**AN INTELLIGENT PARKING ASSISTANT**

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**A RESEARCH PROPOSAL SUBMITTED TO THE DEPARTMENT OF PURE AND APPLIED MATHEMATICS IN THE SCHOOL OF MATHEMATICAL AND PHYSICAL SCIENCES IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF THE DEGREE OF BACHELOR OF SCIENCE IN MATHEMATICS AND COMPUTER SCIENCE OF JOMO KENYATTA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY**

**2023­­**

DECLARATION

We hereby declare that this work has not been previously submitted to any other institution of higher learning. To the best of our knowledge and belief, the project contains no material previously published or written by another person except where due reference is made in itself.

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# DEDICATION

We dedicate this work to the institution of Jomo Kenyatta University of Agriculture and Technology for its invaluable contribution towards our education, our families for their steadfast support during this crucial period and our classmates for walking this journey with us hand in hand.

ACKNOWLEDGEMENTS

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ABBREVIATIONS

|  |  |
| --- | --- |
| **IPA** | Intelligent Parking System |
| **API** | Application Programming Interface |
| **REST API** | A web service that governs interactions between the client and server to  retrieve data and send data to the database. |
| **MongoDB** | This is a non-relational database that provides support for JSON-like storage. |
| **CNN** | Convolutional Neural Network. |
| **ML** | Machine learning |
| **GUI** | Graphical user interface |
| **A\* algorithm** | An algorithm used for finding shortest path between two points |
| **IoT** | Internet of things; is a network of interrelated physical devices that are connected to the internet in order to exchange data. |
| **RFID** | Radio frequency identification; a form of wireless communication that uses electromagnetic fields to identify and track tags attached to objects. |
| **IPv4 and** **IPv6** | These are internet protocols composed of 32-bit and 128-bit address lengths respectively, used to provide unique IP addresses necessary for internet enabled devices to communicate. |
| **HTTP** | Hypertext Transfer Protocol; an application protocol that allows users to communicate data on the World Wide Web. |

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# ABSTRACT

Car parking management in Kenya is crucial to urban development and achieving Vision 2030. Juja, a town in Kenya's Kiambu County, has grown immensely due to many factors, one of them being the presence of Jomo Kenyetta university of agriculture and technology. Consequently, a challenge of poor parking management has arisen, since managing parking spaces in Kiambu is becoming increasingly problematic owing to the usage of manual parking spot allocation. It may be difficult to locate enough parking spots in Juja, especially during busy hours. This study will look at how machine learning may be utilized to find an available parking spot, in turn boosting current understanding of the importance of parking lot placement in parking management. A complete investigation of parking patterns in Juja will be done, followed by the creation of an application that will assist drivers in finding nearby parking slots. The purpose of the study is to determine the most efficient and effective solutions for parking slot positioning, therefore aligning with the rising trend of innovative city projects and contributing to Kenya's sustainable urban transportation. Throughout the investigation, ethical aspects such as data protection and confidentiality will be given proper attention.

# CHAPTER ONE: INTRODUCTION

## Background study

Juja town has gradually expanded over the past couple decades. This has consequently resulted in its urbanization, and as a result various parking issues occur due to the increased population density and commercial activity. Inadequate parking management and enforcement, in particular, can result in disorderly parking behavior, such as double parking or occupying numerous spaces. This mismanagement has the potential to significantly lower the total capacity of available parking places. As a result, the demand for automated parking management emerges.

Machine Learning (ML) is a branch of Artificial Intelligence which focuses on the use of data and algorithms to imitate the way that people learn, gradually improving its accuracy. ML is a very important tool in realizing our objectives especially reducing the relative time taken to provide results to the user. We will use a ML model to identify free parking spaces, this will be entirely based on the data and images supplied to it and the results it will provide. We will specifically use Convolutional Neural Network (CNN) which is a network architecture that is used in object detection and since we are going to be using images, it will be an instrumental tool in realizing our goal by receiving the images of parking areas and returning whether there is a free space or not.

