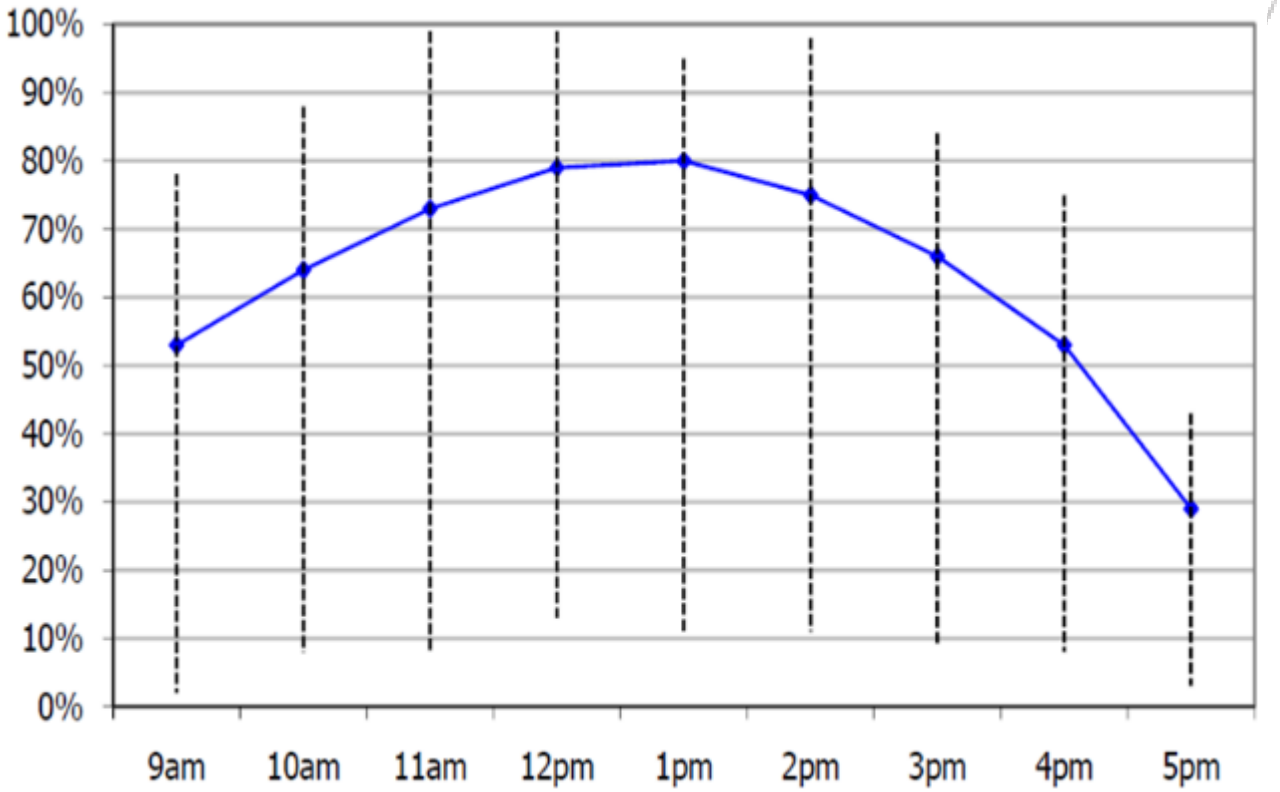

Figure 4.6 Off Street parking demand in Varanasi city

4.9 Parking Interview Survey

Approximately 150 samples were collected from the twelve parking locations around Varanasi CBD and it was found out that: On average, 50% of users prefer to drive to town and 50% do not drive into town. Approximately 80% of them are working, implying that on a weeklybasis, the number goes higher. The number for those schooling and jobless is quite low at about 23%. The pie-chart in figure 4.5 gives a visual view of the above statistics.

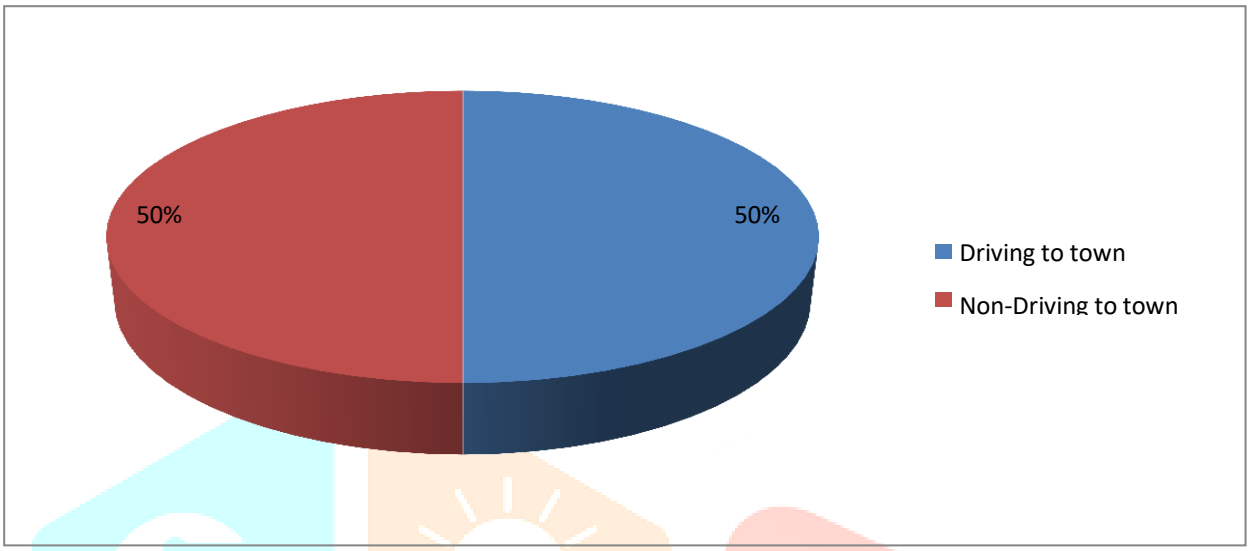

Figure 4.7: Parking Interview Survey

Figure 4.6 shows the different things different people come to the CDB to do, a bigger chunk is occupied by those working since majority of the institutions such as banks, schools, colleges and offices are based in town, a centralized area. These institutions form part of the global innovation index factor for any city.

