



University of Nairobi

School of Engineering

**INTEGRATING GIS AND REAL ESTATE MANAGEMENT SYSTEMS TO
MARKET AND MANAGE FACILITIES ON THE WEB**

BY

LABAN KARANJA NDUNGO

F56/82848/2015

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

July 2017

Declaration

I, Laban Karanja Ndungo, 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.

LABAN KARANJA NDUNGO

Name of student

04/07/2017

Date

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

J. N. MWENDA

Name of supervisor

4th July 2017

Date

Dedication

This project is dedicated to my parents, Dr. and Mrs Machanga, for their support and encouragement in my pursuit of further studies in the field of GIS.

Acknowledgement

First and foremost, I would like to thank God for giving me life and being gracious enough to allow me this opportunity to attain a Master's Degree in GIS. I thank my supervisor Mr. J. N. Mwenda for his support, assistance and guidance offered while preparing for and conducting my project research. I also wish to acknowledge family and friends for bearing with me while I worked on this project.

Abstract

Location drives the real estate industry. It is not just about finding any site but finding the best site. By analysing data around locations - demographics, aerial photographs, and amenities - real estate agents and potential home owners can find ideal locations for property based on preference. Use of GIS technology is particularly fitting to the application of real estate practice considering that property is geospatial in nature, its associated attributes are plentiful, and the relevance of location is a major factor in the assigning of value to a property. With the recent explosion in the use of the Internet in Kenya, mainly due to the increasing popularity of smartphones, the benefits that GIS offers in the realtor space is now capable of being placed in the hands of millions of prospective home owners. Having the right services and information available via the Internet is an important differentiator for real estate companies. Soon, those companies showing where a house is and displaying other important data such as school districts, social amenities, shops, crime data - using map-based viewers, finders, and transport links - will be far ahead of those that do not.

Real estate management and marketing on the web has been done before (Keja Hunt, 2016), but there is yet to be a web application which successfully combines data from disparate Real Estate Management software and uses it to visualize data on a Geographic Information System on the Web in both 2D and 3D. The purpose of this project therefore was to design and develop a web based application that integrates GIS and Real Estate Management Systems and which can be used by a real estate company to improve its services, attract prospective clientele, and ultimately contribute to the company's earnings. To this end, the output of this project meets a need that is present today such as convenient house hunting on the web, but also proves that real estate firms can enhance their operations by embedding GIS web maps – which provide value addition to their current systems - onto their software operations without having to overhaul their mode of operation.

Table of contents

Declaration	I
Dedication	I
Acknowledgement	III
Abstract	IV
Table of contents	V
List of Figures	VIII
List of Tables	XI
ABBREVIATIONS	XII
CHAPTER 1: INTRODUCTION	1
1.1 Background	1
1.2 Problem Statement	2
1.3 Objectives.....	2
1.4 Justification for the project.....	3
1.5 Scope of work and limitations.....	4
1.6 Study Area.....	5
1.6.1 Nairobi City County.....	5
1.6.2 Kiambu County.....	6
1.7 Organization of the Report.....	7
CHAPTER 2: LITERATURE REVIEW	8
2.1 The Housing Situation in Kenya’s Urban Areas	8
2.2 Cloud Computing and Web GIS	11
2.3 Web 2.0 and Web Mapping Technologies	16
2.4 Kenya and the Online Retail Market.....	17
CHAPTER 3: MATERIALS AND METHODS	27
3.1 Background	27
3.2 Web Application Development.....	28
3.2.1 Determination of Factors Considered in choosing housing.....	30
3.3 Data Collection.....	32
3.4 GIS Data Clean up and Publishing.....	34

3.5	Creating the Real Estate Management System	36
3.5.1	Web linkage Implementation	41
3.5.2	Creation of Public Facing Web Application	42
CHAPTER 4: RESULTS AND ANALYSIS		52
4.1	A Tour of the Real Estate Manager Application	52
4.1.1	General CRUD procedures on the system	54
4.1.2	Managing Apartments	57
4.1.3	Managing the apartment from the GIS Platform	63
4.2	A Tour of the Public Facing Web Application	65
4.2.1	Lifestyle Data	68
4.2.2	Find a Home	69
4.2.3	Nearby Facilities	72
4.2.4	Change map background	74
4.2.5	Bookmarked Locations	74
4.2.6	Directions	75
4.2.7	Share	76
4.3	Analysis of Results	78
4.4	Challenges Encountered	79
4.4.1	Challenges in simulating a Real Estate Management platform	79
4.4.1	Challenges in obtaining Lifestyle Data Overlay data	80
4.4.2	Challenges in creation of the Public Facing Web application	80
CHAPTER 5: CONCLUSION AND RECOMMENDATIONS		81
5.1	Conclusion	81
5.2	Recommendations	82
References		84
APPENDICES		88
Appendix A		88
The process of publishing a feature GIS Service		88
Appendix B		94
Creation of Real Estate Management RDBMS in SQL Server Express 2016		94
Appendix C		95

SQL commands that created the database schema / skeleton	95
Appendix D.....	100
Schema of the Rental Apartment/Real Estate Management Database.....	100
RentApartment Database Documentation	100
Appendix E	102
A method to add data to a GIS web service using an ASP.NET MVC Controller action	102
Appendix F.....	105
A method to edit a GIS web service using an ASP.NET MVC Controller action.....	105
Appendix G.....	108

List of Figures

Figure 1: The Project Study Area	6
Figure 2: Percentage of housing units completed for sale by type	10
Figure 3: Cloud Computing Service Models	13
Figure 4: An implementation of Web GIS.....	15
Figure 5: Web GIS supporting the Enterprise.....	15
Figure 6: Knight Frank Real Estate Search.....	20
Figure 7: Searching for a rental house on Jumia.....	21
Figure 8: Property Details on Jumia Search Portal.....	22
Figure 9: House hunting with KejaHunt.....	23
Figure 10: Textbook approach to Property Listing.....	24
Figure 11: Flowchart showing the Project Process.....	31
Figure 12: E-R Model Diagram of the Real Estate Management Application.....	38
Figure 13: Model View Controller (MVC) architecture.....	40
Figure 14: Linking the GIS Platform to the Real Estate Platform (Solution Architecture).....	41
Figure 15: The ArcGIS Online Platform	44
Figure 16: Web App Builder download folder and startup file	45
Figure 17: Node JS server running	46
Figure 18: Web App Builder Startup	47
Figure 19: Web AppBuilder Start Page	48
Figure 20: Making a choice of Web AppBuilder.....	49
Figure 21: Naming and describing the application	49
Figure 22: WYSIWYG Configuration Page	51
Figure 23: Home page of Real Estate Manager application	53
Figure 24: Logging into the Real Estate application	53
Figure 25: Logged in view of the Home page	54
Figure 26: Agent Details page	54
Figure 27: Create operation for Agents	55
Figure 28: Edit operation for Agents	56
Figure 29: Delete operation for Agents	56

Figure 30: Viewing apartment details.....	57
Figure 31: Apartment Basics Section	58
Figure 32: Apartment Details Section.....	59
Figure 33: Apartment Location Picker	60
Figure 34: Apartment Added	61
Figure 35: Viewing the entry from the Web GIS Platform	62
Figure 36: Apartment Audit Trail.....	63
Figure 37: Adding on-site photos and editing details through Collector for ArcGIS.....	64
Figure 38: The Collector for ArcGIS app interface	64
Figure 39: On-site photos attached to GIS feature (Rental Apartment)	65
Figure 40: Public Facing Application Splash Screen	66
Figure 41: First look at application after the splash screen	66
Figure 42: Viewing a legend of displayed data	67
Figure 43: Viewing application options.....	68
Figure 44: Lifestyle Data Overlays.....	69
Figure 46: Results from the GIS Query	70
Figure 45: Querying the GIS platform.....	70
Figure 48: Displaying result on map.....	71
Figure 47: Displaying result detail.....	71
Figure 49: Looking at detail of nearby facilities.....	72
Figure 50: Searching for nearby facilities.....	72
Figure 52: Viewing directions to a facility on the map	73
Figure 51: Getting directions to a facility	73
Figure 53: Changing the Map Background.....	74
Figure 54: Showing Bookmarked Locations	75
Figure 55: The Directions Panel	76
Figure 56: Sharing the application through the share option.....	77
Figure 57: Signing into GIS Platform.....	88
Figure 58: Signing in Page.....	89
Figure 59: Sharing as a Service	89
Figure 60: Choosing the Publish option	90

Figure 61: Publish Dialog	90
Figure 62: Service Editor Dialog	91
Figure 63: Adding Item Descriptions	92
Figure 64: Sharing Options	93
Figure 65: Successful Publish.....	93
Figure 66: Web Application Development Published Service	94

List of Tables

Table 1: Project Data Sources.....	32
Table 2: Web Mapping Services Used.....	33
Table 3: GeoAnalytics Services Employed	34
Table 4: Feature Services created for the Public Facing application.....	35

ABBREVIATIONS

API	Application Programming Interface
ASP.NET	Active Server Pages Dot Net
CAK	Communications Authority of Kenya
CRUD	Create-Read-Update-Delete
CSS	Cascading Style Sheets
CSV	Comma Separated Values
DBMS	Database Management System
DDL	Data Definition Language
EF	Entity Framework
E-R	Entity Relationship
Esri	Environmental Systems Research Institute
FK	Foreign Key
GIS	Geographic Information Systems
HTML	Hypertext Markup Language
HTTP	Hypertext Transfer Protocol
JSON	Java Script Object Notation
KNBS	Kenya National Bureau of Statistics
KODI	Kenya Open Data Initiative
MLPP	Ministry of Lands and Physical Planning
MVC	Model View Controller
NGO	Non-Governmental Organization
PAAS	Platform as A Service
REST	Representation State Transfer
SQL	Structured Query Language
URL	Uniform Resource Locator
WHO	World Health Organization
WYSIWYG	What You See Is What You Get
XML	eXtensible Mark-up Language

CHAPTER 1: INTRODUCTION

1.1 Background

A picture may be worth a thousand words but maps tell stories. A map is defined as a representation of selected characteristics of a geographical location, usually drawn on a flat surface (National Geographic, 2006). Maps speak to the viewer by exposing their many relationships between their constituent features. If the data within a map is known to be authoritative, its testimony is unquestionable making it a powerfully persuasive tool. In a fiercely competitive market, such as the real estate market, this could prove to be the difference between making a sale and being unable to do so.