We will as well create a database using MongoDB, to store the details of the user and their visits. MongoDB is ideal since the application will mostly run in the internet, this will ensure that we have a very low latency and ease of accessing data. APIs are Application Programming Interfaces; they are used to serve as intermediaries between different parts of a system. This data will be passed to the database from the outputs of the machine learning model. The data communication link between the ML model, user and database will be facilitated by the REST API. The REST API serves as intermediary, taking inputs and providing outputs and in this case, the inputs will be from the user and Google maps API and outputs will be coordinates.

As an added feature to the system, we will integrate Daraja API which will enable us to make mobile transactions to pay parking fees. This will be an option offered to the user once they have obtained the free parking space so as to give an all-in-one place experience. This is suitable for cashless payment methods such as M-PESA, Airtel Money, Visa etc. which are the most popular in Kenya.

## Statement of the problem

The construction of Thika super highway, provision of cheaper living standards and provision of education facilities has a major impact on growth of Juja. However, with time, it has brought a major challenge in the parking management. As a result, the county has resorted to manual allocation of parking. Researchers have been able to identify the difficulties in searching for parking space lead to wastage of time and fuel. High-stress levels experienced due to the random search for parking spaces and its impact on economically productive activities is wanting. However, there has been minimal study on the influence of machine learning on parking management in Juja and other big cities in Kenya. As a result, the goal of this study is to address the research gap by assessing the impact of available parking spot location on automated parking management using machine learning. Consequently, create an application that will give drivers accurate and up-to-date information and directions to the nearest available parking places

**1.3** Justification

Drivers encounter difficulty in finding parking areas and mostly have to rely on the residents of a given area for information on where to park. However, this may be dangerous and inconvenient, in the case that they get misleading information or they cannot get the opportunity to stop and ask. In other cases, drivers do not know how to get to the parking locations. IPA will be able to provide directions to the client. Additionally, it can sometimes happen that drivers make their way to a known parking area only to find it is at capacity and therefore have to reroute to a different location, wasting both time and fuel. IPA would solve this problem by directing them to a sure vacant slot, thereby helping drivers save on both. Drivers also tend to break traffic rules, while trying to get directions to a parking area. IPA would assist in minimizing such traffic regulations. By developing this software, we can make significant strides in mitigating parking-related issues and improving the overall quality of urban transportation systems in Kenya. The general time takes to obtain a free parking space will be reduced significantly, we will provide reliable information that will be crosschecked to ensure that it is accurate. Another added advantage is that the model will have a payment system integrated to make user experience seamless. It will provide a bridge between the user and the various services that he or she will require, considering they will need information on the location of the parking space given their location, the app will serve as an interface to determine the various parking that are available.

## Objectives

### General Objective

To develop an intelligent parking assistant.

### Specific Objectives

1. Develop the model for the intelligent parking assistant.
2. Develop a database architecture for the problem
3. Implement the proposed model.
4. Create a user-friendly interface.
5. Verify and validate the implemented method

## Scope of study

The study focuses primarily on the organization of the parking system along Thika road, and around Nairobi town. The study will analyze how drivers find parking in these areas, the challenges they face and aims to provide feasible solutions. It will involve the development of a user-friendly mobile application for Android platforms. Data integration will be conducted to gather parking availability information from various sources, including parking lot operators, and user reports as well as information and functionality attained from Google earth and Google maps.

The proposed solution may not be able to solve errant driver behaviors or limited parking space due to lack of infrastructure or government restricted parking zones.

Some limitations are expected to be encountered during the project study. Some limitations to consider will be:

1. The availability and reliability of real-time parking data may vary, as it relies on data from sensors, parking lot operators, and user reports;
2. The study's coverage will be limited to Juja municipality, which may not represent the entire parking landscape in Kenya;
3. User adoption and engagement are also potential limitations, as the success of the software depends on user acceptance and active usage;
4. Connectivity issues and technical limitations may impact real-time functionality and navigation experiences; and
5. The actual availability and accessibility of parking slots may be subject to external factors such as demand fluctuations and parking restrictions.

# CHAPTER TWO: LITERATURE REVIEW

Car parking management and the development of smart parking systems have been areas of growing interest globally, including in Kenya. Several studies have been conducted, examining various aspects related to parking efficiency, technology adoption, and user experience. This literature review provides an overview of relevant research conducted in Kenya, highlighting key findings and their implications for the proposed car parking assistant software.