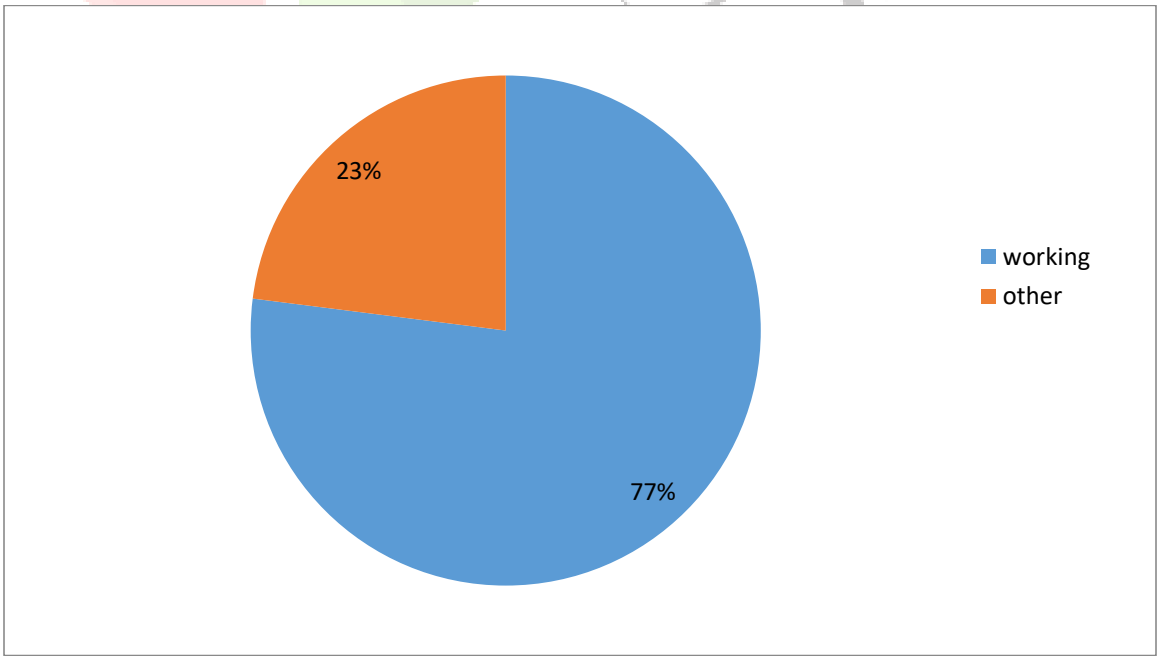

Figure 4.8: Parking Interview Survey

Table 2. On street legally parked vehicles data collection

Hours	Supply: 156				% of occupancy
	15min	15min	15min	15min	
08:00 - 09:00 AM	82	111	120	115	76.92
	Peak 15 min demand: 120				
09:00 -10:00 AM	116	120	126	126	80.77
	Peak 15 min demand: 126				
10:00 -11:00 AM	125	135	132	134	86.54
	Peak 15 min demand: 135				
11:00 -12:00 AM	131	132	134	130	85.9
	Peak 15 min demand: 134				
12:00 - 01:00 PM	130	133	130	131	85.26
	Peak 15 min demand: 133				
01:00 - 02:00 PM	119	122	126	126	80.77
	Peak 15 min demand: 126				
02:00 - 03:00 PM	131	124	129	128	83.97
	Peak 15 min demand: 131				
03:00 - 04:00 PM	128	128	129	135	86.54
	Peak 15 min demand: 135				
04:00 - 05:00 PM	131	129	133	126	85.26
	Peak 15 min demand: 133				
Peak H D	135				86.54

Figure 4.9 Fluctuations of on street parking demand on a typical weekday

Table 3. Off street legally parked vehicles data collection at Building

Hours	Supply: 256				% of Occupancy
	15min	15min	15min	15min	
08:00 - 09:00 AM	73	77	86	106	41.41
	Peak 15 min demand: 106				

09:00 -10:00 AM	113	122	132	139	54.3
	Peak 15 min demand: 139				
10:00 -11:00 AM	142	147	153	153	59.77
	Peak 15 min demand: 153				
11:00 -12:00 AM	155	170	184	177	71.88
	Peak 15 min demand: 184				
12:00 - 01:00 PM	182	172	170	173	71.09
	Peak 15 min demand: 182				
01:00 - 02:00 PM	167	164	163	169	66.02
	Peak 15 min demand: 169				
02:00 - 03:00 PM	179	178	177	191	74.61
	Peak 15 min demand: 191				
03:00 - 04:00 PM	201	204	201	211	82.42
	Peak 15 min demand: 211				
04:00 - 05:00 PM	209	215	215	222	86.72
	Peak 15 min demand: 222				
05:00 - 06:00 PM	212	224	222	220	87.50
	Peak 15 min demand: 224				
06:00 - 07:00 PM	221	215	174	154	86.33
	Peak 15 min demand: 221				
07:00 - 08:00 PM	134	123	102	84	52.34
	Peak 15 min demand: 134				

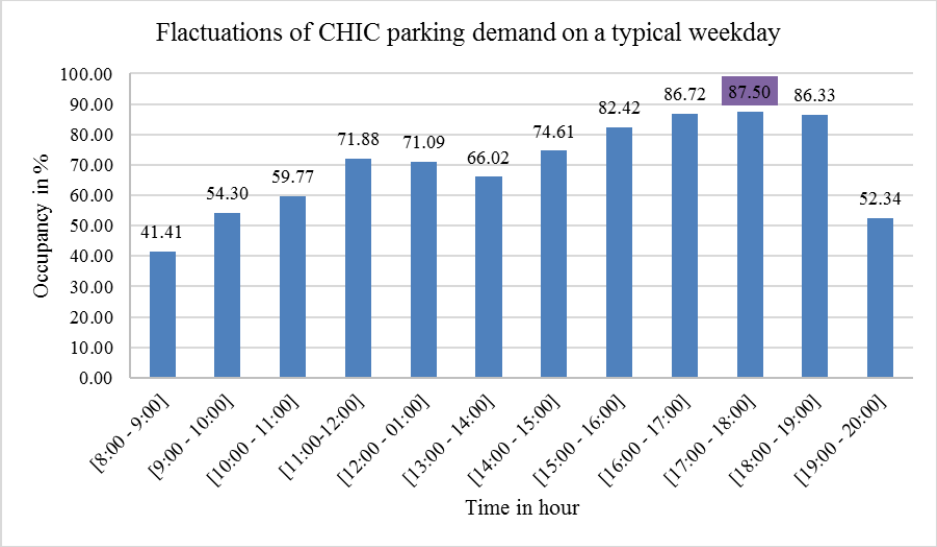

Figure 4.10 Off street parking occupancy fluctuations

CHAPTER 5

VARANSI SMART CITY CASE STUDY

5.1 Introduction

Varanasi Police covers an area of about 112.26 Sq. km. The following map represents the Geographical spread of the area and zone wise distribution of police jurisdictions. This includes Varanasi Municipal Corporation limits.

Residents of Varanasi are facing trouble in finding parking space and frequently end up in wrong parking practices. The Smart Parking solution will alert residents about parking spaces available, allow

them to pay with mobile wallets or bank wallets or mobile wallets like payTM etc through their mobile phones.

Varanasi being a religious and cultural tourist place there are over 70,00,000 pilgrims visiting the place. Therefore, number of floating vehicles enter into the city on daily basis apart from local vehicles. VSCL has identified 9 locations in the city for parking. Out of which there will be one dedicated multi-level parking for two wheelers and one multi-level car parking which will be completed on priority basis.

Fig: 5.1 Varanasi Municipal Corporation Map

5.2 About Varanasi

Among several cities vying for the Smart spotlight, Uttar Pradesh Varanasi has been making progress in leaps and bounds. The city's success story has important learning points for Indian urbanism. Multiple stakeholders, several layers of infrastructure, and a dense urban fabric (with a large proportion of floating population) make Varanasi a relatable case study for India's cities.

Varanasi boasts of international repute; it ranks among the oldest continuously inhabited cities ofthe world, and has received UNESCO'S Creative City of Music tag. In India, the city's significance is both cultural and mystical. Every year, millions of domestic and international visitors flock to India's spiritual soul, eager to absorb the sights and sounds of Varanasi.

5.3 Challenges with Conventional Parking:

1. High Parking Search Time

2. Traffic Congestion on Road

3. Poor Usage of Parking Space

4. Poor Occupancy in Parking Lot

5. Less Revenue / collection

6. Less effective parking operations

7. High Parking violations

8. Accidental Hazards

9. Stress to user & dissatisfaction

10. Pollution – High Emission of gas

11. No flexibility in Parking Charges

12. Suspicious parking / Lack of security arrangements in Parking

13. No real time tracking, data/report for analysis for future need/expansion

5.4 Smart Parking – Mobile Solution & its Benefits (Subset of Smart Kashi Mobile App and Smart Kashi Portal):

1. Mobile App for finding parking space quickly & easily

2. Finding parking space with clear & simple directions reducing traffic Congestion. Parking violation detection real time system also help.

3. Assisting user in directing to correct parking slot help in correct parking at correct slot, making optimal usage of parking space

4. Real time update of entry & exit of vehicle improve occupancy

5. Improved Parking Occupancy increase collection

6. Ease of payment improve collection & save time

7. Real time info, Smart meters, ease of payment improve parking operations

8. Clear, simple directions & ease in parking reduces road accidents

9. Improved user satisfaction by saving time, effort & cost

10. Less parking search time reduces emission of gases & control pollution

11. Provision for demand responsive parking charges – Higher charges during peak hours etc

12. Correct detections of violations & suspicious parking/over duration parking

5.5 General Requirements

1. Installation of sensors in each bay, which register whether the bay is occupied or vacant.

2. Installation & Maintenance of Variable Message Boards in the parking

3. Integration with VMS which is managed from Integrated Command Control Center

4. Network and backup mechanisms for power

5. Installation and boom barriers and cameras

6. The Mobile ticketing devices required for payments and integrated with Parking Management Application

7. Fully functional Parking Management System as specified in FRS

8. This information to relay live to local and Central system where parking management application is hosted, which collates and analyses the data.

9. Mobile App feature to view, book the parking space as mentioned in functional and technical requirements.

10. Smart elements geo tagging with GIS Maps and all the operations from command control center should use GIS Maps as interface

11. Mobile App should use Varanasi GIS Maps

12. Payment gateway integration

5.6 Functional Requirements of Smart Parking Management System (SPMS):

The following requirements are meant for multilevel 2 wheeler and multilevel car parking. Additional requirements of the parking system for multilevel car parking is called out in the last section of smart parking functional requirements.

