University of Nairobi
School of Engineering

Mobile-GIS Based Vehicle Parking Management System, a case study of Garissa Bus Park in the Garissa Urban Authority, Garissa County.

BY
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F56/69984/2011

A project submitted in partial fulfillment of requirement for the Degree of Master of Science in Geographical Information Systems, in the Department of Geospatial and Space Technology of the University of Nairobi

May 2013
DECLARATION

I, Harrison Mwaniki Muthanu hereby declare that this project is my original work. To the best of my knowledge, the work presented here has not been presented for a degree in any other Institution of Higher Learning.

.......................................................... ........................................
HARRISON MWANIKI MUTHANU Date

This project has been submitted for examination with our approval as university supervisor.

.......................................................... ........................................
MR. P.C.WAKOLI Date
DEDICATION

I dedicate this work to God first, for giving me the will to read and ability to understand. Next is to my parents Mr. Gilbert. H. and Mrs. Anne Mwaniki for financing my education this far, to my brother and sister for their moral support. Last but not least, my employer, the Government of Kenya and Urban Development Department in particular for giving me an exceptional opportunity and exposure to Geographic Information Systems.
I would like to express my sincere gratitude to my project supervisor Mr. P.C. Wakoli for the supervisor invaluable guidance, advice and support in the entire cycle of this project. His particular views on all aspects of this project got a boost from his experienced interrogation and subsequent validations to impart the necessary relevance of the project. This project would not be complete without his great supervision and support.

I appreciate the material and technical support granted to me by the Department of Urban Development and the Director Mr. Enosh Onyango, and in particular the survey section, its section heads past and present (Mr. Kiminza Francis and Mr. I.K Mungania) and the Municipality of Garissa and the County Government of Garissa.

I am very grateful to Eng.O.O.Odera of Department of Urban Development for providing me with the engineering drawings for the said bus park and Land Surveyor I.K Mungania for providing me with the geo-referenced digital map of Garissa.

Last but not least, I wish to thank all the lecturers technical and support staff of the Department of Geospatial and Space Technology for making learning GIS a possibility, to all my student colleagues for their support, ladies and gentlemen may God bless you in all your professional and scholarly endeavours.
THE MOTIVATIONAL STATEMENT

“If I can imagine it, a GIS data set must already exist in the proper format and free of charge for immediate use at the touch of a button.” – Chris Gist.
ABSTRACT

Urbanization has been closely related to the economic development of various countries and an attribute of any successful country. This in turn introduces other indices that drive this frontier of development and in particular urban development. Transportation being a key component of urban development has a sector that requires a comprehensive strategy to manage.

According to the new constitution 2010, all county capital ought to be like Nairobi by the year 2030, this study looks at studies undertaken to attempt to solve Nairobi parking challenges to predict the formative challenges that will come to face municipality of Garissa. The researcher focused on Garissa.

Mobile GIS-Based vehicle parking system solution project has been done based on existing parking management system gaps that exist in the management of both private and public parking places. The general objective of the project was to develop a GIS based solution that manages the parking cycle i.e, pre-arrival information provision, parking allocation, parking spaces status visualization, parking access guidance and subsequent revenue management. The secondary objectives was to eliminate time wasted in looking for parking by conjecture, improve the process of accessing parking space and improve vehicle flow and thus reducing congestion on our roads.

Garissa Bus Park is a modern bus park constructed by the Ministry of Local Government’s Urban Development Department. The availability of a geo-referenced aerial photo, engineering layout design and the setting out drawings made it a clear choice for advancing the GIS technology enabled parking management system development.

System development methodology used was the object oriented and the tools used were declared. Data collection was done on site and it was this data that validated the viability of entities, relationships, data flow, processing and output.

The project found out that lack of effective parking management systems is a big contributor to congestion on our urban roads and subsequent low level of service delivery by authorities in managing parking spaces.
In conclusion GIS based parking management ought to be adopted in all public managed and developed parking places since it is the only way to solve spatial and non-spatial parking challenges and requirements.

**DOMAIN OF INQUIRY AND DEFINITIONS**

The following are definitions of terms used in this report.

**Parking:** *verb* - the act of stopping a vehicle and leaving it unoccupied or occupied.

**Parking:** *noun* – a space designated for parking of vehicles whether paved or not.

**Public Parking** – Parking space available for parking by public.

**Short-term parking** – parking for less than five hours.

**Reserved Parking** – Parking space available to a particular vehicle for a period of not more than three hours after a non-refundable fee of Ksh.40.00.

**Engaged Parking** – an occupied Parking lot by vehicle after paying the full parking amount for the day ksh.140.00.

**Parking Lot/ Parking Bay** – a large space constructed to contain subdivisions of specific spaces/ slots to accommodate a single vehicle each at a time.