Adki and Agarkhed (2016), conducted research on cloud assisted time-efficient vehicle parking services. The proposed work introduces a complete framework that solves the urban vehicle parking problem in Turkey. This work helps the end users to efficiently find nearby parking lots along with the available parking spaces with the aid of navigational directions. The system consists of smart phone applications, cloud services, sensing and communication technologies.

Caballero-Gil, Caballero-Gil, and Molina-Gil (2016)*,* came up with a Low-Cost Service to Predict and Manage Indoor Parking Spaces. This work proposes an adaptive recommendation mechanism for smart parking that takes advantage of the popularity of smartphones and the rise of the Internet of Things. The proposal includes a centralized system to forecast available indoor parking spaces, and a low-cost mobile application to obtain data of actual and predicted parking occupancy. The described scheme uses data from both sources bidirectionally so that the centralized forecast system is fed with data obtained with the distributed system based on smartphones, and vice versa. The mobile application uses different wireless technologies to provide the forecast system with actual parking data and receive from the system useful recommendations about where to park.

Aydin, Karakose, and Karakose (2017), proposed a navigation and reservation based smart parking platform using genetic optimization for smart cities. In this study conducted in India, a navigation and reservation-based parking proposal system was developed for smart cities. The proposed method involves the development of small devices that send data to the internet using the internet of things (IoT) technology. The free parking space closest to the current location is found by genetic algorithm.

Saeliw et al. (2019)*,* developed a Smart Car Parking Mobile Application based on RFID and IoT. The objective of this research was to develop mobile application for smart car parking using Radio-Frequency Identification (RFID) and Internet of Things (IoT) which can detect the available parking lot so as to be time saving for people. It would be able to automatically alert users when the parking lot status has changed, improving on traditional system which the users have to access web application.

Hu and Liu (2021), designed an intelligent parking lot assistance system, in which the parking lot is equipped with an industrial camera. The system uses machine vision and A\* algorithm to realize vision-based parking space detection, and proposes a proposed plan for vehicle parking and driving paths. The parking assist system for smart parking lots is designed on MATLAB software.

Ogenche (2016), proposed a geographic information-based parking management prototype that will factor in spatial and non-spatial data as the solution to facilitate good quality secure parking in maintaining the vitality and viability of town centers in enabling retail and leisure uses to flourish. The output was a mobile-web interface that will enable the county government as well as key players to access and monitor space availability which the users will be able to access from their mobile phones.

Kang’ethe (2020), investigated the impact a system that aggregates all parking slots centrally and identifies each uniquely would have on managing Nairobi traffic. The system would be accessible from anywhere using a web based enabled interface. The drivers in the county will be able to log in and preserve slots at a defined time on a first come first serve basis. This aimed to coordinate traffic flow in a more efficient way since the system was able to predict estimated number of vehicles expected in the city per unit of time apart from those that will be in transit and not stopping.

Mukundi (2020), designed an IoT traffic management framework for Nairobi, Kenya. This research aims to advance an endurable traffic management design framework based on IoT and to help resolve some of the traffic issues of Nairobi City. The assessed current generic design frameworks of IoT sensors available in the market today with regard to traffic management and analyzed the benefits associated with the IoT implementation on traffic management as opposed to the Manual traffic management. This research provides an analysis of how different sensors can communicate and help improve the current traffic congestion in the city and how other different facets like, smart parking sensors, smart streetlights, smart highways and smart accident assistance can be integrated in the same study. For the full-scale adoption of IoT in parking management, the system requires data sensors (RFID tags) to give the location of the cars in the parking lots, WIFI with IPv4 or IPv6 for receiving and transmitting information regarding the cars parked and cloud computing technologies to process the information.

The reviewed literature provides insights into the challenges and opportunities related to car parking management in Kenya. It underscores the significance of developing innovative solutions that leverage real-time data, IoT technologies, and user-friendly interfaces. In conclusion, the literature review demonstrates the relevance and timeliness of the proposed car parking assistant software project in Kenya. The findings from previous studies emphasize the need for efficient parking management systems, real-time information dissemination, and user-friendly interfaces. By building upon and expanding upon these existing studies, the project aims to contribute to improved parking efficiency, reduced congestion, and enhanced user experiences in Kenyan urban areas.