The real estate industry is based on finding the best site for a housing property at the best price. By analyzing data around locations such as the demographics of the area, aerial photographs and amenities surrounding the area, real estate agents and potential home owners can find ideal locations for property based on preference. A Geographic Information System (GIS) captures, analyzes, and displays data in a visual, spatial context. In essence, the product of a GIS is a map (Donlon, 2007). Use of GIS technology is particularly fitting to the application of real estate practice considering that property is geospatial in nature, its associated attributes are plentiful, and that location is a key aspect of determining the suitability of a piece of property. GIS helps the real estate industry analyze, report, map, and model the merits of one site or location over another. From identifying the best site for purchase for new commercial development to matching a home buyer's decision criteria to managing a property portfolio, GIS delivers the answers realtors and potential home owners need to make the best choice (Esri, 2006).

With the recent explosion in the use of the Internet in Kenya, mainly due to the increasing popularity of smartphones, the benefits that GIS offers in the realtor space are now capable of being placed in the hands of millions of prospective home owners. This transformational architecture - termed Web GIS (Fu and Sun, 2011) - opens existing tools and existing ways of implementing GIS, integrates them, and simplifies everything. It allows users to take their systems of spatial record, traditional server and desktop technologies, and integrate them into a

system of systems - at the same time, creating a system of engagement, meaning users are connected through devices and applications that feed into one GIS portal.

Having the right services and information available via the Internet is an important differentiator for real estate companies. Soon, those companies showing where a house is and displaying other important data such as school districts, social amenities, shops, crime data - using map-based viewers, finders, and transport links - will be far ahead of those that do not. The purpose of this project therefore is to design and develop a web based GIS application that can be used by a real estate company to improve its services, entice prospective clientele, and ultimately contribute to the company's revenue.

1.2 Problem Statement

Real estate management has been done before (Keja Hunt, 2016), but there is yet to be a Kenya-centric web application which successfully combines data from disparate Real Estate Management software and uses it to visualize data on a Geographic Information System on the web in both 2D and 3D (SoftKenya.com, 2016). To this end, this project meets the present day needs of the common populace such as assisting in finding a convenient place of shelter and proves that real estate firms can make proper use of GIS web maps to enhance their services without having to overhaul their current systems.

1.3 Objectives

Service oriented architectures in GIS now make it possible to hide the technical details of datasets by exposing them through standard web browsers, making them available to wider audiences at a fraction of the cost. In turn, these architectures allow the GIS to support cross-functional enterprise applications aimed at entire business processes.

The main objective of the project is to design and develop a web platform that successfully integrates property data stored in a relational database to a Web GIS platform that utilizes service oriented architectures. The project will endeavor to fulfill the following specific objectives:

- i) Investigate how Real Estate Management is currently conducted by commercial firms
- ii) Design a model for an integrated Web GIS rental home search solution for commercial rental firms
- iii) Establish a real estate geographic information database with rental apartment data
- iv) Establish linkage between geographical attribute information and tabular based data that is present on real estate management software platforms through a web service
- v) Expose the data on these two disparate platforms on a prototype web application that utilizes the best of both platforms and allows realistic visualization of properties and buildings in 2D and 3D and which can be viewed on any device at any time

1.4 Justification for the project

A new house is said by some to define a new phase in a person's life (Canaan, 2017). Making a choice on the apartment or home one will live in determines the routine and lifestyle that one will have for the duration of habitation. Studies show that housing conditions influence individual's outcome in health, education, socio-political participation, and labour participation, among other aspects of life (WHO, 1989). It is therefore important that one makes the right choice in such a matter. While making a housing choice, various aspects of housing are generally considered such as its location, dwelling type, tenure form, age and quality (Smith, 1988). These household choices are influenced by the prices of housing services, the income of the individuals searching and a host of other factors such as household size, life cycle, government regulations, among others (Musyoka, 2012).

Kenyans are used to locating and assessing properties in the old-fashioned way: phone calls and personal visits. This is slowly and definitely changing with the aforementioned penetration of Internet usage and the success of online retail platforms such as OLX and Jumia (formerly Lamudi Kenya) – both of which rank within the top 25 sites visited by Kenyans in the year 2016 (Alexa.com, 2017). Both sites, among many others, offer online real estate search - allowing prospective residential property buyers to sort listed properties interactively based on desired elements. These elements typically address features wanted within a home, such as the dwelling's

size, number of bedrooms and bathrooms, whether a garage or swimming pool is included, and other furnishings.

Equally important in considering the ideal home is to find the ideal location. Length of the commute time, crime frequency, proximity to cultural and retail options, and the location of desired schools are all vital factors in ensuring a comfortable life in the new home at the new location. While some websites are beginning to address this concern by including small overlays within a property's webpage, none overtly considers that the home buying process may not start with the selection of home features, but by determining the "best-fit" neighborhood in conjunction with the aforementioned features (Dowling, 2014).

Real estate agents that present detailed information on available homes and land can realize increased interest in their properties and thus increased sales (Benjamin, 2005). This project attempts to create an easy to navigate and understand web platform that provides the capability for users to filter apartments for rent by diverse select criteria and which allows realtors to combine the property feature data they currently possess with spatial location attributes for better management and marketing of their properties. In so doing, this project aims to assist two categories of people:

- i The home shopper - by allowing buyers to research neighborhoods as simply as many websites currently allow general property research
- ii The realtor – by providing commercial real estate companies with an efficient and honest marketing tool for shopping the properties in their catalog as well as managing them.

1.5 Scope of work and limitations

The research conducted for this project was focused on creating a web platform through which the following actions can take place:

- i) Individuals seeking rental homes can display residential areas that not only fit their ideal features but which also satisfy their desired neighborhood features
- ii) Realtors can manage data on the properties which they have put up for rent and integrate their management data with the spatial data they have

The web platform that is created will have the following basic functionality:

- i) A Web Application interface with a detailed map of the study area flanked by side panels with property information and GIS layer toggles
- ii) A backend data management portal through which realtors manage their property data and upload new property data to both a relational database and a GIS database
- iii) A GIS Web portal that is used to manage the spatial data that informs the location of the properties

Creating such a platform will entail the following:

- i) Creating a GIS database of rental properties and buildings which are managed by the realtors
- ii) Creating a relational database of the rental property data for the non-spatial attribute data of the properties to simulate a real estate management information system
- iii) Creation of a non-public web service platform that can update both databases simultaneously to have synchronized databases
- iv) Creation of a public user facing map driven interface for the house/home hunters to carry out their searches

The programming effort in this project resulted in a web GIS application that integrates existing real estate property data with related city and neighborhood data for the selected study area into an interactive local mapping website.

1.6 Study Area

The study area was limited to Nairobi and Kiambu Counties since these were the areas in which many realtors seemed to be offering houses for rent over the period of the project. These counties are also relatively highly urbanized in relation to the rest of the country and therefore tend to register the most demand for urban housing.

1.6.1 Nairobi City County

Nairobi City (which is Kenya's capital and largest city) and its surroundings form the Nairobi County. Nairobi is the most populous city in East Africa, with a current estimated population of about 3 million. According to the 2009 Census, in the administrative area of Nairobi, the population of Nairobi County stood at 3,138,369 people within a surface area of 695 square

kilometers. Geographically, Nairobi County is located approximately between latitudes 1°10'S and 1°27'S in the North – South direction. Longitudinally it extends from 36°40'E to 37°0'E in the East-West direction.

1.6.2 Kiambu County

Kiambu County is a county in the former Central Province of Kenya. Its capital is Kiambu and its largest town is Thika. The county is adjacent to the northern border of Nairobi County and has a population of 1,623,282 as per the 2009 Kenya Population and Housing Census. The county is 40% rural and 60% urban owing to Nairobi's consistent growth northwards. Geographically, the county lies between latitudes 00° 25' and 10° 20' South of the Equator and Longitude 36° 31' and 37° 15' East.

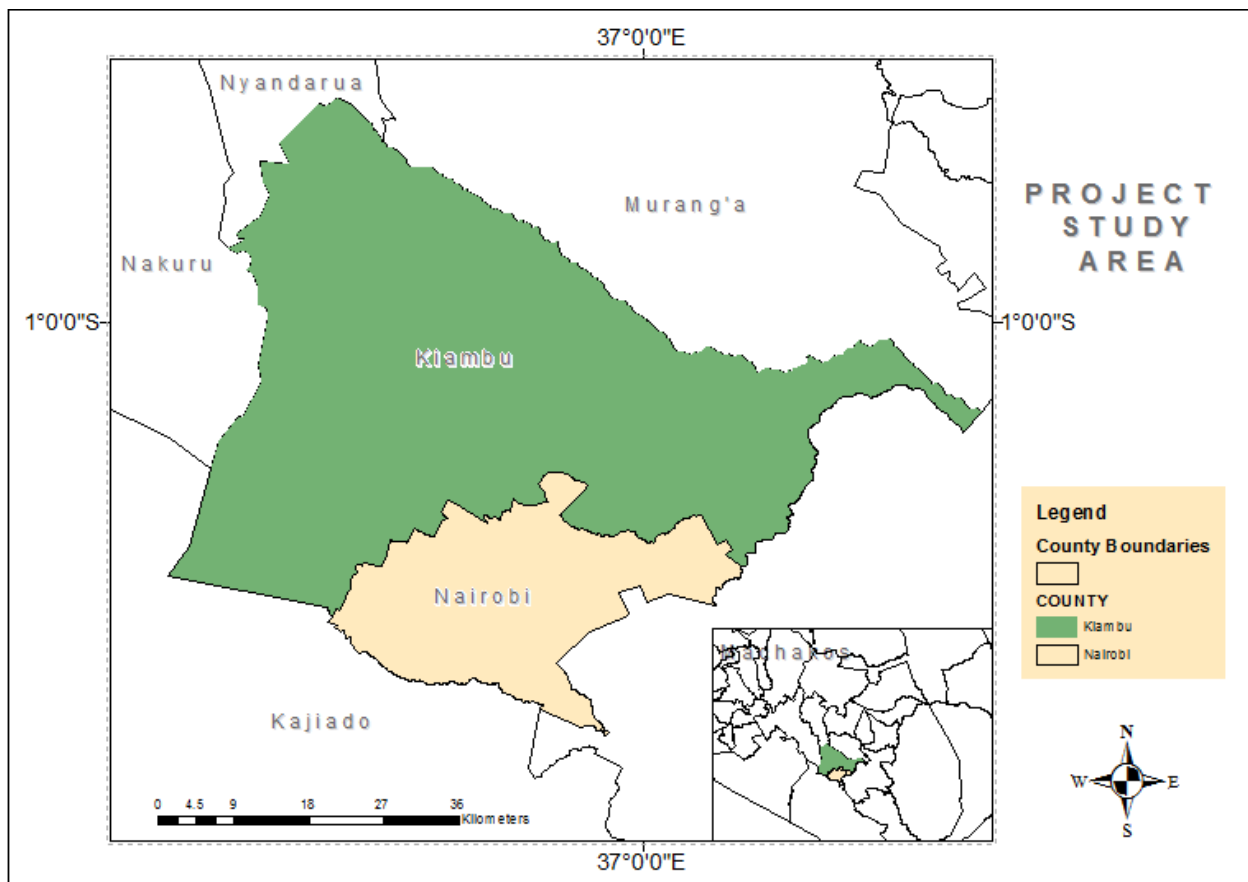


Figure 1: The Project Study Area

1.7 Organization of the Report

The project report is organized in five chapters. The first chapter provides background information on the role of location in making real estate purchase or rental choices. It also briefly introduces the use of GIS, and more specifically makes a case for how Web GIS may be instrumental in the creation of applications that bridge the worlds of real estate management and GIS. Chapter Two contains literature review that dwells on the emergence of online real estate search applications, the emerging web mapping technologies that are currently being used within these applications and their role in marketing rental apartments for Kenya's expanding higher middle class which generally shops for housing that suits different household needs (Cytonn Investments, 2016).