**Control points** – locations that can be accurately identified on a raster dataset and in real world coordinates

**Decimal degrees** – degrees expressed as a single real number (e.g. 22.456677) rather than as composite of degrees, minutes and seconds and direction (e.g. 07° 55’ 24”E). The minus sign indicates the western and southern hemispheres.
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CHAPTER 1: INTRODUCTION

1.1 BACKGROUND

Under the Kenya’s vision 2030, as seen in the Kenya’s Vision 2030 popular version, it is projected that 65% of Kenyans will be living in the urban centers by the year 2030. Urbanization as has been witnessed in Kenya needs to be managed and not contained, since it must happen anyway. As a country that is rapidly urbanizing service delivery pressures are facing the authorities created by law and mandate to provide these services in the urban areas.

A key component of urban development is urban transportation. In Kenya it is estimated that 78% of urban residents commute by road. With the low income group travelling by public transport, the middle and the high income groups prefer private vehicles.

As seen by the World Urban Development Magazine in developing countries like Kenya, urban transportation is not generally designed for safe travel by non-motorized means, but rather to increase vehicle speeds. The majority of the victims of traffic accidents tend to be low- and moderate-income pedestrians. This makes motorable road transport a clear preference, the parking problem often beats this logic.

As the dream of Kenya becoming a middle income country becomes a reality, more and more Kenyans are expected to enter into the middle income bracket and preference of private transport emerges, and the demand for systems to manage the urban transportation becomes more and more urgent.

While development partners and the donor community was encouraging full cost recovery for water services, upon which the poor directly rely on, no similar pressure was imposed on road users who by and large represent a much higher income group especially the motorists.

The issue of vehicle parking management will solve this problem and also create an opportunity to the general management of urban areas and in urban transportation in particular.

Streamlining the management of parking management and increasing revenues to the management are some but a few reasons why urban management boards and county government need to consider investing in effective systems that manage the utility of the parking spaces available in their areas of jurisdiction.
The Institute for Transportation and Development Policy (ITDP) has been developing interventions on cost recovery in urban areas with a particular emphasis of transportation infrastructure assets and related installations. The reason is that this has become a big part of sustainable development of the same. Further to this transport has been seen to be critical to achieving the MDGs. However, simply building more roads is not going to alleviate poverty, and may make poverty situation worse. In order to maximize the impact on poverty alleviation the following two measures were recommended:-

1) Cover domestic spending on urban transportation infrastructure with fuel taxes or other user charges e.g. parking charges.
2) Increase the percentage of total urban transportation infrastructure system expenditures recovered from user fees, parking charges, congestion charging fees, and fuel taxation to at least 100 percent.

Garissa being a regional capital for the older North Eastern province and its adjacency to the old Eastern and Coast province has had its own share of urbanization pressures and related service delivery challenges.

In the last three years, one of the major investments in the urban transportation that was made is the construction of Garissa Town Bus Park. For improved service delivery and sustainability purposes it has been found that a system is required to:

1) Accurately map parking spaces.
2) Enrich the spatial access of these parking spaces through identification.
3) Interfacing the spatial and non-spatial parking information to customers.

It was seen by Waema and Mitulah (2008) that the former City Council of Nairobi realizes a collection 40% of what it is entitled to, reducing the human interface in the collection and monitoring of the vehicle parking revenue has since become a key result investment area to the former City Council of Nairobi.

Technology solutions have been attempted in the past and significant improvement has been witnessed in many other parts of financial management in the City Council of Nairobi and other major municipalities in the country, as a study by University of Nairobi’s Institute of Development Studies show that Municipal council’s that adopted Information Communications
Technology have shown significant growth in revenue and other governance reforms. This makes it a relevant part of effective management of resources and process in the urban management.

The technology that has been adopted however lacks one dimension that now can no longer be ignored and that is the spatial dimension or component of any attribute or entity in these municipalities. Parking revenue management as a part of the wider urban transportation management question has a very important spatial component since all parking space lie on some surface.

Garissa Bus Park has got 200 parking spaces and the bus park has got 650 vehicle trips per day. It cost a vehicle Ksh. 140.00 per day, a reservation of up to three hours costs Ksh. 40.00 with the balance payable upon entry to the bus park for occupancy. The Municipal By-Laws prohibits picking or dropping of passengers outside the bus parks. This causes a challenge of buses roaming around town looking for the available parking lots in the bus park.

1.2 PROBLEM STATEMENT

The challenge of managing parking spaces and their utility is a big one. It has so many dimensions that it leaves the city managers in a precarious situation any time they attempt to fix the problem of urban transportation. *The High Cost of Free Parking* by Donald Shoup (2005) introduced many city planning practitioners and policy makers to the challenges and importance of planning for vehicle parking. Although often taken for granted, the details of parking regulations can actually have wide-ranging impacts on city life, from reducing traffic and pollution to increasing local revenues.

As seen in Master plan for urban transport in the Nairobi metropolitan area, for example Katahira Engineers International, (2005), identifies Nairobi area CBD parking management as one of key result areas in fixing urban transportation problems. Although Kenya is still developing country increased automobile-dependency, has increased parking demand and almost entirely outstripping supply. Described more positively, parking management can provide significant economic, social and environmental benefits.
In the past, parking in Garissa town was not seen as a factor that could influence any economic activity since it was never scarce. This has changed in the recent past and lack of management of available parking spaces has been identified as a reason for vehicle congestion.