1. The Kashi Smart Parking Management System (KSPMS) should enable VSCL to obtain real time situational awareness about the occupancy of parking lot.

2. The KSPMS should enable VSCL or any other appointed third party to manage parking locations

3. The smart parking solution should provide real time location based view to citizens about proximity of parking lots and availability of parking lots

4. The smart parking solution should enable the above functions with minimum manual intervention. The smart parking solution is envisaged for closed parking lots, open parking lots and road side parking as implemented as applicable

i. **Multi-Level Parking Spaces**- Such parking spaces are managed by VSCL through sub contracted vendors initially and the parking lots have boundary walls and a defined entry and exit points. Parking spaces have specified number of slots available at each floor for two wheelers and four wheelers as required.

ii. **Open Parking Spaces**- Such locations are managed by VSCL through sub contracted vendors and have a boundary wall and defined entry and exit points. These kind of parking spaces have specified number of slots available, typically in an open ground or road.

iii. **Road side parking spaces** - These locations will be identified by traffic police at various locations of the city. These identified parking areas will have clear demarcations for parking and required sign boards. These will be managed sub-contractors.

5. Configurable with multiple parking locations and available number of slots for each locations

6. The smart parking solution should be able count the number of vehicles entering and exiting any parking structure except parking on road sides

7. The smart parking solution must geo-reference all the parking lots.

8. The smart parking solution will use video camera based analytics for parking lots without sensors (Open parking) and two wheeler parking and sensor based solutions to determine number of vehicles entering and exiting parking lots for multi-level parking. The smart parking solution should do so at each floor, in case of multilevel parking and communicate the data

9.The smart parking solution should report occupancy of parking lots to a central software application deployed at the command center using the network laid out as a part of this tender document

10. For Multi-level car parking the parking slots will be identified with unique ID and can be booked from internet or mobile device

11. Application should be able to manage third party contractor details

12. Real time display of parking slots availability for each location should be available on Mobile App and on web page

13. Receive & Send parking details to Mobile App

14. Receive & Send details to parking location wireless devices including Mobile App bookings and display units

15. The parking block time for Mobile App user should be configurable from Server and displayed in Mobile App

16. Application should be able to configure time allowed to extend for blocked parking and the same will be displayed on Mobile Apps like: He can extend time by 5 minutes if he is nearby so that the blocked parking will be released after 5 minutes for only multi-level car parking

17. The bookings received from the Mobile App should be updated at the control center and also at the parking location displays

18. The availability of parking slot should be displayed on Variable Message System (VMS) from control center and not through Mobile ticketing device

19. The total number of slots and free slots for parking must be displayed on a digital signboard near the entrance of the parking lots or as specified by VSCL.

20. The smart parking solution should facilitate real time revision of parking fees and should enable real time communication of rules to handheld terminal and parking kiosks. A sign board should be displayed in entry gate to notify the user regarding demand based parking fee

21. Save information in SQL or equivalent database

22. Reporting & Analytics - The smart parking solution should enable accounting and mapping of individual parking spots.

23. Audit trials of open loops for car parking should be automatically displayed on dashboard

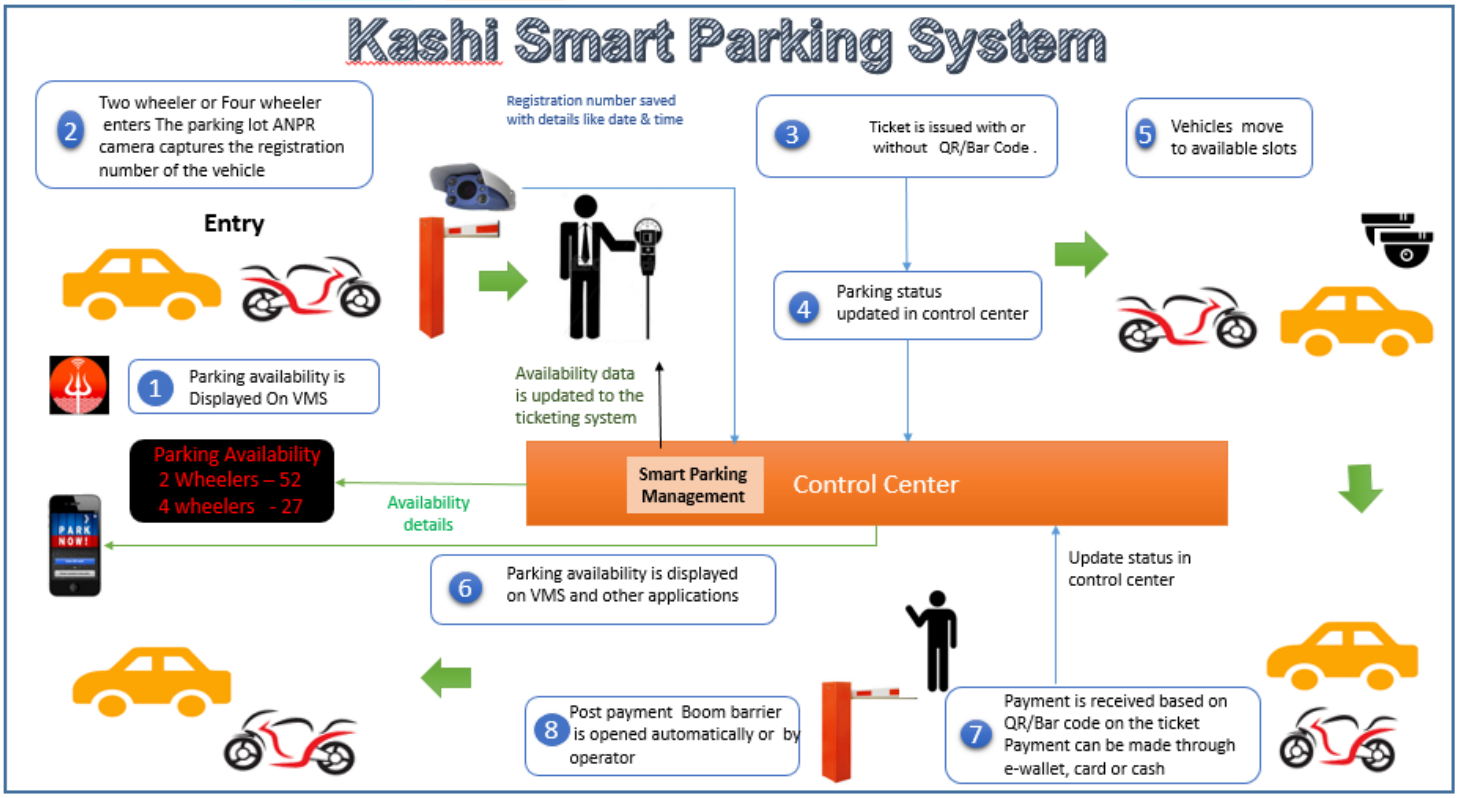

Figure5.2 : Illustrative Representation of Kashi Smart Parking System

5.7 The solution:

A customised solution for Varanasi depended on the mammoth task of mapping and overlapping multiple datasets of the city's development. Accordingly, the SPV used ArcGIS Platform Technology to create an enterprise-wide integrated City GIS. In the process, multiple data sources and data levels became available for analysis, including information on administrative boundaries, public services, religious places, education and health, tourism and recreation, transportation, water bodies, and locations of infrastructure related to water, sewerage and drainage systems in the city.

ArcGIS Platform became a digital mesh that superimposed all smart components of the city over a common set of base maps. Some of the smart systems currently improving management and coordination of city services include.

Solution's

1) Surveillance System Infrastructure at Field Locations

This Component covers planning & implementation of the Surveillance system comprising cameras and other field equipment at locations identified by Varanasi Competent Authority, Actual placement of pole & number of cameras at each location, type of cameras, fixation of height & angle for the cameras to ensure maximum coverage in consultation with Varanasi Competent Authority.