## 2.1 Point of Departure

As indicated by these studies, further optimization of the parking system is a vital requirement to the general transport system which is still lacking in efficiency. This project aims to provide better solutions for this current problem using different methods and techniques. It proposes to do this by making use of real-time data as opposed to employing IoT technologies as the main solution.

# CHAPTER THREE: METHODOLOGY

## 3.1 Introduction

The efficient utilization of parking spaces in urban areas has become a pressing concern due to the escalating number of vehicles and limited parking infrastructure. To address this issue, this research proposal aims to develop and implement an Intelligent Parking Assistant Model that leverages Google Maps, webcam images and machine learning algorithms to assist drivers in locating available parking spaces in real-time. This chapter outlines the methodological approach we intend to employ to design, implement, and evaluate the effectiveness of the model.

## 3.2 Proposed Solution

The primary objective of this study is to create a user-friendly and accurate parking assistant tool that optimizes the process of finding vacant parking spaces within Juja Constituency. We will employ a multi-faceted methodology that encompasses data collection, model training, and performance evaluation to achieve our research goals.

**Figure 1: Waterfall model**

### 3.2.1 Requirement gathering and analysis

### 3.2.2 System Design

This section describes how the system will interact with the user and tries to elaborate on the conversion of data collected into a form more suitable for implementing the model.

The flow chart below visualizes the process flow of the system.

User

Does User Have an account?

YES

Register User

Are there any errors?

Login User

Is user in the system?

Get User Login Details

Get User Details

NO

NO

YES

Display landing page

YES

Is there parking space available nearest to the user?

Display Available parking spaces

Ask for user’s location

YES

NO

YES

Display map for manual search

d

NO

NO

**Figure 2: Flow chart of system**

By creation of the flow chart, it helps in understanding how the users will interact with the system and the errors that may occur keeping in mind that users may end up doing the unexpected. This will help in organization of thoughts before the implementation of the actual system while also help users understand the system easily.

### 3.2.3 Implementation

Machine Learning Model**:** Once we have carried out data collection, we will proceed to the model development stage. Machine learning algorithms, such as support vector machines (SVM), random forests, convolutional neural networks and deep neural networks, will be employed to train the Parking Assistant Model, where convolutional neural networks (CNN) will be useful for image recognition and processing. We will explore various feature engineering techniques to extract relevant information from the data, such as parking occupancy rates, time of day, weather conditions, and local events. By combining these features, the model will learn to predict the likelihood of finding an available parking space at a given location and time.

Frontend: This will involve the development of the graphical user interface (GUI). In particular, ReactJS will be used to create the required pages, that is, the sign in and landing pages, while tailwind will help in the styling of each page in a simpler manner. For additional functionality we will maximize on the available JavaScript libraries to help in the frontend development.

Backend: The development of the heart of the software will be done here. Initially, the database would be setup in accordance to the requirements of the system. The development of the REST API to be used to setup accounts for the users and facilitate membership will follow suite. This will be done using Django REST framework and Django. It will be integrated with a machine learning model, Google Earth and Google Maps to offer the directions required to get to the parking slot. Google Earth helps triangulate the location of the parking slot and offer the co-ordinates to Google Map, also providing real time images of parking space. In addition, external API would be linked e.g. Daraja API for M-PESA payment services, Google Places to help locate the parking spaces using the coordinates provided to it and Google Maps to direct users to a specific location. In addition, we will use MongoDB to setup the database to ensure efficient online data storage and retrieval. The backend and the frontend will interact using the REST API and HTTP to communicate between the servers and the client machine.

### 3.2.4 Testing

To evaluate the efficacy of the Intelligent Parking Assistant (IPA), we will conduct a series of simulations and tests using images obtained from Google Maps API. During the simulation phase, we will use historical parking data and compare the model's predictions against the actual parking availability to assess its accuracy and performance. Furthermore, a beta test will be conducted to assess the user experiences while using the application. Post-field test surveys and interviews will also be conducted to gather user feedback and assess the practicality and user-friendliness of the IPA system. In addition, the software will be tested by using Jest for the frontend and unit-test for the backend to ensure correctness and security, thus enhance user confidence in the software product.

### 3.2.5 Deployment

The final software product will be deployed for use by the public and its functionality and acceptability will be tested by use of reviews from Google App store and even apple store.