This has been brought about by the increased business activity in Garissa and the influx of refugees and returnees as they are referred to by the locals from the former failed republic of Somalia. The increased number of vehicles and people in the town of Garissa has brought the issue of parking into focus and relating it to other major regional and international cities, thus tackling this issue is a priority to the government of Garissa and Kenya at large.

This began with the intervention of the Ministry of Local Government construction of a modern bus park in the town of Garissa; this alone has not entirely solved the problem of parking. It is evident that motorist in Garissa still:

1) Have difficulties in searching for parking space and hence waste time and fuel going round the bus parks.
2) Have high stress level due to unpredictable search for parking spaces and its impact on their economically productive priorities.
3) Reverse congestion effects to the Garissa-Wajir highway motorist therefore effecting transit motorists.
4) Pollution and other environmental hazards due to hooting and other traffic offences due to stress.

These problems occur due to

1) Lack of simplest pre-arrival parking information systems for motorists and the general public regarding parking availability in the bus park.
2) Lack of accurate mapping of parking slots and parking bays.
3) Lack of a customer interface of spatial and non spatial parking data.

The current system in place at the Garissa bus park is a simple pay receipt at the entry of the parking on when a corresponding available parking space is confirmed by the exit gate official thorough a radio communication. A system that manages a cycle from availability enquiry, reservation, payment occupancy and relieving of parking spaces will solve these management challenges. In particular the beneficiaries will be:-
1) **Motorists:** will have pre-arrival parking information systems that informs on the availability and location of parking slots in the bus park.

2) **Town Managers:** accurate information based decision support system in parking demand management, pricing and overall policy making in parking management.

3) **Town environment, public health & safety:** less congestion on roads hence increase accessibility in case of emergency and rescue, less pollution and noise, lower stress levels on city travelers and motorists.

This project proposed to use Mobile Geographic Information Systems (GIS) based systems to manage and enhance the utility of parking space and with particular emphasis of geospatial technology enabled parking accessibility management and revenue enhancement.

### 1.3 OBJECTIVES

#### 1.3.1 Overall objective

The general objective of the project was to develop a mobile-GIS based solution that manages the parking cycle i.e., pre-arrival information provision, parking allocation, parking spaces status visualization, parking access guidance and subsequent revenue management. The secondary objectives was to eliminate time wasted in looking for parking by conjecture, improve the process of accessing parking space and improve vehicle flow and thus reducing congestion on our roads.

#### 1.3.2 Specific objectives

1) To collect data relevant to Garissa bus park and a sample of motorists.

2) Create Garissa bus park map layer displaying all the parking slots.

3) Create a geo-database that interfaces with the motorist and refreshes the map on the parking slot status.

4) Develop a mobile application that queries the database and return results to the motorist.

5) Simulate a parking status display via web browser.

### 1.4 JUSTIFICATION FOR THE STUDY

For the public, the risks of traveling in areas with inadequate parking information vary with the type of trip. For those going to the airport, difficulty finding a parking spot can lead to a missed flight. For travelers going to a central business district, the risk is evident in a late arrival at a
show or business meeting which can lead to loss of business and add unnecessary losses to the person and economy.

Fig. 1 Map of Garissa County and Town

For commuters seeking to transfer to transit, the risk is a missed transit departure. Lack of a map depicting the status of parking slots in a city has made it impossible for a motorist to decide on the direction of parking lot search, this leads to motorist make round trips in CBD hoping for luck. This system will endeavor to create a web map that can demonstrate the parking lots and colors depicting their status in the parking lot acquisition cycle, available, reserved, occupied, and relieved /available parking space. This will attempt in enhancing customer relationship with regards to parking management.

The users and output of this system as below:

Motorist: the geodatabase will interface with the motorist through the mobile application and queries will be responded to with the parking state.

Garissa Urban Government: The entire system and components will be of use for further advancement and currently for management of the bus park, decision making and overall policy and strategic uses.
Hardware, software and infrastructure: desktop application that interfaces with mobile and web, this will allow the parking management enforces the request made by customers and customers interact with the system conveniently.

1.5 SCOPE OF WORK

The scope of this project is the management of the accessibility of parking spaces of the Garissa bus park.

This entails a pre-arrival parking subsystem, reservation subsystem, payment, and corresponding visualisation of the parking slot on the Garissa bus park layer.

The payment component is limited to the payment of reservation and subsequent or full parking fees. This is due to the fact that comprehensive revenue management has got vast accounting procedures that are outside the scope of this course.

Visualization will be web and mobile and the former is sufficient since many mobile devices can run ordinary web browsers.

This project confined itself to the issues of mobile GIS based Vehicle Parking management system since in the past the spatial component on this matter has not been explored and dealt with comprehensively. The payment cycle from identifying or requesting a parking space, reserving, paying, occupying and disengaging a parking lot can be better managed by use of this spatial dynamic since the parking problems are spatial problems.

Garissa being a modern bus park has enough digital data to facilitate this in the form of:

1) A geo-referenced aerial photo of Garissa Town.