A detailed survey shall be conducted, by the MSI along with a team of Competent Authority and Varanasi police, at each of the strategic locations. This survey shall finalize the position of all field equipment's and the orientation/ field of view of the cameras. Appropriate field of view snapshot shall be taken by a handheld camera for future reference at the time of survey. The surveyors shall also finalize the approximate location of foundation for junction box and camera poles. The route for all the underground cable laying shall be finalized during this survey (wherever required). Every detail, finalized during the survey, shall be demarcated on an AutoCAD drawing by the MSI and submitted to Competent Authority in the form of a detailed site survey report along with other details for its approval.
System shall provide inter-operability of hardware, operating system, software, networking, printing, database connectivity, reporting, and communication protocols. MSI shall prepare the Detailed Report for field level requirements such as e.g. Cameras (types & numbers), Camera Mounting requirements, Power Requirements, Connectivity Requirements etc. for perusal of Competent Authority. Indicative list of the field level hardware

To be provided by MSI is as follows:

- Cameras (Fixed Box Cameras, PTZ Cameras, ANPR cameras, FRS camera etc.)
- IR Illuminators3. Local processing unit for ANPR / RLVD cameras

- Switches
- Outdoor Cabinets6. Pole for cameras / Mast
- Outdoor Junction box
- UPS
- Networking and power cables and other related infrastructure

The indicative list of locations for the camera installation is mentioned in Annexure II & solution requirements in Annexure III in the RFP document along with minimum technical requirements of associated hardware to implement a complete Surveillance system.

2) Public Address System (PAS)

Public Address System shall be used at intersections, public places, market places or those critical locations as identified by Competent Authority to make important announcements for the citizens/public. It shall be able to broadcast messages across all PA systems or specific announcement could be made to a particular location supporting single zone / multi zone operations. The system shall also deliver pre-recorded messages to the loud speakers attached to them from CD/DVD Players & Pen drives for public announcements. The system shall contain an IP based amplifier and use PoE power that could drive the speakers. The system shall also contain the control software that could be used to control/monitor all the components of the system that includes Controller, Calling Station & keypad, Amplifier (Mixing & Booster).The MSI shall describe in detail the design, operational and physical requirements of the proposed public announcement system to demonstrate compliance with all the specified requirements of RFP.

3) Variable Message Signboards (VaMS)

Variable Message Signboard (VMS) shall be installed at identified strategic locations. The VMS shall communicate information & guidance about traffic, diversions etc. to the citizens / public on the road. They shall also be used for showing emergency/ disaster related messages as and when required. The MSI shall describe in detail the design, operational and physical requirements of the proposed Variable Message Signboards to demonstrate compliance with all the specified requirements in this RFP.

The VMS unit shall be able to communicate with the Integrated Command and Control Centre System (ICC) using GSM Data/ Wi-Fi/ Ethernet/SMS Channel. GSM data channel (GPRS) / Wi-Fi shall be used to send online messages and SMS channel shall be used to send configuration packets to configure the SIM. Ethernet port shall also be extended to ground level using necessary cables for local troubleshooting. Each unit shall be provided with a unique identification number and shall communicate with the Integrated Command and Control Centre System (KICCC).

VMS shall be managed and operated from the Integrated Command and Control Centre (KICCC) system using handled by a server where information in the form of data messages shall be fed in a manner to bedisplayed on a specific VMS installed at a particular location or across all locations. The VMS boards shall be viewable from a distance of 100m and various angles on the road. For installing VMS Signboards, the MSI shall provide Gantry with spans, as required at various locations (single lane road, double lane road). Spans need to be specified depending on the number of lanes that need to be bridged. MSI shall consider additional space for lateral clearance as well as a vertical clearance height as per NHAI (National Highway Authority of India) guidelines Variable messaging System will be used by other applications like ITMS, Smart Parking, Environment monitoring etc. as mentioned in respective sections.

4) Pelican Signals:

Pelican Signal (Pedestrian Light Controlled Crossing) shall be a definitive light controlled crossing signal featuring a set of traffic lights (Green Man & Red Man Signal) with a push button, operated by pedestrian and shall also be able to facilitate differently-abled/Senior Citizens for crossing. The controls to operate the light signals shall be on the pedestrian's corner while the light signal for crossing on the other side of the road. Pelican Signal shall be installed at identified locations.

Configuration

Sample drawings below is for indicative purpose only; the bidders may propose their own design meeting the specifications of a Pelican Signal.

Fig: 5.3 Pelican Signal

CHAPTER 6

Results

6.1 Test Results

This section captures the expected outcome from the different scenarios in which the system will interface with the user as well as other parameters. If the outcome is opposite of what is expected, then the requirements have to be reviewed and code has to be debugged. This is to ensure that good quality assessment is done end to end for a fully-functioning system.

6.1.1 Test Scenario One

The first scenario is the administrator mapping the parking spaces available from Google maps. This is dependent on the respective environment or vicinity. Figure3.7 shows the expected outcome.

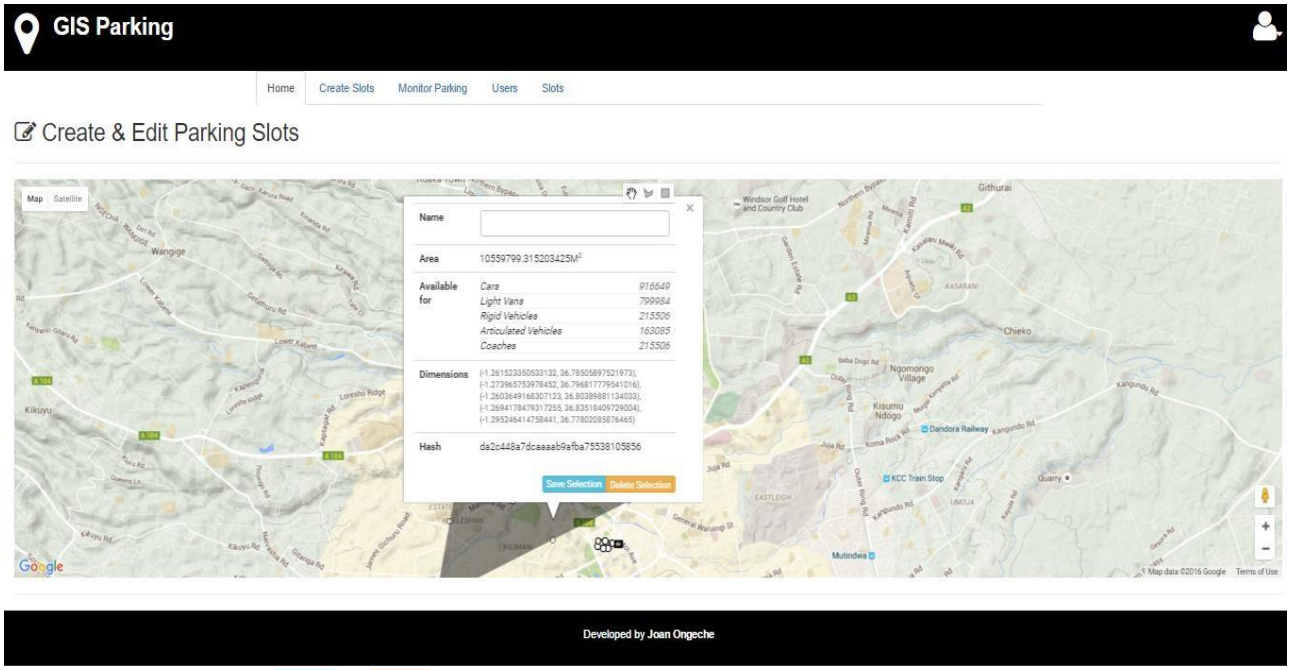

Figure6.1:Creation of Parking Slots

6.1.2 Test Scenario Two

The web interface is linked with the android application through which the users will access directly from their phones. Once they download the application, they should be able to see the system as indicated in figure