Chapter Three contains literature on the materials and methodology used including: The Study Area, Data Collection exercises, Database Design, Implementation and Deployment of both the Real Estate and Web Real Estate Search applications that resulted from this project. Chapter Four looks at the results attained from the use of both applications and gives screenshots of the applications' output and examines how the application process works. Chapter Five is the last chapter of the project report and brings it to a conclusion while providing recommendations on how this project can be followed up on.

CHAPTER 2: LITERATURE REVIEW

2.1 The Housing Situation in Kenya's Urban Areas

Housing is enshrined as a basic human right in the Kenya Constitution and therefore the realization of the right to housing for every citizen must be pursued in order to realize Kenya's 2020 vision for housing and urbanisation for 'an adequately and decently housed nation in a sustainable environment'. Apart from being a right, housing contributes greatly to the socio-economic development of the country due to its backward and forward linkages (KNBS, 2014). Housing provides the basic human necessity of shelter and has important implications on household functionality, productivity and social harmony (Musyoka, 2012). The type of housing one is exposed influences that individual's outcome in health, education, socio-political participation, and labour participation, among other aspects of life (WHO, 1989). For this reason, the choice of house or home, for many households, is typically one of the most carefully made decisions and especially so in urban areas. Kenya is currently experiencing rapid population growth, even with fertility rates in Kenya being on the decline (KNBS, 2015). Urban areas are enduring the most of this population explosion, mainly due to rural urban migration and natural population growth, leading to an upsurge in demand for housing in the urban areas.

The urban population in Kenya is projected to grow by over 50 per cent by 2033 at the urbanization rate of 4.2 per cent (KNBS, 2010). Urbanization is normally associated with significant economic and social benefits, since urban centres tend to be centres of growth in economic activities and functions. The City of Nairobi, for instance, contributes 60 per cent of Kenya's Gross Domestic Product (GDP) with only 8 per cent of the country's population (Dafe, 2009). Similarly, Nairobi and Mombasa may have only 10 per cent of the national population, but contribute a whopping 40 per cent of wage earnings in the country (World Bank, 2011). Even so, urbanization has its challenges, chief among them the provision of basic infrastructure services to support the urban socio-economic fabric. Supply of decent urban housing, especially for low-income households, is severely lacking in Kenya's major urban areas. It is estimated that Kenyan urban areas experience a demand of 250,000 housing units per annum and a provision of 50,000 per annum – leaving a deficit of 200,000 units per annum (MLPP, 2016).

Thus, Kenya's population growth rate and demographic patterns, as well as the rate of urbanization provide necessary stimulation for household demand for urban housing (Musyoka, 2012). Even though the government is committed to ensuring provision of adequate shelter for all Kenyans as stipulated in various policy documents, it is simply unable to meet the demand and thus concentrates its activities to the small-scale provision of housing for civil servants as well as slum upgrading. This is in keeping with the national housing policy that champions for a 'market-enabling' approach of infrastructure provision and land use planning by leaving the provision of housing to the private sector. Though it is yet to bridge the gap in demand, the private sector has taken up the challenge with great fervour, resulting in commercial real estate business recording the highest rates of growth at 14.1%, compared to 10.1% in financial services and 7.1% growth in agriculture. Real Estate has also constantly outperformed other asset classes in terms of returns on investment, regularly returning 25% per annum, compared to an average of 10% per annum in the traditional asset classes (Cytonn Investments, 2016).

Continued growth in the sector is expected to grow on the back of improved macroeconomic conditions, sustainable high returns, and a changing operational landscape as developers strive to satisfy the high housing deficit. This is further assisted by an increase in the number of middle class population with sufficient disposable income and an increased rate of urbanisation at 4.4%. The types of housing units built by housing developers tell an interesting story about which units developers are most excited about. The graph below captures the number of housing units completed in 2010 and 2011 as recorded by (KNBS, 2014).



Source: (KNBS, 2010)

Figure 2: Percentage of housing units completed for sale by type

Rental flats can be seen to take the biggest share of housing units completed for sale and rent in both years at 82.2, 75.7 and 30.8 and 77.1 per cent respectively. Building rental flats is big business and this shows in the willingness of developers to put up rental flats. Even so, high financing costs negatively affect the supply of houses within urban counties such as Nairobi County, especially due to lack of availability of development land which results in relatively high prices. This has forced housing developers to search for land elsewhere.

Due to rapidly improving infrastructure infrastructural developments such as improved roads, the SGR, electrification, and ICT, satellite towns are now opening up for housing development. New developments are now being seen in areas such as Athi River, Mlolongo and Ruaka, targeting the new middle class and promising all types of amenities. In the context of rental apartments, housing can be viewed as a consumable service. Landlords provide shelter as a service to willing households, who base their decision to pay for a set of housing services on social and demographic needs (Piyush Tiwari, 1997). With 80 per cent of Kenya’s urban dwellers being

tenants and 44.7 per cent of monthly household income being spent on housing related costs including rent and utilities (KNBS, 2015), the rental retail market is poised to be one of the more profitable sectors of service industry in the country.

2.2 Cloud Computing and Web GIS

Cloud Computing is described by NIST (National Institute of Standards and Technology) – a body which promotes the U.S. economy and public welfare by providing technical leadership for the nation’s measurement and standards infrastructure (NIST, 2011) – as follows:

“Cloud computing is a model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (for example, networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction.”

Cloud computing provides technological capabilities — that would otherwise be only available off-premise — on demand as a service via the Internet. Consumers of these services need not own assets in the cloud model but pay for them on a per-use basis. In essence, they rent the physical infrastructure and applications within a shared architecture. (Kouyoumjian, 2010) Cloud offerings range from data storage to end-user Web applications to other focused computing services. Cloud computing differs from traditional computing by providing a scalable and elastic architecture. Cloud computing supports the ability to dynamically scale up and quickly scale down, offering consumers highly reliable cloud services, quick response times, and the flexibility to handle extreme demand fluctuations. Cloud computing also supports multi-tenancy, meaning that a system offered on the cloud can be pooled as a resource that is shared by many organizations or individuals. Cloud vendors are able to use virtualization technology to convert one server into many virtual machines, thus maximizing hardware capacity and allowing customers to leverage economies of scale.

Three base service models are available using cloud services:

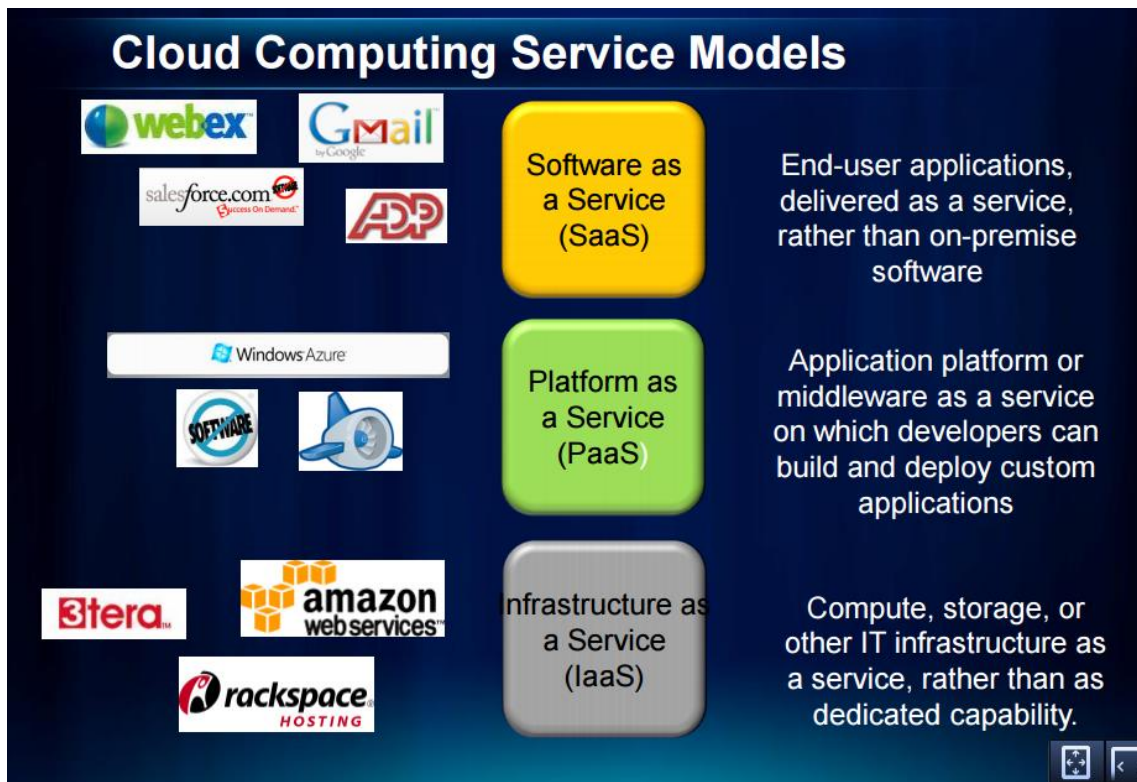
- i) **Software as a Service (SaaS)** - End-user applications delivered as a service, rather than as traditional, on-premises software. The most commonly referenced example of SaaS is

Salesforce.com, which provides a customer relationship management (CRM) system accessible via the Internet (Kouyoumjian, 2010).

- ii) **Platform as a Service (PaaS)** – An application platform on which developers can build and deploy custom applications. Solutions provided in this tier range from APIs and tools to database and business process management systems, to security integration, allowing developers to build applications and run them on the infrastructure that the cloud vendor owns and maintains. Microsoft's Windows Azure platform services best exemplify PaaS solutions (Kouyoumjian, 2010).
- iii) **Infrastructure as a Service (IaaS)** - Encompasses the hardware and technology for computing power, storage, operating systems, or other infrastructure, delivered as off-premises, on-demand services rather than as dedicated, on-site resources such as the Amazon Elastic Compute Cloud (Amazon EC2) or Amazon Simple Storage Service (Amazon S3) (Kouyoumjian, 2010).