2) An engineering design layout for Garissa bus park.
CHAPTER 2: LITERATURE REVIEW

While analysing the requirements of a mobile GIS-based parking management system, the researcher had to review a vast repository of information most of which is covered under urban transportation studies and in particular the field of Intelligent Transportation Systems (ITS). The literature reviewed is supposed to demonstrate deviation from the old paradigm that parking is always available and that it is not a subject of prudent management. Smart parking management systems and ITS strategies are explored to effect parking demand management strategies to the city managers for improved service delivery, customer relationship management and revenue collection.

The review also sought to conduct a survey on the development of technologies and infrastructure in the management of parking in cities their use for all categories of users.

### 2.1 Parking Situation in Kenya

In Kenya, parking development interventions have not contained demand for parking, this has far-much outstripped supply, this was found by Katahira Engineers International, (2005). The study was based on aerial photos, site surveys in the Central Business District (CBD) and interviews from relevant agencies/organizations, the capacity and demand was summarized as below. The city of Nairobi is quoted above since it depicts the Kenyan situation and any Municipality aspires to be like Nairobi, the case study though is Garissa town and all our focus will be on Garissa although fed by Nairobi City Council past studies.

<table>
<thead>
<tr>
<th>ITEMS</th>
<th>CAPACITY</th>
<th>DEMAND</th>
<th>DIFFERENCE</th>
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<tbody>
<tr>
<td>OFF-ROAD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARKING BLDG</td>
<td>4035</td>
<td>3158</td>
<td>877</td>
</tr>
<tr>
<td>PARKING LOT</td>
<td>1702</td>
<td>1484</td>
<td>218</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>5737</td>
<td>4642</td>
<td>1095</td>
</tr>
<tr>
<td>ON-ROAD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PARKING LOT</td>
<td>4480</td>
<td>4480</td>
<td>0</td>
</tr>
<tr>
<td>CURB</td>
<td>-</td>
<td>2278</td>
<td>-2278</td>
</tr>
<tr>
<td>SUBTOTAL</td>
<td>4480</td>
<td>6758</td>
<td>-2278</td>
</tr>
<tr>
<td>TOTAL</td>
<td>10,217</td>
<td>11,400</td>
<td>1,183</td>
</tr>
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Table 1 Parking Space and Demand in Nairobi CBD 2005.

From field surveys and observation presented in table 1, it is found that the demand for on-street parking is higher for the following reasons.
i. It is more convenient because a driver may park very close to his/her destination depending on the availability of parking space.

ii. On street parking is cheaper since it is not time based or space based and one can park anywhere and at any time since the charge is flat rate (at the time Sh.70 and now Sh. 140).

iii. Some of the off-street parking are basement parking and are reserved for building tenants.

From the above data and reason then parking demand at the time exceeded capacity and the study projected estimates of generated car traffic to and from CBD as shown in the Table 2.

<table>
<thead>
<tr>
<th>YEAR</th>
<th>2004</th>
<th>2010</th>
<th>2015</th>
<th>2025</th>
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<tr>
<td>CARS</td>
<td>231,948</td>
<td>236,583</td>
<td>241,218</td>
<td>317,674</td>
</tr>
<tr>
<td>INCREASE RATE</td>
<td>-</td>
<td>1.02</td>
<td>1.04</td>
<td>1.37</td>
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Table 2. Projected estimates of generated car traffic to and from CBD.

From the above survey result and data and assuming that the increase rate of generated/attracted traffic and car parking demand is the same the future parking demand is in Table 3.

<table>
<thead>
<tr>
<th>Item</th>
<th>2004</th>
<th>2010</th>
<th>2015</th>
<th>2025</th>
</tr>
</thead>
<tbody>
<tr>
<td>Off-Road</td>
<td>4,640.00</td>
<td>4,733.00</td>
<td>4,826.00</td>
<td>6,357.00</td>
</tr>
<tr>
<td>On-Road</td>
<td>6,760.00</td>
<td>6,895.00</td>
<td>7,030.00</td>
<td>9,261.00</td>
</tr>
<tr>
<td>Total</td>
<td>11,400.00</td>
<td>11,628.00</td>
<td>11,856.00</td>
<td>15,618.00</td>
</tr>
</tbody>
</table>

Table 3. Generated Traffic and Car Parking Demand

Based on current parking conditions in the CBD and the expected future parking demand, it was found necessary by the study, to undertake measures aimed at improving the parking conditions both in short term and in the long term. The proposed counter measures were as follows:

i. Development of multi-storey parking.

ii. Parking guide system.

iii. Sensitivity analysis of parking fees in CBD
For reason and purpose of this project the last two are the source of the requirements and justification for this project. Let me look at the proposal of a parking guide system and its objective.

The informative Nairobi study (of which all county capitals of Kenya want to be, including Garissa) explains “adequate parking guide system is to maximize the parking space utilization and to minimize traffic congestion caused by cars looking for vacant parking space in busy central business district. The parking guide system is usually installed at the entrance of central business district, say for Nairobi at Kenyatta Highway/Uhuru Highway round about. This is an electric panel that informs the parking situation: - whether fully occupied or if there is available space, and shows the minimum access route to vacant parking space”.