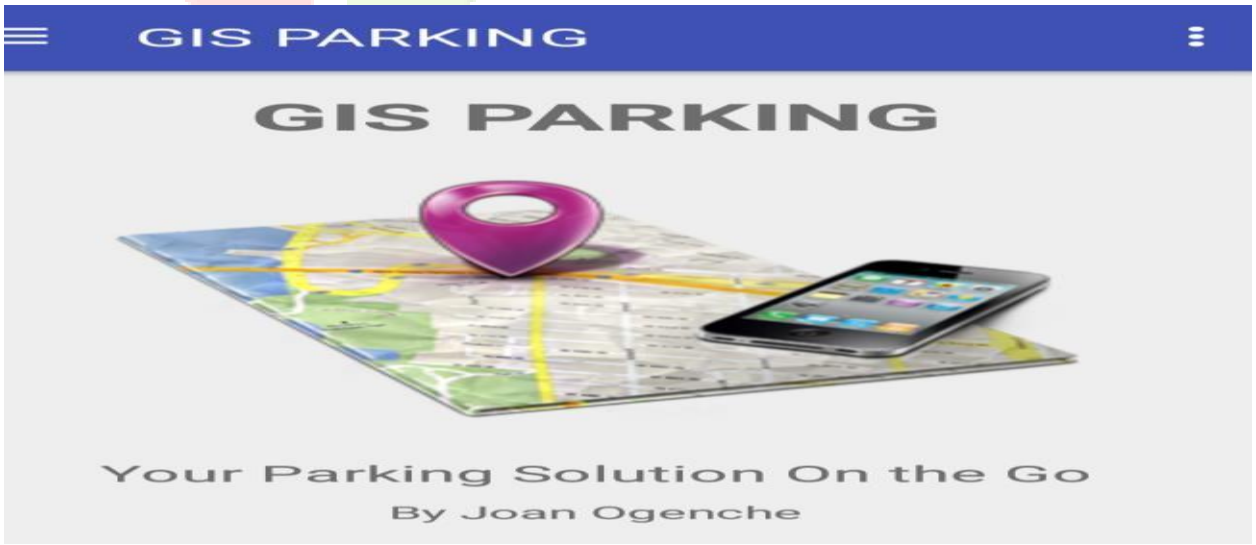

Figure6.2 Test Scenario Two

6.1.3 Test Scenario Three

As the user navigates through the application, the tab on the left side displays some parameters which user should key in prior to which they will not be able to proceed to book, reserve, or view parking information. It is a prerequisite for the details to be filled.

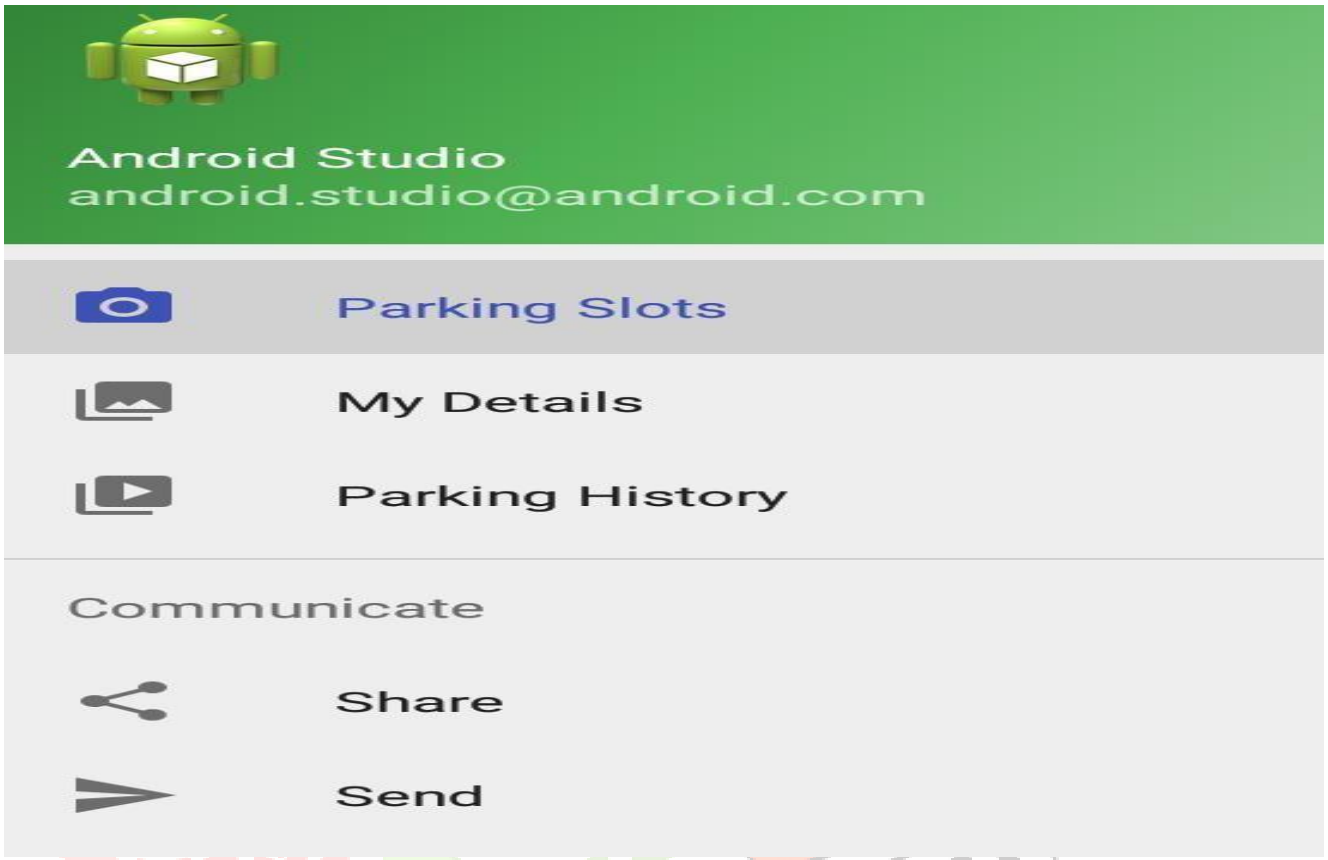

Figure6.3:Test Scenario Three

6.1.4 Test Scenario Four

Once a parking is created by the administrator from the Google maps environment, once a user opens the application from their smart phone, all the specified locations and the respective spaces should be visible in real time. This is what informs the user of a specific locality where there is available parking space, whether the space is reserved and whether they can cancel an already reserved space. The question of collision of users will be solved by having alerts or signals in use since same message can be sent to nearby users which may create deadlock.