These service models have been seen to be the preferred choice for businesses in lands where the electrical grid is unreliable and/or which lack telecommunication infrastructure. Businesses such as Cheki (Lazauskas, 2013) in Kenya and Nigeria boast huge subscriber bases and are powered by cloud servers – implementing the IaaS model. It is also quite telling that a majority of Cheki's users access the site on smartphones – indicating that cloud computing and mobile phone usage are almost synonymous.

The future of software is tightly coupled to the capabilities that will be offered by cloud computing and software as a service. This is especially so with data intensive software and applications such as those which support Geographical Information Systems (GIS). The emergence of cloud computing and the service based models has brought new possibilities in this realm. Service oriented architectures in GIS now make it possible to hide the technical details of datasets by exposing them through standard web browsers, making them available to wider audiences at a fraction of the cost. Cloud GIS services can also be deployed in environments that can be made to scale up or down as required, with the service provider only being charged for actual usage. This allows cloud clients to be confident they are consuming services from systems that are highly reliable and flexible enough to handle large traffic fluctuations (Blower, 2010).



Source: (Kouyoumjian, 2010)

Figure 3: Cloud Computing Service Models

The following key benefits of cloud based GIS are steadily driving its growth in the global market:

- i) Cloud based GIS platforms allow organizations to deliver new capabilities rapidly and in a more cost-effective manner.
- ii) Cloud based platforms (examples include GISCloud, GeoMedia from Hexagon and ArcGIS Online) generally employ pay-as-you-go pricing models which allow for free trials for potential GIS service clients. Since assets are rented, the duty of maintaining the physical data centers is left to the cloud vendor, alleviating the customer's responsibility for software and hardware maintenance, ongoing operation, and support.
- iii) Cloud services are regularly updated, if only for the vendors to keep up with the competition and provide the best services. This reinvestment in the IT architecture and service benefits clients by ensuring that consumers are consistently provided with a robust, updated solution. Cloud clients can be confident they are consuming state-of-the-art systems that are highly reliable and flexible enough to handle large traffic

fluctuations. An example of this would be Esri Inc.'s cloud based service, ArcGIS Online – which is updated close to 6 times a year ensuring that clients are on the forefront of technology

- iv) Cloud services are available 24/7, accessible from any browser on any device regardless of time zone. This provides faster and easier access for workers to do their jobs, though it necessitates the use of the Internet always.

Cloud based GIS Computing has given birth to a transformational architecture - termed Web GIS (Fu and Sun, 2011) – which opens existing GIS tools and existing workflows, integrates them, and simplifies everything. It allows users to take their traditional server and desktop technologies, and integrate them into a system which connects users through devices and applications that feed into one portal.

As a pattern for delivering GIS capabilities, the key concept behind Web GIS is that all members of an organization can easily access and use geographic information within a collaborative environment. This ensures that staff in the organization with little or no GIS knowledge can also benefit from and contribute to the organization's GIS platform. Web GIS leverages existing GIS investments by providing a platform for integrating GIS with other business systems and promotes cross-organizational collaboration. Consequently, web GIS extends the reach of GIS to everyone in an organization, enabling better decision making.

At the center of the web GIS pattern is the generic concept of a *portal* that represents a gateway for accessing all spatial products in an organization. The portal helps organize, secure, and facilitate access to geographic information products. Client applications on desktops, web apps, tablets, and smartphones interact with the portal to search, discover, and access maps and other spatial content. In the back-office infrastructure, two components power the portal: cloud based GIS servers and ready-to-use content (Law, 2014). It is within such a framework that the web GIS environment supports the entire organization or the entire enterprise. It makes mapping in GIS available to everyone.



Source: (Law, 2014)

Figure 4: An implementation of Web GIS



Source: (Law, 2014)

Figure 5: Web GIS supporting the Enterprise

With such a framework in place, it is then possible to pinpoint the role Cloud based GIS can play in the implementation of a Real Estate Management System with spatial capabilities.

2.3 Web 2.0 and Web Mapping Technologies

“Web 2.0”, a term first coined in the late nineties (DiNucci, 1999), refers to cumulative changes in the ways software developers and end users use the Web.

In his “What is Web 2.0” article, Tim O’Reilly pointed out that the Web was beginning to become characterized by exciting new applications and Web sites which exhibited specific features (O’Reilly, 2005). Among these features were the following:

- i **Content generated from external sources:** Web 1.0, the original Web, was characterized by read-only content and a top-down information flow. Web 2.0 is a read-write Web that features an abundance of user-generated content (UGC) and a reverse (bottom-up) information flow. These Web sites exhibit dynamic content because of the products, comments, and knowledge offered by other users. Consequently, this draws users to the sites
- ii **The Web as a platform:** The Web is a platform for computing and software development. Among these developments are Software as a Service (SaaS), where software capabilities are delivered as Web services or Web applications, and cloud computing, where dynamically scalable and often virtualized resources are provided as a service over the Web.
- iii **Interactive and Responsive programming models:** Web 2.0 systems support lightweight and easy programming models such as AJAX (Asynchronous JavaScript and XML) which allow minimal data exchange with servers and do not require the page to be completely redrawn each time a user changes their request. This provides for responsive Web applications, which allows a single Web page to asynchronously send and receive responses to multiple XML/JSON (JavaScript Object Notation) requests and empower users to create new functionality by mashing up, or assembling, various Web sources in creative ways.
- iv **Data is the next “inside intel”:** Every significant Internet application is backed by a specialized database. Data is important, especially when there is significant cost in

creating the data. Companies can license unique data or aggregate data, for example, by facilitating user participation. Once the amount of data reaches critical mass, it can be turned into a system service (Fu & Sun, 2011).

- v **Software that reaches beyond a single device:** Web applications can be accessed by an increasing variety of devices, including Web browsers, desktop clients, and smart phones, stemming from advances in wireless communications.
- vi **Rich usability:** Popular Web 2.0 applications have a graphic user interface that is easy to use, minimalistic designed and simple to navigate.

These Web 2.0 principles now form the foundation of today's applications. The geospatial industry, including both consumer Web mapping companies and professional GIS companies, seek to follow these key tenets to provide rich user experiences, encouraging user participation, and in the development of lightweight APIs so users can create their own applications (Maguire, 2008). Commercial Web mapping applications (also christened GeoWeb applications) such as Google Maps, ArcGIS Online, Microsoft Bing Maps, Mango Maps and CartoDB are good examples of Web 2.0. The user interfaces are intuitive, dynamic, responsive, and rich. These sites provide maps for mobile devices and provide services based on your location, allowing you to find facilities nearby. GeoWeb 2.0 makes GIS not only more accessible to people in their offices, homes, and on the go, but also more flexible through Web-based APIs. Developers can use these APIs (application programming interfaces) to facilitate seamless integration with other information systems.

2.4 Kenya and the Online Retail Market

According to the Communications Authority of Kenya (CAK), Kenya has an estimated total of 23.2 million internet users currently, with 14.7 million of them using the internet on their mobile devices (CAK, 2014). The continued expansion of 3G services and the increased popularity of online transactions have expanded the data/internet market and which has continued to receive a major boost from the mobile data/internet services. With the continuous expansion of internet connectivity more users are expected to be registered thus propelling the growth prospects of this sub-sector even further (CAK, 2014). As the growth in Internet usage in the country persists, so does the unique opportunities for growth in the retail sector. Over the past five years, the average

value of consumer spending has risen by as much as 67%, making Kenya the continent's fastest-growing retail market (Oxford Business Group, 2016). The rise in formal retail activity is seen clearly by the expansion of dedicated property in major urban areas, centred around Nairobi. The year 2015 saw a near tripling of Nairobi's modern retail space, with close to 170,000 square metres of new leasable area coming on-line. This rise in capital investment – combined with encouraging fundamentals, such as an urban population that the UN expects will rise by 2.8m over the next five years to reach 14.7m by 2020 – has led to Kenya being singled out as a hot real estate prospect in several recent publications (Oxford Business Group, 2016).

In the developed world, online real estate searches are a popular and practical means to shop for properties for rent, purchase or lease. In February 2014, 316 million visitors in the U.S. went to an online real estate website from their desktop computer. Those numbers do not necessarily indicate a homebuyer or a unique visitor - they may have been realtors, other home sellers, or real estate website developers - but they do suggest a viable business model. Online research was not confined to the desktop computer; the two largest websites, Zillow.com and Trulia.com, estimated that mobile device users accounted for almost half their website traffic (Hagey, 2014).

Kenyans, however, are used to locating and assessing properties in the old-fashioned way; phone calls and personal visits. This is slowly and definitely changing with the aforementioned penetration of Internet usage and the success of online retail platforms such as OLX and Jumia – both of which rank within the top 25 sites visited by Kenyans in the year 2016 (Alexa.com, 2017). Both sites offer online real estate search, allowing prospective residential property buyers to sort listed properties interactively based on desired elements. These elements typically address features wanted within a home, such as the dwelling's size, number of bedrooms and bathrooms, whether a garage or swimming pool is included, and other furnishings.



A web-based approach to offering real estate has already begun taking root in Kenya with established real estate companies such as Knight Frank (**Figure 6Error! Reference source not found.**), Lloyd Masika and Tysons Ltd creating websites which display real estate offerings from multiple agencies or sellers. The site with the most web traffic in the Kenyan market is online retail giant Jumia, which is ranked among the top 20 most

visited sites in Kenya (Alexa.com, 2017). The rest of the online web traffic as concerns real estate is taken up by smaller players such as *KejaHunt* (Keja Hunt, 2016), *MySpace Properties Ltd* (MySpace Properties Kenya, 2017), *Ryden International* (Ryden International, 2017), *Azizi Realtors* and *HomeScope Properties Limited*. Of the sites mentioned, only 3 of the sites listed provide interactive maps that show available properties that the website visitor may filter based on their specific requests.

Figure 7 shows a filter on the website *house.jumia.co.ke*. In this example, the user selects a rental apartment in Ruaka, priced between KShs. 10,000 and KShs. 35,000. From those results, the visitor can click on any interesting properties for more information, photographs, and listing agent contact information, as seen in Figure 8. The *Jumia* web experience is one of the more unique experiences when shopping for Kenyan real estate online. The embedded web map is a feature one does not find on most Kenyan real estate sites. Some of the sites actually replicate the old-school method of house hunting but add a touch of convenience to it. *KejaHunt* is an example of such a site. Figure 9 basically explains how *KejaHunt* operates – with surprisingly high levels of success despite the rather manual approach.