The second requirement presents both a new opportunity and a means of amelioration of urban transportation problems of congestion, parking menace and improves customer information flow. Mobile GIS based parking management systems come in handy in the fulfillment of the two requirements which have been obtained through a professional study and other scientific methods.

2.2 INTERNATIONAL PRACTICE IN PARKING MANAGEMENT

It was also seen by Federal Highway Administration, *an in-depth analysis of success stories from six sites in the US* (2007). The full cycle of an efficient parking management processes is adequately covered from pre-arrival parking information systems, lot-specific parking information systems, floor-, aisle-, and spatial aware parking information systems, parking reservation systems and parking navigation systems have greatly been used to help achieve community goals.

The study concludes that any technology enabled Parking management system that is well planned, stakeholders involved, well funded and communicated and eventually executed will always obtain support for the residents. A stirring example is the city of Baltimore parking management system project in the US, it is said that during an initial test period, the system increased customer satisfaction and improved traffic flow in the hourly facilities.

The stakeholders’ praise for the system is evident. Says Harry Zeigler, Assistant Manager for the Maryland Department of Transportation’s Office of Transportation and Terminal Services at
BWI Airport, “The impact of Smart Park at BWI has been tremendous—it has not only made parking easier and faster, but it has improved customer satisfaction and reduced illegal parking.” This explains the need for a customer focused parking management system for the people of Garissa.

2.3 CURRENT STATUS OF PARKING MANAGEMENT IN GARISSA BUS PARK.
Garissa Bus Park management is largely manual, a motorist gets in to the bus park, goes round seeking an available parking space, and if identifies one he/she occupies it and the parking attendant comes and demands the payment and issues the motorist with a receipt upon payment. This in itself means that a motorist must search for parking and if none exists, the motorist will still go round looking and hoping for luck.

The Garissa bus parking flow chart is described in figure 2.

![Garissa Bus Park parking procedure flowchart](image)

Fig. 2. Garissa Bus Park parking procedure flowchart.
From the above flow chart it is evident that a motorist can drive around for long before he/she can secure a parking lot. From the interviews carried out by the researcher with the parking management of Garissa Bus Park, it is estimated that there is an average of 1200 vehicle trips to Garissa Bus Park per day. This flowchart does not describe the ideal situation and from the requirements collected from the management, the proposed parking process flowchart in Garissa Bus Park figure 3.

Fig. 3. Proposed Garissa Bus Park parking procedure flowchart.
2.4 TECHNOLOGY OPTIONS REVIEWED.

In this literature review, the researcher sought to know the technology options applied in the field of parking management systems. The options reviewed were:

1) Smart parking management systems.
2) Intelligent Transportation management systems.
3) Geographic Information Systems based parking management systems.

Smart parking management systems take advantage of innovative technologies for motorist to access and pay for parking using personal communication devices or the ordinary smart cards. According to Hongwei Wang and Wenbo Hey (2011), searching for a vacant parking space in a metropolitan area is a daily and time-consuming concern for most motorists.

This commonly results to adverse traffic congestion and air pollution. To alleviate such traffic congestion and improve the convenience for drivers, many smart parking management systems aiming at satisfying the involved parties (e.g., parking service providers and motorists) have to be developed and deployed. Seamlessly integrating Pay-by-Phone technology to produce a smarter, faster, and more efficient way to park, a mobile based Parking management system is the convenient parking payment and management solution for our country due to the accessibility of mobile phones, largely to all motorists and the development of mobile pay services in Kenya.

Currently, most research work on smart parking is from the perspective of system design, which focus on implementing a wireless sensor network to detect parking information and provide real-time parking service, these are outside the scope of this project although useful considerations for the advancement of the same.

Intelligent transport systems vary in technologies applied, from basic management systems such as car navigation; traffic signal control systems; container management systems; variable message signs; automatic number plate recognition or speed cameras to monitor applications, such as security CCTV systems; and to more advanced applications that integrate live data and feedback from a number of other sources, such as parking guidance and information systems; weather information; and the like. Additionally, predictive techniques are being developed to allow advanced modeling and comparison with historical baseline data.
The ITS as seen by M. M. Rashid, A. Musa, M. Ataur Rahman, and N. Farahana, A. Farhana, (2012), use in parking management has been more useful in convenient revenue collection and abit of pre-arrival information provision. The vehicle registration number plate recognition identification is an important application in the field of Intelligent Transport System (ITS) and Electronic Toll Collection (ETC). The objective is to extract and recognize vehicle registration numbers from vehicle images, process the image data finally utilize for access record and prepare electronic bill. Electronic Toll Collection (ETC) or Electronic Car Parking Payment is one of the major research topics in Intelligent Transportation System (ITS).

The system is divided into sub-systems which are ‘FULL’ display system, image acquisition and plate number recognition, auto direction system and auto payment system. Firstly, data is acquired from ultrasonic sensors of each parking space to count the availability of parking spaces in the parking area. Then, image of the car is acquired in the entrance to be analyzed, from my own observation on the development of this technology much is about data acquisition and processing that are much outside the scope of this project although very important for advancement of the same.