### 3.2.6 Maintenance

The application will be continuously updated and maintained to ensure it provides the best services to our clients. Additionally, we will address potential limitations of the methodology, such as the reliance on Google Maps data and potential biases in the training dataset by continuous integration and deployment which will in turn help to keep up to date with the latest software and improve on the software.

In conclusion, this methodology aims to develop a cutting-edge IPA that utilizes machine learning techniques and Google Maps data to aid drivers in locating available parking spaces efficiently. By adopting a comprehensive approach that includes data collection, model training, and real-world evaluation, we anticipate that the IPA system will make a significant contribution to alleviating parking-related challenges in urban areas and enhance the overall driving experience for users.

## 3.3 Model Formulation

In order to achieve the set objectives, we’re going to have a MongoDB database to store all the user’s information, their login credentials, and the history of the parking spaces they have ever occupied, the database will also store coordinates of parking spaces we know and this will be provided by the machine learning model as per the input provided. This will therefore aid in the general search for parking spaces in future and also to analyze trends in Juja.

We will then construct a machine learning model that will leverage on deep neural networks and convolutional neural networks (CNN) to study and obtain meaningful insight from the data provided which in this case will be images. We will also harness the power of computer vision to aid the machine learning model function more efficiently and save on time it takes to determine whether the provided areas are free on not.

The source of the images to be provided will be Google maps API, we will gather satellite images and the history of the patterns of parking in Juja and use it to the machine learning model. And from the training we will subject a few test cases to it to evaluate its functionality.

We will then construct the REST API to handle the requests from the user and communicate with both Google maps API and the machine learning model. This will require functions to login, get the location of the user, send co-ordinates to the model and receive back results of free parking slots.

Finally, we will develop a user-friendly user interface with the aid of tailwindcss and ReactJS. With all of these in place, we will integrate them together to form the complete product.

1. **Assumptions:**
2. Reliable Data Sources: The accuracy and reliability of the data from various sources, such as sensors and user reports, are assumed to be sufficient for making parking availability predictions. The model relies on the availability and quality of data to provide accurate results. For instance, the model assumes that the data obtained from Google Earth and Google Maps is reliable and up-to-date, providing accurate parking slot locations and navigation directions.
3. Effective Payment Integration: The model assumes successful integration with mobile payment methods such as M-PESA for secure and seamless payment transactions.
4. Parking Slot Independence: The availability of parking slots is assumed to be independent of each other. This assumption allows the model to treat each parking slot as a separate entity and make predictions based on individual slot availability.
5. Stationary Parking Demand: The model assumes that the parking demand remains stationary during the prediction interval. It does not account for sudden changes in demand due to special events, emergencies, or other unpredictable factors.
6. **Boundary Conditions:**

The application operates within the boundaries of the integrated data sources (Google Earth, Google Maps) and the availability of mobile payment services. The accuracy and availability of parking data depend on the coverage and quality of the data obtained from these sources and additionally on the data collected from parking lot operators and user reports.

## 3.4 Method of solution

1. Develop a model for the intelligent parking assistant: To achieve this objective, we ae going to come up with a model for the whole system. The model will comprise of a machine learning model, database, REST API and finally the user interface for the user to communicate with the system. The machine learning model will be constructed using CNN to facilitate images as input, deep neural networks to further study the images and the trends that will be provided by the pattern obtained from the images as well and finally computer vision to determine the objects in the images. Several algorithms will be implemented as well to account for factors such as events and open-parking areas. The machine learning (ML) model will not only take images as input but also the data from the database to study the pattern of parking within Juja as well so as to aid in hastening the location of available parking slots. The model will then be connected to Google maps API and the REST API to facilitate communication between these three modules of the system. The model will receive input from Google maps API and then give an output of the parking areas that are free to the REST API which will then relay to the user the location of available parking spaces.
2. Creation and population of the database: We will use MongoDB to create the database. The database will compose of several tables such as the users table to store the details of the user, a visits table to outline the areas that are known and have been visited by specific users and finally we will have a table to store records of parking spaces that are known in Juja. Population of the database will be specific to the table that is being populated. The users table will be populated by the users themselves and this will be through a registration form, the visits table will be filled automatically when the user gets to their destination, this will guide the future searches of other users. The table containing the locations of parking spaces will be populated by the machine learning model after the training and the data will be verified.
3. Implementation of the model using python: We will create the machine learning model using TensorFlow specifically using python programming language. We propose that in addition to this we could come up with a TinyML, that is, a light weight machine learning model that can be hosted on the mobile application and this will in turn reduce the time complexity of operation of the system. The REST API will also be created using python, specifically Django rest framework that will be facilitate the communication between these components of the system.
4. Creation of user-friendly user interface: The user interface will be created using ReactJS which is a JavaScript framework. We will use it to create several pages, these pages will be the landing page, the search page, the registration page, the login page and finally the page to list the results of the search, a page to view the directions to the designated location and finally a page to return reviews on their experience in using the application. In addition to this we could also include a page to view all the previous visits to different places. This will be the comprehensive outline of the pages to be used in the system.
5. Verification and validation of the model: The verification of the system will be conducted by testing the site and the directions given by the applications and actually visiting the location. We will as well check the coordinated of the parking areas provided by the machine learning model and making necessary modifications in the machine learning model and the general system.