This type of approach basically substitutes a house hunter with an agent, armed with the hunter's tastes in mind, and charges a convenience fee for the service. House details are provided by the agent – who is presumed to have made an honest search for the required apartment and viewing schedules are handed to the client. Other sites tend to offer a more textbook approach to online real estate search. Sites such as *ryden.co.ke* allow one to search for available properties by filtering through a list of standard features on a web page and having the available properties displayed as a list on the page. This approach relies on a text description of the location of the property to convey to the client how to get to it. The site acts as an online brochure through which clients can basically see listings of properties and then organize to view these properties to get an idea of the environment around them.

Properties People Services Research Blog



Buy  View any properties that contain the word(s) "Nairobi, Kenya" 

Distance This area only ▾ Division Residential ▾

\$0 Price maximum

 More filters

Sort Price: high to low ▾ Currency USD United States Dollars ▾

 Grid View  List View

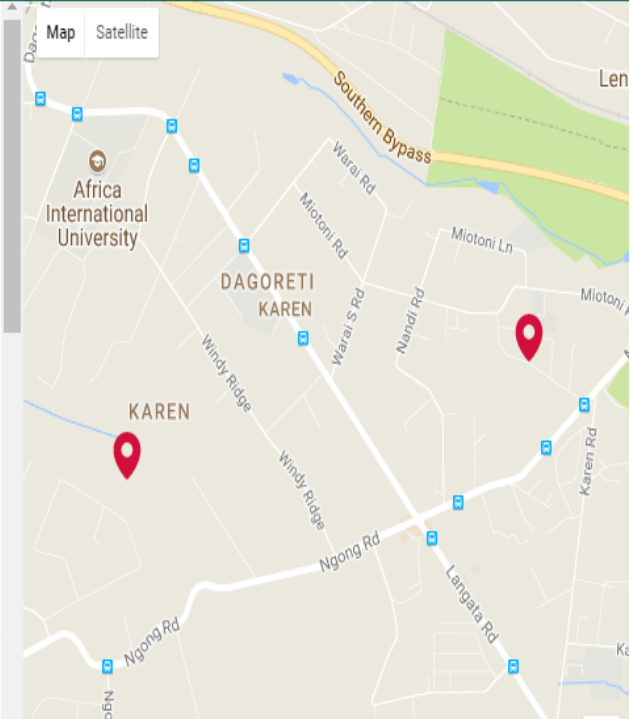




Figure 6: Knight Frank Real Estate Search


Login / Register
+ OFFER PROPERTY

More filters
REFRESH
SAVE SEARCH

[Home](#) > [Region: Nairobi](#) > [City: Nairobi](#) > [Area: Ruaka](#)


20 Results found for Apartments For Rent in Ruaka - Rent Flats | Jumia House



Secure Executive Bedsitters Touching ...


Ruaka, Ruaka, Nairobi, Nairobi
KSh 11,000
 1 Bedrooms
 1 Baths
 1 Rooms (total)


[MORE DETAILS](#)
📞
✉️
★




Modern 1 Bedroom Apartment in Ruaka

Ruaka, Ruaka, Nairobi, Nairobi
KSh 25,000
 1 Bedrooms
 1 Baths
 5 Rooms (total)





VAAL
 REAL ESTATE
LIVE & INVEST
 IN KILIMANI
 0725 111 444
 0790 554 433
 ROSEWOOD



JUMIA HOUSE
 INVITATION
[Contact Us](#)

📄 Journal
📧 Feedback

Figure 7: Searching for a rental house on Jumia

PROPERTY FEATURES

Indoor features:

- ✓ Ensuite
- ✓ Walled

Eco features:

- ✓ Water tank
- ✓ Borehole

Outdoor features:

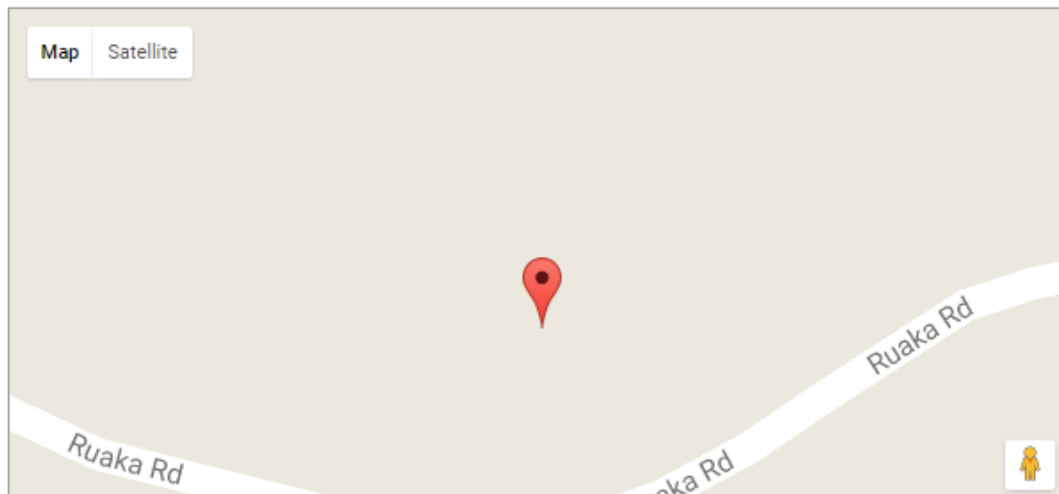
- ✓ Open car spaces
- ✓ Secure parking
- ✓ Fully fenced

Other features:

- ✓ Pets Allowed

LOCATION

FULL SCREEN MAP



Miamu Properties (12288)

📍 Joe's Complex, 2nd Floor, Suite No 7, Ruaka



✓ TRUSTED SELLER



Your Agent: Miamu Properties

📞 SHOW PHONE NUMBER

💬 REQUEST CALL-BACK

ASK ABOUT PROPERTY

First Name *

Last Name *

🇰🇪 Phone *

Email


Hello, I found your listing on JUMIA HOUSE. Please send me more information about STYLISH NEW TWO BEDROOM APARTMENT RUAKA. Thank


✉ CONTACT AGENT


Yes, I wish to receive occasional emails about


Figure 8: Property Details on Jumia Search Portal


How it works


1. You describe the house you'd like to us 


2. Make payment for the same 

3. Our field officers search for the house 



4. And send you various options via whatsapp 

5. You schedule a viewing and pay for the house 

6. Our moving team helps you move in! 

[Proceed](#)

Figure 9: House hunting with KejaHunt

Search by Location

- > Nairobi
- > Coast
- > Upcountry
- > Foreign

Search by Category

- Houses
- Apartments
- Residential Plots
- Offices
- Industrial
- Farms
- Ranches
- Beach
- Business

Nairobi, Karen / Langata: Properties for Sale / Let

Page: 1 of 2



5 BEDROOM HOUSE ON 0.5 ACRES, on Muiri Gardens near Galleria in Karen.

Karen / Langata, Nairobi

Price: 63,000,000

A charming and homely, 5 bedroom (4 en-suite) family home, of great character sitting on half an acre of landscaped and mature gardens, in a gated area. Located on Muiri Gardens 700m from Galleria Shopping Centre, off Langata Road. Home of great character with generous use of hard wood finishes and with ample of storage space.

[View Details](#)



0.25-ACRE COMMERCIAL PLOT, off Kikuyu Road, in Dagoretti

Karen / Langata, Nairobi

Price: 12,000,000

0.25 - acre red soil plot, 200m off Kikuyu Road and 400m from Dagoretti - Karen Road, near Yellowstone Gardens. This is a developed area with demand for middle-income housing. The plot is ideal for residential for development

Figure 10: Textbook approach to Property Listing

None of the websites mentioned shows any local information, at least not in map form or in otherwise readily searchable formats. Instead, only features pertaining to the house itself are listed as well as the price.

While the average real estate website can provide quick listings of properties that match the ideal features that a client has in mind, it lacks knowledgeable data about the surrounding area. Currently, most real estate websites pay little attention to important elements in the immediate vicinity of a property or building. Is the crime rate low? Are there any schools nearby? How far away from major roads or entertainment spots is desired? Are there retail spots or health facilities or playgrounds nearby? These additional elements must be considered at some point when looking for a home, and ideally, they should be considered early in the home search process.

Making decisions based on geography is basic to human thinking. By understanding geography and people's relationship to location, we can make informed decisions about the way we live on our planet (Esri, 2007). Having this in mind, one can see why for many people finding the ideal location comes before finding the ideal features in a home. Length of the commute time, crime rates, proximity to cultural and retail options, and the location of desired schools are all vital factors in ensuring a comfortable life in the new home at the new location. While some websites are beginning to address this concern by including small overlays within a property's webpage, none overtly considers that the home buying process may not start with the selection of home features, but by determining the "best-fit" neighborhood in conjunction with the aforementioned features (Dowling, 2014).

Considering the fact that Nairobi residents have been found to spend 40 per cent of their income on rent (Business Daily, 2015), it would be prudent to include such factors in the search for a home. Kenyan consumers are accustomed to buying homes based on their physical characteristics instead of lifestyle and neighborhood preferences. While the number of bedrooms and the availability of water are important features, more and more people want their dwelling

places to truly reflect their needs, aspirations and social connections, and for the price they are paying for it, it should.

“Lifestyle search” is one of the newer and more innovative ideas in residential real estate that attempts to match the best properties with the right owners. Using neighborhood attributes, from demographics to the location of schools and other civic and social amenities, lifestyle search uses spatial analysis to match buyers’ desires to the best property (Thompson, 2011). Searching in this manner allows consumers to localize their home searches and it supplements the realtors’ knowledge with local information and the latest socio-demographic statistics. Different variables can be considered and outcomes weighted by how viable each is, in terms of meeting a person’s need.

A unique and intuitive web GIS application that includes the location aspect in online search for real estate would be a more informative way of marketing properties for realtors as well as a more efficient method of searching for prospective homes for online house hunters. Such an application should be easy to navigate, offer search functionality that takes advantage of data about a property’s surrounding area and be simple to maintain (Dowling, 2014).