Geographic Information Systems, (being a computer based system a system designed to capture, store, manipulate, analyze, manage, and present all types of geographical data) based parking management systems have the capability of utilising the two reviewed technology options and introduce a new and powerful dimension to Parking management, visibility to the parking data that is abstracted in their database and text reports of the immediately reviewed technology options.

In Kenya GIS has been in use in land information systems, public health, agriculture and public works, it has been my view that if the technology was harnessed to manage parking then every stakeholder would accrue immense benefits.

Parking service providers and managers will be able to monitor parking status which changes more efficiently than in using the manual non-spatial data. The visualization from the spatial data and analysis power of GIS increases use of information for decision making and management purposes. Mobile GIS based vehicle parking management system is preferred to the other two reviewed technologies due to, the unique power of GIS, which specifically are:-
**Analysis** - Spatial analysis is a big reason to go GIS way because it includes all of the transformations, manipulations, and methods that can be applied to spatial and non-spatial linked data to add value to them, to support decisions, and to reveal patterns and anomalies that are not immediately obvious. This can quickly allow the parking managers analyse the spatial distribution of parking status with and precision.

**Integration** - GIS has data handling capabilities more than any other platform, spatial and non-spatial is conveniently integrated and distributed to concurrent users with different background and use of the information. Parking managers can use CAD data from Engineers, Digital maps from Surveyors, applications from Computer Scientists, data from databases, webservers, mapservers etc. This makes GIS a clear preference over the other two technologies.

**Interface** – one of the reason of GIS is how it interfaces with the audience “the people”, with advancing technologies, GIS has a universal accessibility and dissemination modes i.e. mobile, desktop, web, cloud and manual.

**Data Management** - GIS can manage a variety of data in various forms, vector, raster for spatial and non-spatial and integrate this for various publishing platforms.
CHAPTER 3: MATERIALS AND METHODS

3.1 MATERIALS

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<thead>
<tr>
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<tr>
<td></td>
<td><strong>DATASETS</strong></td>
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<td>Garissa Bus Park CAD layout Drawing</td>
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<td>2</td>
<td>Garissa Engineering Bus Park Setting out</td>
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<td>Garissa Town Aerial Photo</td>
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<td>7</td>
<td>Arc GIS 10 desktop &amp; Mappetizer</td>
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<td>Aerial Photo</td>
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<td>CAD bus park design</td>
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<tr>
<td>16</td>
<td>Internet and communication</td>
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<tr>
<td>17</td>
<td>Technical articles and Journals</td>
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**TABLE 4. List of material used in the project**

In constructing the mobile GIS –based parking management system, the first point is that there are two distinct and core datasets. The first of these relates to the parking space, and essentially represents the physical, spatial data and non-spatial data. The second relates to the vehicles using the parking, and provides the vehicle, service and revenue data (attribute and application data). The basic structuring elements for the parking management system are the parking slots and the vehicles in the parking, with the specific identifier for the latter group being the plate number. In database terms, these two will be given a unique identifier, and all other data will be linked to one or the other. These two database-structuring elements will then be linked, where necessary, through the parking identifier (parking ID). Within this contextual framework, the primary data
can then be grouped or structured in a number of different ways. The system described here is based upon a detailed ‘data flow diagram’ which is shown in fig 4 below. The two major data types are defined as base data and physical-spatial data.

The first data type (the base data) is constructed around a raster image (most often in the form of an aerial photograph) of varying resolution, which provides a visual backdrop. This raster image provides the basis for the georeferenced vector map of the site, to which parking slot numbers can be added to provide parking identification. The second data type (the physical-spatial data) relates the site parking layout. Thus it comprises all data regarding the spatial planning framework elements that impinge on that site and is depicted by a CAD representation of the parking layout.

The term ‘spatial’ here relates to the non-physical-spatial definition of the site. This includes layout boundaries or spatial structuring elements already proposed for the site.

The data sources used for this project included a geo-referenced aerial photo for Garissa municipality, this was obtained from the survey section of the department of urban development, in the new Ministry of Lands, Housing and Urban Development. The photo was taken in august 2010 and represented in figure 4, The properties of the aerial photo are described in table 5.
Fig. 4 An aerial photo of Garissa Town.

<table>
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<td><strong>Raster Information</strong></td>
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<td>Number of Bands</td>
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<td><strong>Extent</strong></td>
</tr>
<tr>
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</tr>
<tr>
<td>Left</td>
</tr>
<tr>
<td>Right</td>
</tr>
<tr>
<td>Bottom</td>
</tr>
<tr>
<td>spatial Reference</td>
</tr>
<tr>
<td>Linear Unit</td>
</tr>
<tr>
<td>Datum</td>
</tr>
</tbody>
</table>

Table 5. Garissa Town Aerial Photo, Image Properties
Fig 5 A CAD designs of Garissa Bus Park layout.

After transforming the CAD dataset, by use of the ordinary Georeferencing tools of ArcGIS tools of Rotate, Scale and shifting we were able to get the following result.
Fig. 6 Geo-referenced parking layer of Garissa Bus Park.