In summary, the car parking assistant software utilizes a predictive model based on historical data and real-time inputs. It incorporates data preprocessing, feature engineering, and continuous model refinement. The user will provide their location by logging in and this will be passed to the REST API and the search for the available parking spaces, this will be subjected to the database to return parking spaces within 500-meter radius, the calculation will be done by a custom build algorithm to determine the results that are within the radius. The coordinates will finally be subjected to the machine learning model to determine if there is an available space. The model will finally return if the coordinate of an available parking space that will be passed to the user interface. By following this methodology, the Intelligent Parking Assistant mobile application can provide drivers with accurate parking information, navigation guidance, and convenient payment options, as well as predict parking availability. The model formulation focuses on data integration, user interaction, and seamless user experience, ensuring a reliable and user-friendly solution for parking management.

## 3.5 Expected Outcomes

Upon completion of the project, the following outcomes are anticipated:

1. A fully functional car parking assistant software that provides real-time parking availability information and navigation guidance.
2. Increased awareness and utilization of available parking slots, leading to reduced congestion and optimized parking resource usage.
3. Improved user experience through features like user reviews, payment integration, and parking spot reservation.
4. Valuable insights into parking patterns and trends, which can be used by urban planners and authorities to optimize parking infrastructure and policies.

## 3.6 Our Contribution

The development of a car parking assistant software has the potential to revolutionize the parking experience and alleviate parking-related issues in urban areas. By combining real-time data, intelligent algorithms, and user-friendly interfaces, this project aims to empower drivers with the necessary tools to locate free parking slots efficiently. The project's outcomes can have significant positive impacts on traffic flow, resource utilization, and user satisfaction.

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# APPENDICES

## APPENDICE 1: WORK PLAN

This research study will cover a period of seven months. Table below shows the various activities that will be undertaken during the research and their respective timelines.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Year** | **2023** | | | | | | |
| **Month** | **Jun** | **Jul** | **Aug** | **Sept** | **Oct** | **Nov** | **Dec** | |
| Literature review |  |  |  |  |  |  |  | |
| First semester report preparation |  |  |  |  |  |  |  | |
| First semester presentation |  |  |  |  |  |  |  | |
| Research and data collection |  |  |  |  |  |  |  | |
| Application and model development |  |  |  |  |  |  |  | |
| Testing |  |  |  |  |  |  |  | |
| Data collection and analysis |  |  |  |  |  |  |  | |
| Final year report preparation and submission |  |  |  |  |  |  |  | |
| Final year presentation |  |  |  |  |  |  |  | |

**Table 1: Work plan**

## APPENDICE 2: BUDGET

During the undertaking of this project, certain requirements will be necessary in order to facilitate the successful actualization of this project’s objectives. The expected expenditure will be as shown below.

|  |  |
| --- | --- |
| **ITEM** | **COST** |
| **SERVERS** | $135 (19,000 KES) |
| **DOMAIN NAME** | $14 for a one year subscription |
| **COLLABORATIVE EFFORTS** | $40 per month |
| **MISCELLANEOUS** | $20 |
|  |  |
| **TOTAL** | $369 (53,000 KES) |

**Table 2: Budget**