CHAPTER 3: MATERIALS AND METHODS

3.1 Background

The programming effort in this project resulted in two applications:

i) A Private Real Estate Management Platform

This platform consists of a web application with a relational database management system (RDBMS) backend that allows a realtor to key in data about rental apartments that are up for sale. This platform is only available to the realtor and thus one requires log in credentials to access this bit of the platform. Using this platform, the realtor can enter details about the rental apartment as well as pin it on a map in order to retrieve its coordinates and store all this data in the RDBMS. The realtor is also able to input details about various interconnected aspects or attributes of the industry such as details concerning the agents who run the rental properties, the owners of these properties as well as the transactions that the properties are involved in. This web application basically simulates the operations of a typical Real Estate Management System. What separates this application from those currently in the market is that it is synchronized with a commercial online Web GIS Platform (ArcGIS Online) which hosts the geographic component of the data in the GIS platform. The GIS platform is then used to create the resulting public facing application. The Real Estate Management Platform in this application was labelled as an Apartment Management System.

ii) A Public Facing Web GIS application

The Web GIS application that was developed for this project is unique in online home real estate searches compared to current online websites. This Web GIS application offers the following information and functionality, most of which are not currently found in existing real estate websites:

- a) Integration of existing Real Estate property data from the Management Platform with related city and neighbourhood data for sections of Nairobi and its environs into an interactive mapping website.
- b) 2D and 3D (where applicable) views of buildings and properties

- c) Ability to search via proximity to facilities which are of interest to people searching for rental homes such as schools, restaurants, Automated Teller Machines (ATM) and malls
- d) Ability to include data on recent crime incidents as a layer to assist in the choice of optimal home search locations
- e) Zoom and search
- f) Directions to desired properties

These sets of functionalities set the public-facing application apart from what is currently on offer at common online rental retail sites which do not offer any details about the environs of a potential home. These functionalities also allow the public facing application to provide home hunters with a curated and detailed list of properties from the Real Estate Management platform, serving as a trustworthy directory of available homes for rent.

The study area was limited to a subset of Nairobi and Kiambu Counties to minimize the processing time and storage size of the various large datasets. The choice of study area was determined based on the following factors:

- i) Areas in which appropriate demographic datasets were available
- ii) Areas within which real estate is highly sought after
- iii) Areas within which realtors may have advertised property

3.2 Web Application Development

The research conducted for this project was based on how to display residential areas that satisfy a homebuyer's or plot seeker's desired neighbourhood features by creating a web GIS application that displays in a single webpage a detailed map of the study area flanked by side panels where users may toggle various layers on and off for a custom display as well as filter data based on features of the properties on offer. The research also attempted to simulate how a realtor would manage this web application from the back end and integrate with a standard Real Estate Management System. These map layers that can be toggled include basic neighborhood data such as schools, hospitals, parks, airports, major roads, and railroads.

This project was developed primarily using tools from Esri ArcGIS Developer Platform as well as Microsoft's Visual Studio 2015 Community Edition and SQL Server 2016. Layers and data were processed using Esri ArcMap 10.5 to import shapefiles, to convert data from various data formats to geodatabase and through Esri's ArcGIS Online platform to web service form. The programming languages that were used included the following:

- i) HTML 5 and JavaScript – to create the interface of the web application
- ii) Web AppBuilder for ArcGIS (Developer Edition)
- iii) Esri's ArcGIS API for JavaScript version 4.2 for the map viewer portion of the real estate web application
- iv) ASP.NET MVC and C# for the Real Estate Management application backend – to retrieve and update data on the Real Estate Relational Database

All data were projected to WGS 84 - an Earth-centered, Earth-fixed terrestrial reference system and geodetic datum. This is because WGS84 is based on a consistent set of constants and model parameters that describe the Earth's size, shape, and gravity and geomagnetic fields and is the reference system for the Global Positioning System (GPS). It also translates well on web maps used for consumer consumption which use the WGS 84 Web Mercator projection – a de facto standard for Web Mapping Applications. The final web GIS application was created using datasets published to ArcGIS.com by the author and added to a custom implementation of Esri's Web App Builder for ArcGIS (Developer Edition) which was modified with programming written in JavaScript v3.20 and its associated Dojo toolkit (Dojo, 2017). Notepad++ was used as the webpage editing program. The full process of creating the web application is discussed in section named **Creation of Public Facing Web Application**.

The flowchart in Figure 11 outlines the process that was followed to create the prototype applications. In regard to determining the most appropriate software to use in coding this project, initial research suggested that the most cost-effective way to create these applications would be to use Open Source tools to achieve the desired ends. Some of the options available for the creation of the Web GIS application included the use of Google Maps coded with Hypertext Markup Language 5 (HTML5) and JavaScript for the client facing end; Python and MySQL or Google Fusion Tables for the backend for server-side communication. However, it was later

found that Esri's ArcGIS templates provide pre-coded web GIS applications that can be customized more easily using JavaScript, Dojo and HTML. Furthermore, Esri provides a free developer platform where web designers and programmers can create and host applications and the web services used as content in mapping applications. This platform greatly reduced the time needed to learn programming languages in order to create the Web GIS application. The end product was ultimately created through Web AppBuilder for ArcGIS - an intuitive application that allows users to easily build fully featured HTML web apps and whose tools provide an extensible framework for developers to create custom widgets and themes. This allowed for more concentration to be placed on the application workflow rather than on gaining detailed programming skills required to program the web GIS application from scratch.

3.2.1 Determination of Factors Considered in choosing housing

Although studies are yet to prove the exact reasons that Kenyan urbanites choose the housing that they live in, one can with a high degree of certainty infer that security and level of income are the two most important factors to consider in choosing a rental (Preston, 2013). From discussions with random Kenyan urbanites, it can be concluded that the following are factors that affect choice of rental housing:

- i) Commute Times – This is especially so for people who work in Urban Centres but live in the suburbs on the outskirts of the said area. No one wants a long commute time to work and everyone wants an area that has multiple means of transport available.
- ii) Lifestyle – This is especially so for the upper middle class. People would like to be seen to live in a respectable area to improve their standing socially.
- iii) Local Amenities – These include restaurants, shopping and family attractions. The need for such has driven the great demand for Gated Self-Contained Communities in the Kenyan Real Estate Market recently.
- iv) Health – For many Kenyans, health is a major concern and proximity to a health institution is an important factor to consider when searching for a home.
- v) Crime – Security of a potential home is important when trying to locate a place where one can raise a family. For this reason – proximity to a Police Station or Police Post is a boon for a rental apartment.

vi) Schools – For individuals with children, this is a major factor. It isn't just about the schools that are closest to the residence, the performance of the schools also matters.

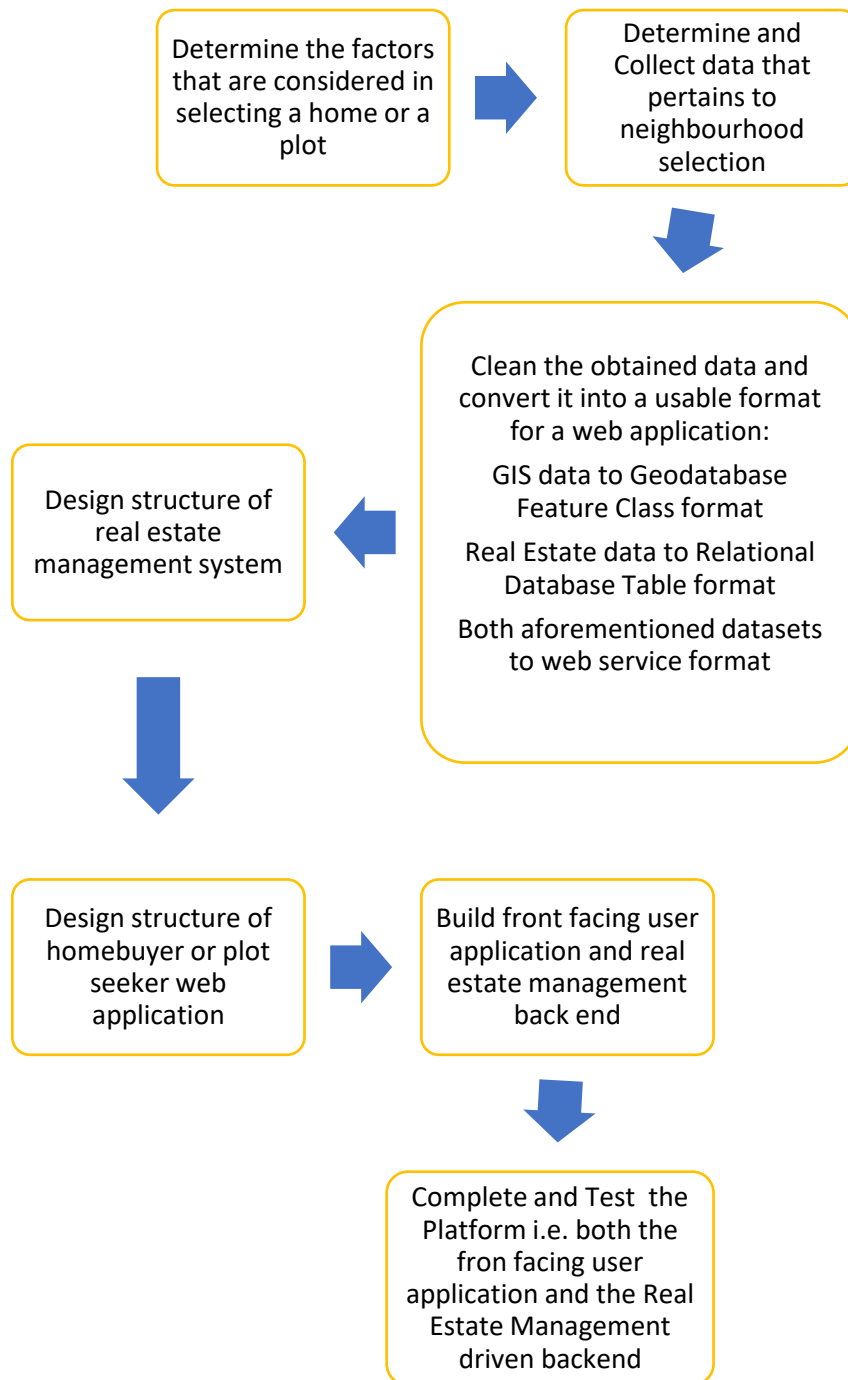


Figure 11: Flowchart showing the Project Process

3.3 Data Collection

This process involved the identification of data required for database design and creation as well as the development of the linkage between a working GIS System and a simulation of the Real Estate Management System. The following table details the data sources for Nairobi and Kiambu Counties that were collated to cater for the Web GIS Application:

Table 1: Project Data Sources

Layer	Source	Format	Collection Date
Wards	Unofficial (sourced from ArcGIS Online)	Shapefile	2013
Constituencies	Unofficial (sourced from ArcGIS Online)	Shapefile	2013
County Boundaries	Unofficial (sourced from ArcGIS Online)	Shapefile	2013
Crime	Media, Non-Governmental Organizations	Shapefile	2016
Primary Schools	Kenya Open Data Site	Shapefile	2009
Secondary Schools	Kenya Open Data Site	Shapefile	2009
Roads	Kenya Roads Board	Shapefile	2013
Railroads	Esri Eastern Africa	Shapefile	2010
Health Facilities	Kenya Open Data Site	Shapefile	2010
Financial Facilities	Esri Eastern Africa	Shapefile	2015
Parks and Recreation	Esri Eastern Africa	Shapefile	2015
Restaurants	Esri Eastern Africa	Shapefile	2015
Parking	Esri Eastern Africa	Shapefile	2015
Transportation hubs	Esri Eastern Africa	Shapefile	2015
Shopping hubs	Esri Eastern Africa	Shapefile	2015
Entertainment Spots	Esri Eastern Africa	Shapefile	2015

a) Sourcing of Publicly Available Basemap Layers

Error! Reference source not found. shows publicly available basemaps and reference layers delivered as online tiled web mapping services which were identified for use as contextual Basemap layers.