3.2 DEVELOPMENT OF THE METHODOLOGY

The methodology begins with an assembly of geospatial information. Information gathered will be divided into two categories as follows:

- Base data
- Spatial and Physical data
3.3 BASE DATA AND PROCESSING
The source of this data is a photographic image of the site. There are two major image types available: Satellite images and aerial photography. Relatively high accuracy is required for the positioning of the parking layout. This is adequate for the first phase of the work.

Fig. 7 methodology flowchart diagram Garissa Bus Park.
The image provides a good basis for parking typology database. The ge-referenced image is also used to generate an accurate vector map of the area. This will be used for the on-going design of services and infrastructure. The slots are then numbered as part of the attribute creation process.
3.4 SPATIAL AND PHYSICAL DATA

This data will be used to create an overlay of the design framework on the base data. This section deals with the integration of the different data sets described above. The resulting geo-database was used to create a web mapping application that was used to access the map data. The success of this project lies in the creation of an interactive application that was used to search, find and identify map features hence enhancing parking management efficiency in terms of service allocation and monitoring of revenue collection.

3.2.1 Vectorization and editing

The CAD representation of the parking was imported into ArcGIS followed by the editing of the parking layout to ensure that each parking slot was an entity to which attributes could be assigned as shown in figure 8.

![Fig. 8 Garissa Bus Park, parking layout layer.](image)
3.5 GEOREFERENCING
The second step in manipulating this data is to ensure that the parking layout is georeferenced and accurately superimposed on the raster image backdrop. The scale may be adjusted by leveraging the scaling resource on the georeferencing toolbar in ArcGIS as shown below.

![Georeferencing interface](image)

Fig. 9 Garissa Bus Park, parking layout layer.

Attribute information was then added to the vector format data. This database comprises fields such as the parking identification number, vehicle plate number, service, amount and balance. The following figure shows parking slot number 11 highlighted with its attribute information in the table below.

A core objective of this project was to have the services of the parking i.e., available slots, occupied slots and reserved slots uniquely represented in a dynamic color scheme where green represents available slots, blue for occupied slots and yellow for reserved spaces. Each time the database is updated, the vector layer also changes accordingly for visualization and querying from the web application interface as shall be demonstrated.
The categories of parking slot information were drawn using the unique values of the service field. If for instance the value for one parking slot is updated from available to occupied, the database is such that the color displayed for this slot automatically changes from blue to green. A category describes a set of features with the same attribute value, for example, parking services categorized by a value such as occupied, available, or reserved. Using categories, different symbols were assigned to represent each category defined by unique attribute values.

3.4 BUILDING A WEB MAPPING APPLICATION TO ACCESS AND QUERY THE MAP DATA MAPPETIZER FOR ARCGIS

Mappetizer is a tool for ArcGIS by ESRI. It gives you the opportunity to convert maps within ArcMap into the SVG (Scalable Vector Graphics) format. You can then use these XML based files to view them on your local machine and to publish them on the Web. Mappetizer supports both vector based object data and image based data.

The parking lot layout plan was made ready for export into Scalable Vector Graphics by making all the desired layers visible. The Mappetizer add-on was used to configure application settings for object information and display. These include toolbar components that would appear on the web interface such as a measure tool, a co-ordinate read-out tool, a scale display tool, the zoom-in zoom-out tools and the go-to-previous-extent tool.

Fig. 10 Mappetizer Installation
Custom information was then added to the application acknowledging the author and giving a brief comment about the use of the application as shown below: Added to this application were search tools which can search and identify specified fields and values and highlight them on the map for visualization with a chosen selection color.

The final output therefore is a web based interface through which a user may interact with the GIS system. These users range from a manager who is based at the office and needs to monitor the status of parking spaces. A parking attendant with a hand-held mobile device can access the system and update parking information which will immediately reflected at the office from where his colleagues can work out revenue sums and perhaps communicate via SMS with clients who may seek to have parking slots reserved for them. The available parking ID can be sent to them while they send their vehicle plate number. This is a prototype that can be conveniently implemented at the scale of a Garissa business district.
CHAPTER 4: RESULTS AND DISCUSSIONS

4.1 SPATIAL COMPONENT

This section contains the results of this project; the results are the web visualisation of the sparking slots and the message confirming the reservation and payments. This web visualisation is possible to be deployed in a big screen at the entry of the bus park.

Fig. 11 Web View of the Garissa Bus Park, Parking Status

Among the operations that can be done on this interface is to search through queries on any status of parking a user is interested in. A query shown in the figure below where Red is the specified color for highlighting the search results. For instance in figure 11, the user desired to know the available spaces and on entering ‘AVAILABLE’ and clicking ‘OK’ the available spaces appear in red as shown in figure 12.
Fig. 12 Results of a query depicting occupied slots

A geodatabase was developed to store information on the status of parking, client details and revenue collection details. The advantage of a geodatabases is that all this information has a spatial dimension and this is adequately represented.

Fig. 13 Populated Geodatabase.
4.2 NON SPATIAL COMPONENT (Short Messaging service)

Web application login, for parking space reservation.

Login

Fig 14 Home Page
Fig 15 New Reservation request.

Fig 16 Parking Slot Allocation after payment is made
CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This chapter will highlight an overview of the limitations, recommendations and conclusive remarks of the project when matched to the general and specific objectives. This project aimed at developing of a vehicle parking management system that supports convenient access of parking and payment of the same by the motorist for Garissa public Bus Park.