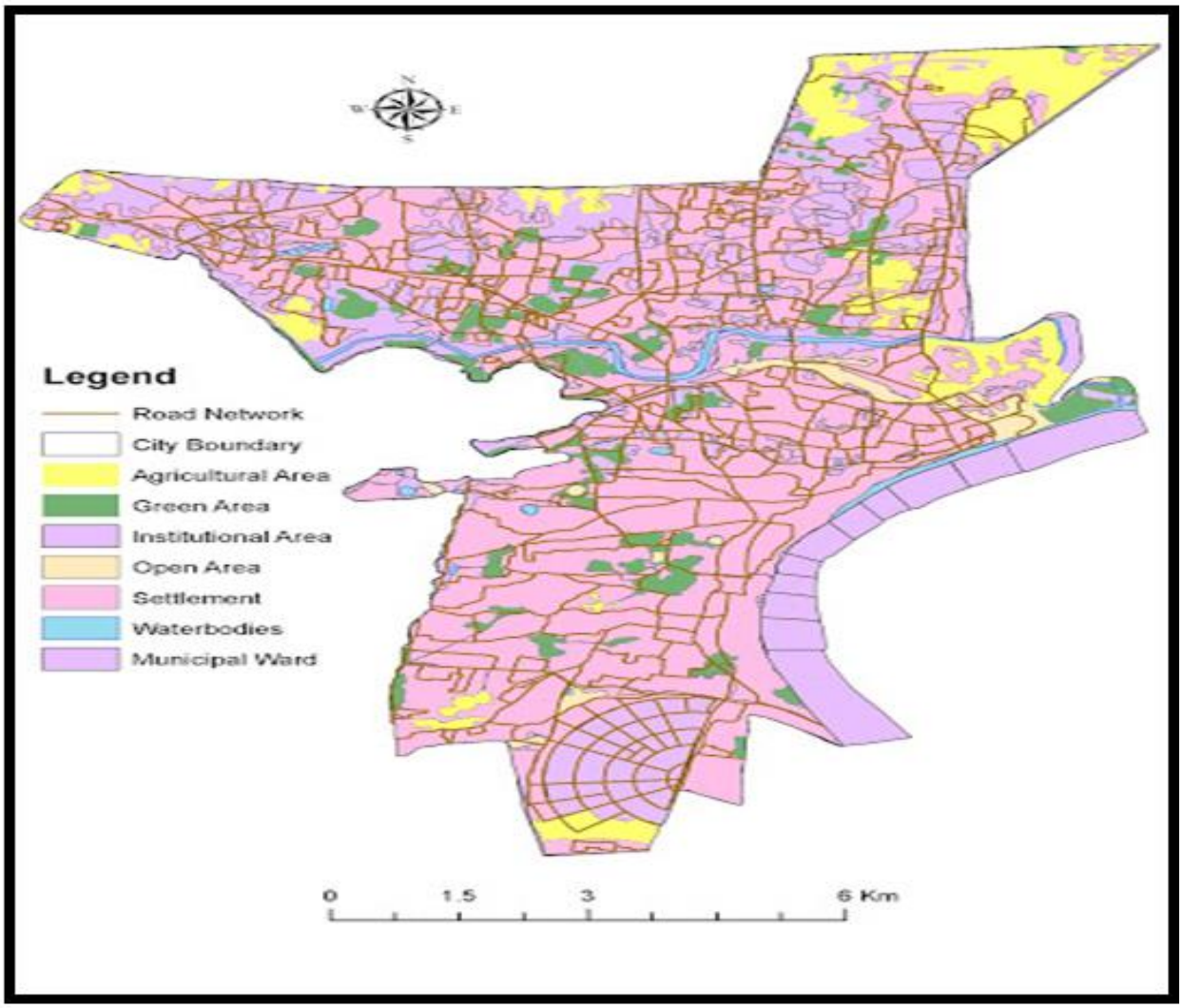

Figure6.4 GIS Map showing locations of different Areas in Varanasi CBD

a GIS Map either as hard copy or online map can solve the issue of lacking information about parking locations but it might take time to access this map very easily. To handle this issue, we have worked with other people from with programming skills to develop an android application that can easily be downloaded from play store and installed in telephones and tablets so that anyone with an internet connection can access easily information about parking facilities in Varanasi CBD. Therefore, there will be no more jam or traffic problems related to large number of vehicles stacked at narrow streets or spending much time searching for a parking in the CBD. It was realized that cost of on street parking is very low compared to off street parking cost.

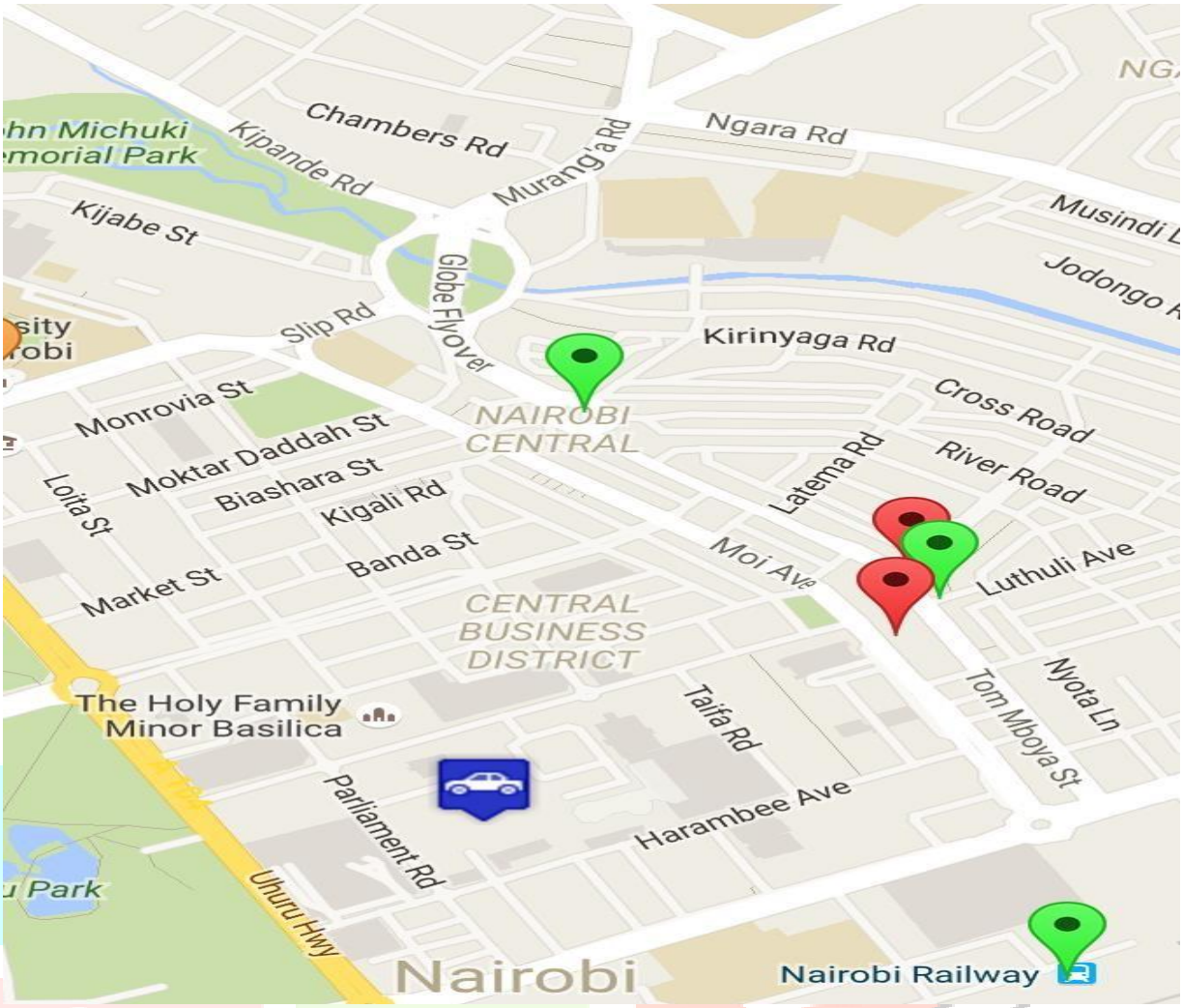

Figure 6.5 Test Scenario Four

The green labels indicate that there is free space available for parking, the amber labels indicate the space is reserved and red shows that the space is already parked on.

6.1 Actionable insight

Authorities use spatial analytics powered by GIS to harness real-time data, and design better decision support systems. In the process, authorities are gaining actionable insight for informed decision making. By taking data quality and content into account, 50mx50m pixel size was determined for calculating parking demand. That is why fixed parking demand (Figure c) was added to dynamic parking demand (Figure d) and subtracted parking supply with GIS based algebraic calculation.