Table 2: Web Mapping Services Used

Web Map Services	Rest Endpoints
Esri World Imagery	http://services.arcgisonline.com/ArcGIS/rest/services/World_Imagery/MapServer
Esri World Street Map	http://services.arcgisonline.com/ArcGIS/rest/services/World_Street_Map/MapServer
Esri World Topographic	http://services.arcgisonline.com/ArcGIS/rest/services/World_Topo_Map/MapServer
Esri Ocean Basemap	http://services.arcgisonline.com/ArcGIS/rest/services/Ocean_Basemap/MapServer
Esri World Light Gray Base	http://services.arcgisonline.com/ArcGIS/rest/services/Canvas/World_Light_Gray_Base/MapServer
OpenStreetMap	http://trac.osgeo.org/mapserver/wiki/RenderingOsmData
Google Maps	https://maps.googleapis.com/maps/api/staticmap?parameters

b) Sourcing of cloud based GeoAnalytics services

Error! Reference source not found. shows publicly available geo-analysis capabilities delivered as online cloud based services. Intended to simplify the workflows of developers and GIS professionals, these services operate under a credit-based usage model that offers a low barrier to entry and allows users to pay only for what is used.

c) Sourcing of Apartment data

Data on apartments was sourced by going through current online real estate search portals and manually keying them into the Real Estate Management Database.

Table 3: GeoAnalytics Services Employed

Web Service	REST Endpoints	Purpose
ArcGIS Online Geometry Service	http://tasks.arcgisonline.com/ArcGIS/rest/services/Geometry/GeometryServer	Contains utility methods which provide access to sophisticated and frequently used geometric operations.
World Route service	http://route.arcgis.com/arcgis/rest/services/World/Route/NAserver	Used to find the best way to get from one location to another or to visit several locations
Closest Facility service	http://route.arcgis.com/arcgis/rest/services/World/ClosestFacility/NAserver/ClosestFacility_World/solveClosestFacility?parameters	Used to find closest facilities based on a given distance
Geo-Enrichment Service	http://geoenrich.arcgis.com/arcgis/rest/services/World/geoenrichmentserver/GeoEnrichment/?f=pjson	Provides the ability to get information about the people, places, and businesses in a specific area or within a certain distance or drive time from a location

3.4 GIS Data Clean up and Publishing

The GIS Shapefiles that were sourced were cleaned up in order to create feature classes for publishing on Esri’s ArcGIS Online Platform. The process of publishing is detailed in Appendix A. The following are the feature classes that were cleaned up, and the definitive attributes that they presented:

Table 4: Feature Services created for the Public Facing application

Feature Service	Feature Service Attributes
Crime Data	Year, Month, Region, County, SubCounty, Town, PreciseLocation, IncidentType
Transport Layers (Group Layer)	Sub-layers Railroads – RailName Major Highways – HighwayName, FUNC_CLASS, FerryType Secondary Highways – HighWayName Streets – Street_NM
Primary Schools in Nairobi and Kiambu	Name_of_School, Level_of_Education
Secondary Schools in Nairobi and Kiambu	Name_of_School, Level_of_Education
Health Facility data	F_Name, Agency, Sublocation
Nairobi and Kiambu boundaries	Sub-layers Nairobi and Kiambu Wards Nairobi and Kiambu Constituencies County Boundaries
Desired Facilities (Group Layer)	Sub-layers Parks and Recreation Restaurants Parking Transportation Hubs Automobile Maintenance Shopping Entertainment Financial Institutions

3.5 Creating the Real Estate Management System

The Real Estate Management System was built to simulate a plain RDBMS (Relational Database Management System) driven web interface. This system is meant to assist a Real Estate Management team to add and update details of rental apartments into both the GIS platform and the RDBMS platform in one go. In this way, users of the Real Estate Management System, will be able to work with both GIS and RDBMS platforms without necessarily having to be GIS proficient or database proficient. The linkage between the two systems happens by way of REST Web APIs provided by the GIS Platform. To get started, the Real Estate Management database on the RDBMS had to be designed.

a) Real Estate Management System Database Design

Database design is the process of producing a detailed data model of a database and simulating how it will be represented. The Real Estate database forms the foundation of all activities that will be performed concerning rental apartments such as the adding of units into the system, updating of unit details as well as recording transactions that involve rental units. By not going through the database design process, one risks having a poorly constructed database that does not meet the user's requirements resulting in duplicate, missing or redundant data.

The Real Estate/Rental Apartment database was designed to meet the feature functionality of the web based geo-visualization tool as well as perform basic CRUD functionality as pertains to adding and updating details on apartments being offered for rent by various agencies. The database design process was informed by the datasets that were intended for use (namely apartment details) and the information products that are needed by the end users. This ensures that the resulting database meets user requirements, has efficient data structures and retrieval mechanisms having considered the normalization principles, supports data sharing, multiuser access and editing as well as is easy to update and maintain. The design process employed a 3-step model which included External modelling, Conceptual modelling and finally Logical modelling.

i) External Modelling

The external model is meant to identify user needs and how data should be accessed. Its main aim is to help ensure that there is a common understanding of the organizational goals, technical expertise and business processes.

The potential users of the Rental Apartment/ Real Estate database are;

a) Day to day administrative users of the Real Estate Management Platform

These will be staff members of the organization running the portal who are tasked with the update of the database by either adding details about new apartments or running edits on existing ones. This exercise involves maintaining both spatial and non-spatial data.

b) Citizens

The general public are interested in viewing apartments for rent and making comparisons between the various offers based on preference.

ii) Conceptual Modelling

This is the synthesis of all the external models into an E-R diagram showing all entities involved, attributes and relationships as shown in Figure 12.

iii) Logical Modelling

Once the conceptual model was done, it was mapped onto the logical model DBMS. The following steps were carried out;

a) The database was created in the SQL Server Express 2016 relational database by running the commands detailed in Appendix B.

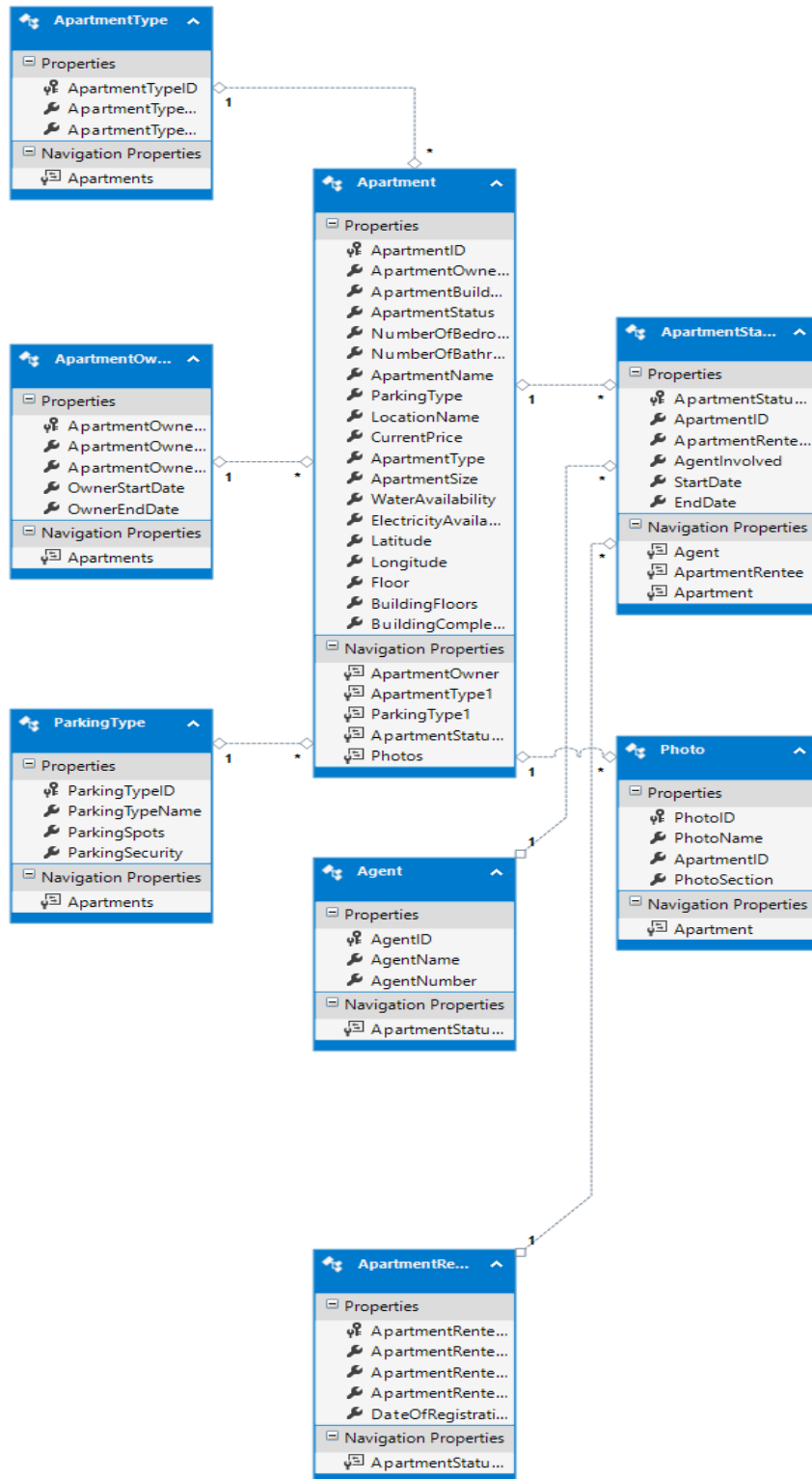


Figure 12: E-R Model Diagram of the Real Estate Management Application

- b) The DDL was created from the matching conceptual model. This created the skeleton or schema of the entities described in the conceptual model. The commands that were run to create this skeleton are shown in Appendix C. Appendix D describes what the tables created using the aforementioned SQL commands stand for (the entities that they represent), the data that their individual attributes possess and the format in which they are stored.