6.1. Conclusions

A GIS based tool to manage parking introduces many firsts; firstly, it integrates spatial and non-spatial data into one that makes it convenient for all the users. The analytical power of GIS is a critical component of prudent parking management. A simple search for example, can be advanced to produce specialised application like navigation and parking access route generation.

Mobile phones and related applications have made IT and telecommunications benefits a reality to Kenyans and developing countries at large, mobile pay has been an outstanding development on this front. This application has applied the power of mobile phone and web to deliver this application and interface to the motorist. Lastly fusing these two tools produces a first in parking management systems since all urban development challenges are spatial problems and Mobile-GIS comes in handy.

6.2. Limitation and Recommendations

The project has had its own share of limitations if a comprehensive parking management system was to be considered and developed. The time taken to develop and deploy the system was limited, considering the technology development in this field more time would be necessary to develop a comprehensive system.

The advanced development and application of these systems will be realised if the following recommendations are adhered to:

1) Consider new enforcement technologies that integrate with GIS system to track parking space status, location and payment. In the interim, continue to manually assess deployment to match enforcement needs to parking management needs.

2) The parking management agencies should consider the use of mobile GIS in management since mobile phone has been accessible to a majority of Kenyans, making it an available and convenient system interface.
3) It is recommended that with increase accessibility to internet will improve the accessibility of web mapping and related applications in relation to urban development.
REFERENCES


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3) JEFFREY F. PANIATI, FEDERAL HIGHWAY ADMINISTRATION, Advanced Parking Management systems, a cross cutting study, Taking the Stress Out of Parking (January 2007).


APPENDIX A

SMS application Code.

ModuleDBconn
PublicpubconnAsNewADODB.Connection
Publicdb_pathAsString
PublicServerNameAsString
Publicserver_nameAsString
PublicpwordAsString
PublicdbnameAsString
PublicdbuserAsString
PublicchkAsInteger = 0
PublicDbConAsNewADODB.Connection
PublicRsAsNewADODB.Recordset
PublicPubSqlAsString
PublicCurrentUserAsString
PublicPoliceStationAsString
PublicPstationidAsString
PublicpubUserIdAsString
PublicpubUserNameAsString
PublicpubUserRightsAsString
PublicteAsString
PublicdBalAsLong = 0

PublicSubOpenDb()
DbCon = NewADODB.Connection
Try
  If DbCon.State = 0 Then
    db_path = "Data Source=P1;DSN=P1"
    'ProgressBar1.BackColor = Color.AliceBlue
    DbCon.ConnectionString = db_path
    DbCon.Open()
  EndIf
Catch ex As Exception
  MessageBox.Show("Sorry, there was a problem connecting to the Database", "No Connection", MessageBoxButtons.OK, MessageBoxIcon.Warning)
EndTry
EndSub

PublicSubOpenTable(ByValstAsString)
Try
  Rs = NewADODB.Recordset
  OpenDb()
  Rs.Open(st, DbCon, 3, 3)
Catch ex As Exception
  MessageBox.Show("Sorry, there was a problem connecting to the DataBase " & ex.Message, "No Connection", MessageBoxButtons.OK, MessageBoxIcon.Warning)
EndTry
EndSub

PublicFunctionIsDBNull(ByValdbvalue) AsBoolean
  Return dbvalue.IsDBNull.Value
EndFunction

PublicFunctionFixNull(ByValdbvalue) AsString
  If dbvalue.IsDBNull.Value Then
    Return"
  EndIf
Else
'NOTE: This will cast value to string if 'it isn't a string.
Return dbvalue.ToString
EndIf
EndFunction
EndModule

PublicClassGISparkmisnewreservationrequest

PrivateSubGISparkmisnewreservationrequest_FormClosing(ByVal sender AsObject, ByVal e As System.Windows.Forms.FormClosingEventArgs) Handles Me.FormClosing
t.Abort()
EndSub

PrivateSubGISparkmisnewreservationrequest_Load(ByVal sender As System.Object, ByVal e As System.EventArgs) Handles MyBase.Load
Lbldate.Text = Date.Now.ToString("dd MMMM yyyy")
now = DateTime.Now
    t = New System.Threading.Thread(New System.Threading.ThreadStart(AddressOf showtime))
t.Start()
EndSub

PrivateSubSetText(ByVal [text] AsString)
If Me.Lbltime.InvokeRequired Then
Dim d As NewSetTextCallback(AddressOf SetText)
Me.Invoke(d, NewObject() {{[text]}})
Else
Me.Lbltime.Text = text
EndIf
EndSub

PrivateSubshowtime()
While True
System.Threading.Thread.Sleep(1000)
now = now.AddSeconds(1)
Dim t As System.Threading.Thread = Nothing

Dim now As DateTime

DelegateSubSetTextCallback(ByVal [text] AsString)

Private Sub Button3_Click(ByVal sender As Object, ByVal e As System.EventArgs)
    Me.Hide()
    GISparkmishome.Show()
End Sub
End Class