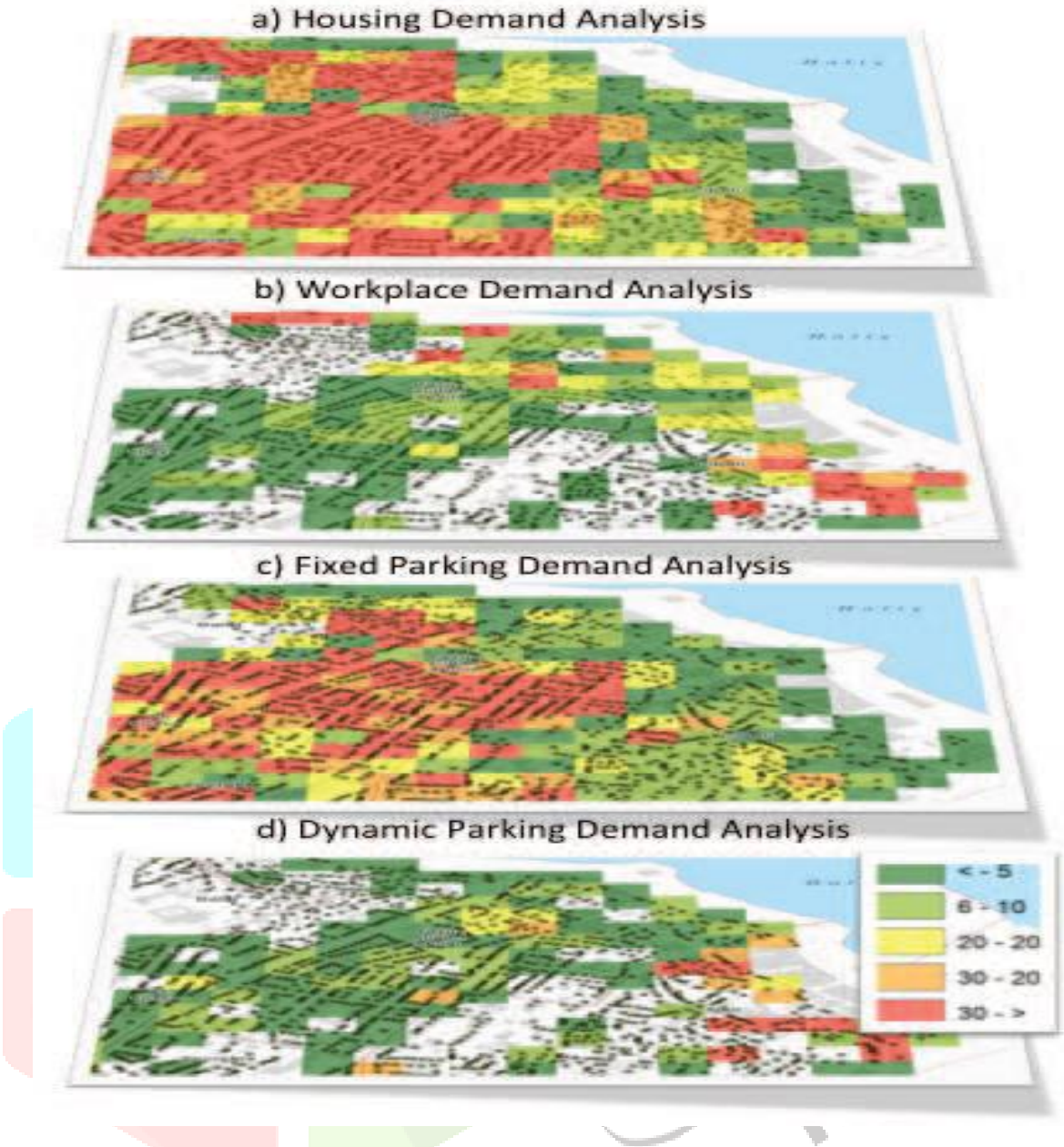

Fig6.6 GIS software results

6.2 Improved business processes and workflows

Smart integration of different features over a common GIS platform has standardised procedures across different departments. Inter-department collaboration has improved through geospatial mapping and geo-tagging of city assets.

6.3 Improved asset management

An Enterprise integrated GIS provides insights into use patterns of civic assets to improve urban planning in Varanasi. For water and sewerage systems, geospatial utility asset management is helping authorities operate and manage utilities in a better way. Pixel-based parking demand was eliminated and converted to point geometry with demand weight. Parking demands and

required/candidate parking data sets were used with road network data sets for parking site selection.

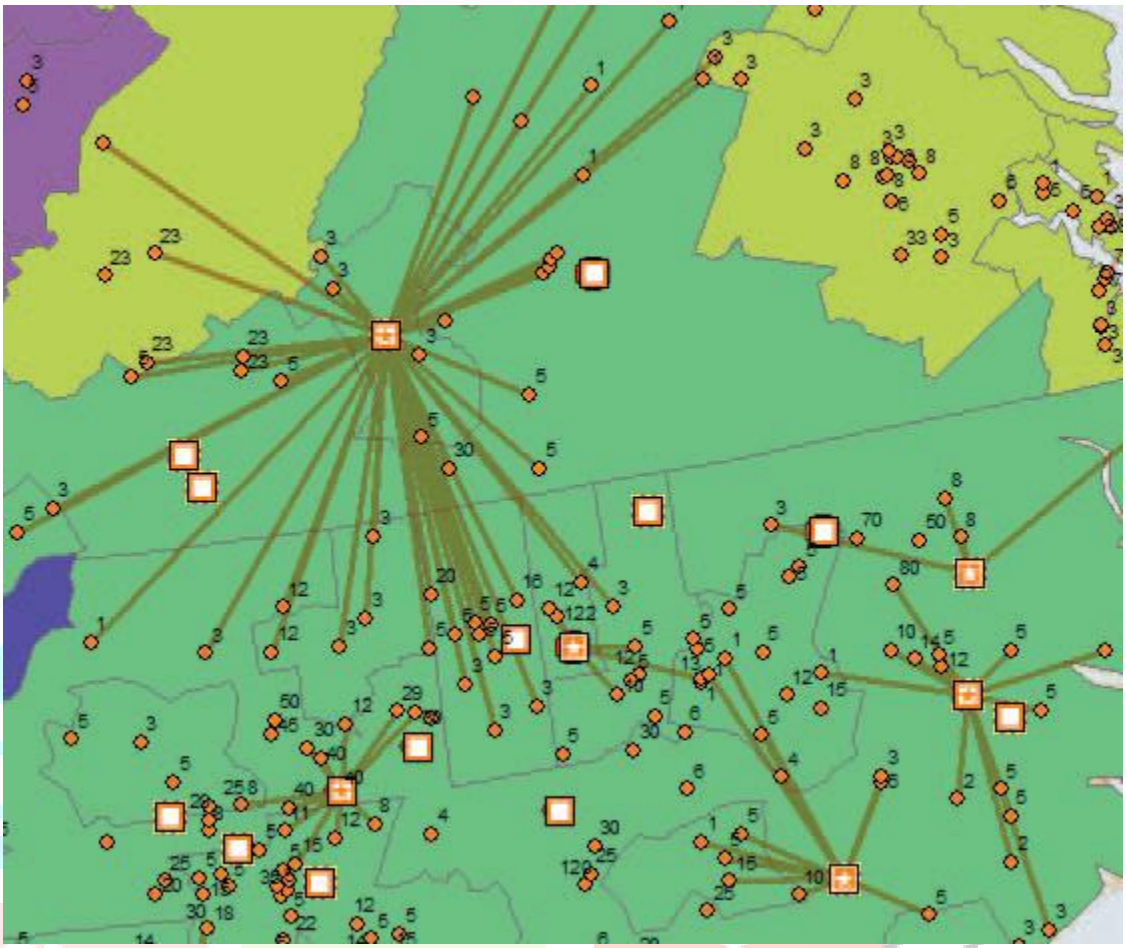

Fig.6.7 Allocation of required parking facilities depending on the capacity

6.4 The Benefits

The ArcGIS Platform Technology provides for customized solutions across different localities through IoT components. These integrated components generate thematic results in real time. The system has also proven its flexibility for use in rapid response. In response to COVID-19, Varanasi generated GIS operation dashboards for health services, heat maps for containment zones, and CCTVs to monitor citizen movement and social distancing. The Platform also helped manage health response; it used drones to sanitize hotspots, established telemedicine facilities for remote health care and diagnosis, while also analysing infrastructure availability to address the health crisis.

Better and location-customized experiences await all citizens of Varanasi. Beyond improving the urban environment, GIS has now equipped the city with options to minimise air pollution, improve water management, create safer public areas, and respond intelligently to emergencies. The technology is steadily ensuring that city's culture maintains its rich heritage while assuring Varanasi's denizens the benefits of a new Indian urbanism.

Selection of the parking Location

From the surveyed samples, there were two main reasons for parking at the selected locations which are proximity to their location (50% on average) and cheap (42%). This is as described in figure 4.6

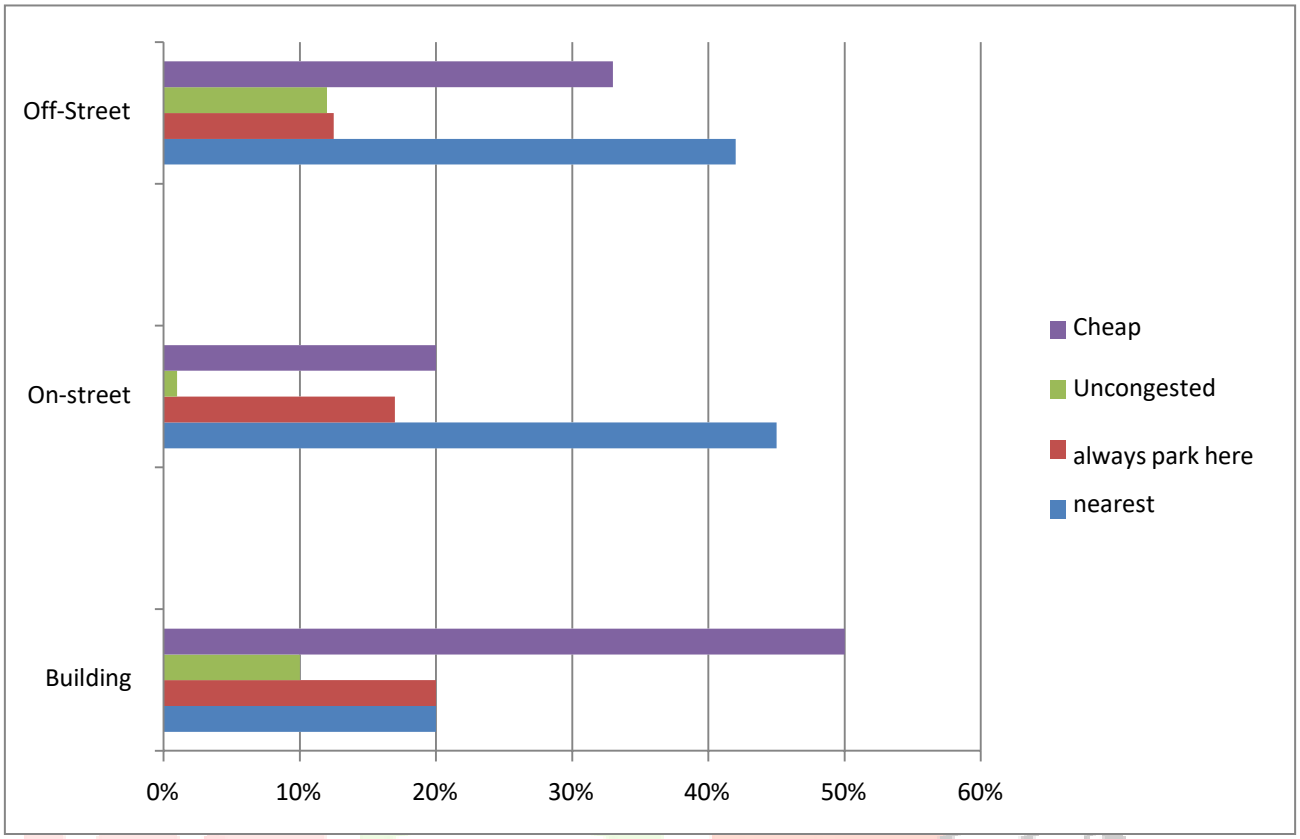

Fig.6.8 Reason for selection of the parking location

Chapter7

Conclusions and Recommendations

7.1 Conclusion

Parking remains a key challenge not only in Varanasi but also for many cities across the world. This geographic information based system for managing parking has many benefits such as;

i. Integration of spatial and non-spatial data that creates convenience for all users.

ii. GIS is structured in a dynamic way that paves way for capturing of data, storage, manipulation and analysis which is critical and prudent in managing parking.

iii. Searching for data in the application can easily be advanced to create specialized services like navigation and parking route access generation to mention but a

few.

iv. If this strategy is followed to the letter by all the stakeholders involved in urban planning ,transportations specifically, the issue of congestion, illegal parking and high traffic volumes will be well managed to ensure a smooth flow of activities and operations bearing in mind that Varanasi is not only the city of U.P. But also a major commercial centre in the India.

v. According to the traffic demand forecast, various counter measures will be applied with regard to the system in order to reduce traffic problems which are mentioned in this dissertation. The number of automobiles is increasing by the day and traditional methods of relaying parking information which comprised of road signs and off-road visual displays are quite limited in that, just a few road users could access the information at a time. The system discussed herein can deliver adequate information to as many road users at a time.

7.2 Recommendations

It is recommended that proper training is done with the users. This is because there are a lot of challenges around getting to understand and interact easily with the software for it to deliver as expected.

Furthermore, it is recommended that road deficiencies can possibly be examined while removing or adding transportation links to the network via a GIS-Transportation model. Decision makers could then make electronic decisions and thus predict outcomes prior to any actual decision on the ground. This will undoubtedly, lead to more economically optimum decisions and reasonably, predict the consequences.

In order to address the strategies and measures of revitalizing of the central business district area, a lot has to improve such as; improvement of the carriageways, improvement of bus terminals and stops, improvement and widening of sidewalks and pedestrian crossings, improvement of intersections and installation of traffic signals and CCTV as well as pavement marking and traffic control signs that are working.

This study was limited to the central business district only in Varanasi, it is recommended that the whole city embraces the GIS based plan in urban planning across all sections, this is because the effect would be spiral since the city's parts are interlinked. When this is done, then the other subsequent areas will also follow suit.

7.3 Suggestions for future research

In the future work, I plan to use spatial-based sensors which will allow usage of a central supervisory station user interface, albeit at increased cost. An active sensor may be added to validate the collision information. The system can be further extended to include the augmented reality which is a live, direct or indirect, view of a physical, real-world environment whose elements are augmented by computer generated sensory input such as sound, video, graphics or GPS data. Microcontrollers can also be used bearing in mind that the current dynamism in technology is creating a huge investment in micro controller applications who sea curacy is high. Ideally, maps take time to make, and to justify the cost of making them, it is important that they be valid for as long as possible. Traditionally, this has meant that maps are made up only of the more permanent features of the earth's surface: roads, rivers, mountains, and streets. Over the past two decades, however, the widespread availability of GPS and mapping software has changed the balance in this equation, making it possible to create maps of virtually anything for almost nothing. Neo-geography is one result :the possibility of making personal maps, showing personal views that may be of interest only to the maker and for just a brief time. A GPS navigation system, fed by sensors, might show the state of congestion of the road system in real time and an air-traffic controller might see a real-time map of airplane traffic (Bowden, 2014).

REFERANCE

- Accident Analysis in Hyderabad City, sponsored by Ministry of Home Affairs; sponsored by GoAP, Hyderabad
- Analysis, Modelling and Management of Air Pollution due to Motor Traffic under Multimodal Environment", R&D Project Sponsored by MHRD, New Delhi. 2000-2003. (Rs. 5.00 lakhs).
- Centre for Transportation Engineering; sponsored by MHRD, GOI, New Delhi
- Development of Landuse Transportation Demand Model for the Spatial Allocation of Activities and Landuse in Metropolitan Areas; sponsored by Ministry of Education, GOI, New Delhi
- Development of Optimal Road Network Patterns in Andhra Pradesh; sponsored by Ministry of Education, GOI, New Delhi
- Development of Standards for Highway Capacity under Mixed Traffic Conditions; sponsored by UGC, New Delhi
- Effect of Traffic Workshop on the Behaviour of Traffic in Hyderabad City; sponsored by CSIR, GOI, New Delhi
- Modelling Urban Growth with Decision Support System; sponsored by MHRD, GOI, New Delhi
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- R-11: Transportation Modelling on Regional Basis for Trunk Route System; sponsored by MOSRT&H, GOI, New Delhi
- R-13: Study of Road Intersections under Mixed Traffic Conditions; sponsored by MOSRT&H, GOI, New Delhi
- R-2 Phase-II: Weigh-in-Motion (WIM) Axle Load Spectral Analysis; sponsored by MOSRT&H, GOI, New Delhi
- R-3 Phase-III Establishment of Permanent Traffic Counting Stations on National Highways in Andhra Pradesh; sponsored by MOSRT&H, GOI, New Delhi
- R-43: Trip Length Frequency Analysis for Commodity Carriers in AP, sponsored by MOSRT&H, GOI, New Delhi
- Road user cost study on National Highways in the state of AP: Data collection; sponsored by CRRI, New Delhi
- Rural road pavement performance study, sponsored by NRRDA, MoRD, GOI, New Delhi
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- Sabnam, Masiha, Mousumi Das, and Parismita A. Kashyap. "Automatic Car Parking System." ADBU Journal of Engineering Technology 4 (2016).
- Geng, Yanfeng, and Christos G. Cassandras. "A new “smart parking” system infrastructure and implementation." Procedia-Social and Behavioral Sciences54 (2012): 1278-1287.
- [3] Wang, Wenbo, et al. "Automatic parking of vehicles: A review of literatures.” International Journal of Automotive Technology 15.6 (2014): 967- 978.
- Alfatihi, Sanaa, Soukaina Chihab, and Y. Salih Alj. "Intelligent parking system for car parking guidance and damage notification." Intelligent Systems Modelling & Simulation (ISMS), 2013 4th International Conference on. IEEE, 2013.
- Yusnita, R., Fariza Norbaya, and Norazwinawati Basharuddin. "Intelligent Parking Space Detection System Based on Image Processing." International Journal of Innovation, Management and Technology 3.3 (2012): 232.
- Shiyao, Cui, et al. "The Research and Implement of the Intelligent Parking Reservation Management System Based on ZigBee Technology." Measuring Technology and Mechatronics Automation (ICMTMA), 2014 Sixth International Conference on. IEEE, 2014.
- Wang, Yu, and Xiaoxi Zhu. "A robust design of hybrid fuzzy controller with fuzzy decision tree for autonomous intelligent parking system." American Control Conference (ACC), 2014. IEEE, 2014.
- Geng, Yanfeng, and Christos G. Cassandras. "A new “smart parking” system infrastructure and implementation." Procedia-Social and Behavioral Sciences54 (2012): 1278-1287.
- Rajabioun, Tooraj, Brent Foster, and Petros Ioannou. "Intelligent parking assist." Control & Automation (MED), 2013 21st Mediterranean Conference on. IEEE, 2013. [10] Doulamis, Nikolaos, Eftychios Protopapadakis, and Lambros Lambrinos.