b) Real Estate Management Web Interface

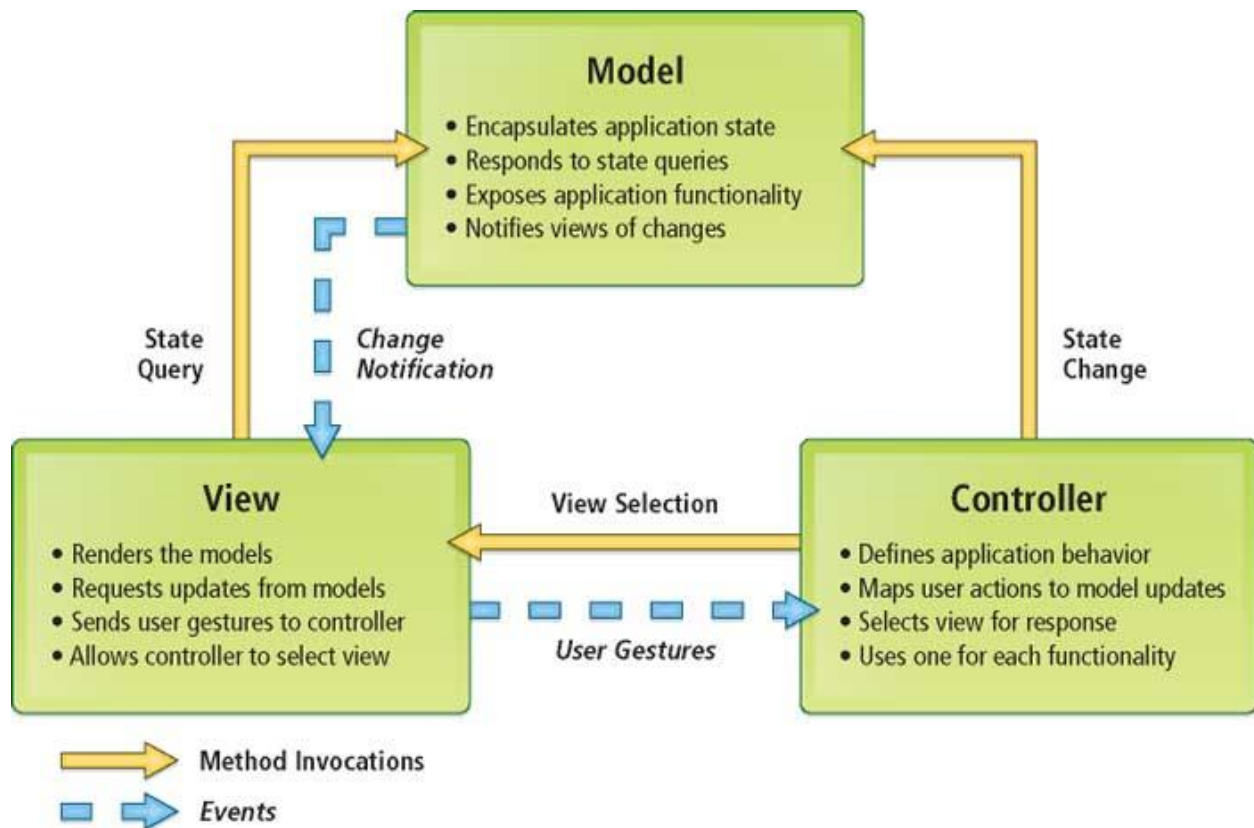
The Real Estate Management Web Interface was developed primarily using tools from Microsoft's Visual Studio 2015 Community Edition IDE (Integrated Development Environment) and SQL Server Express 2016 (from whence the database was created). The web interface application was created as an ASP.NET MVC 5 application using the Entity Framework 6 and Visual Studio 2015.

NET Framework (pronounced dot net) is a software framework developed by Microsoft that runs primarily on Microsoft Windows (Wikipedia, 2016).

ASP.NET is an open source web framework, built and maintained by Microsoft, for building modern web apps and services with .NET. ASP.NET creates websites based on HTML5, CSS, and JavaScript that are simple, fast, and can scale to millions of users (Microsoft, 2017).

MVC stands for model-view-controller. MVC is a pattern for developing applications that are well architected, testable and easy to maintain. MVC-based applications contain:

- i) **Models:** Classes that represent the data of the application and that use validation logic to enforce business rules for that data.
- ii) **Views:** Template files that your application uses to dynamically generate HTML responses.
- iii) **Controllers:** Classes that handle incoming browser requests, retrieve model data, and then specify view templates that return a response to the browser (Anderson, 2013).



Source: (DeMeritt, 2009)

Figure 13: Model View Controller (MVC) architecture

Controller classes are invoked in response to an incoming URL request. The controller class is the file that hosts the code written to retrieve data from a database, and ultimately decides what type of response is sent back to the browser. View templates are then called by the controller to generate and format an HTML response that viewers/users see on their browsers. This helps maintain a "separation of concerns" between the code that actually does the work and that which is only used for display and helps keep code clean, testable and more maintainable. This means that the view can change without having to change the code that retrieves data from the database.

Entity Framework (EF) is the Microsoft preferred method of data access for .NET applications. It allows developers to program against a conceptual model that reflects application logic rather than a relational model that reflects the database structure. This frees applications from hard-coded dependencies on a particular data source. Entity Framework can be used together with

ASP.NET MVC to run create, read, update, and delete operations against entities and relationships in the conceptual model to equivalent operations in the data source. Though working with EF typically involves creating a database from code, since the Real Estate Management database was already created, a Database First approach to coding was used meaning that model codes (classes, properties) were created from the database in the project and those classes became the link between the database and controller.

3.5.1 Web linkage Implementation

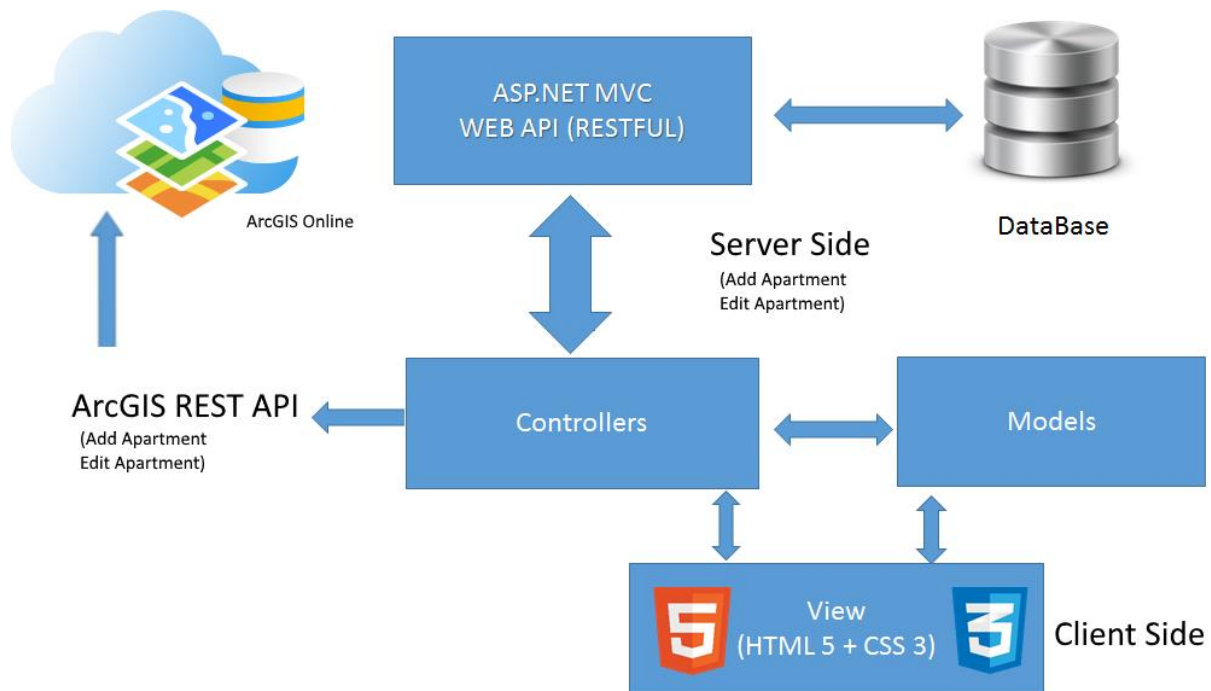


Figure 14: Linking the GIS Platform to the Real Estate Platform (Solution Architecture)

In order to create linkage between the Real Estate Management Web Interface and the ArcGIS Platform it is necessary to make use of the ArcGIS REST API. The ArcGIS REST API, short for Representational State Transfer, provides a simple, open Web interface to services hosted by ArcGIS Enterprise platforms – which include ArcGIS for Server and ArcGIS Online. Resources and operations exposed by the REST API are accessible through a hierarchy of Uniform Resource Locators (URLs) – otherwise referred to as endpoints - for each GIS service published with on the platform (Esri, 2013).

The REST API is stateless, meaning that each request made on the API must contain all the information necessary for the intended process. The ArcGIS REST API works with any scripting language that can make RESTful web service calls through HTTP GET and POST requests and parse the responses. This includes C#, the language through which ASP.NET Controllers are coded. Thus, it is possible to - while inserting a newly added record into the database - simultaneously add data to a GIS Web Service hosted on ArcGIS Online in the Controller method. Appendix E gives a snapshot of how this was achieved in this project.

Each service published to the ArcGIS Online Platform is published as a feature service. Feature services allow users to serve vector features over the Internet and provide symbology for use by the same features when they need to be displayed. Features are organized into layers through which queries and edits can be performed.

Feature Services support a number of operations including the following:

- i) Query – Executing this operation with the required parameters results in either a feature set for each layer in the query or a count of features for each layer.
- ii) Apply Edits - Executing this operation with the required parameters results in applied edits to features associated with multiple layers or tables in a single call (POST only)

The Apply Edits operation was utilized to make edits to apartments on the GIS system as shown in Appendix F.

3.5.2 Creation of Public Facing Web Application

The Public facing web application was created by creating a custom configuration of Esri's Web Application Builder for ArcGIS. The Web AppBuilder for ArcGIS is an intuitive application which allows one to easily build web apps. It includes powerful tools to configure fully featured HTML apps and provides extensible framework for developers to create custom widgets and themes. Key features of the Web AppBuilder for ArcGIS include:

- i) Ability to create HTML/JavaScript apps that work on devices of all shapes and sizes such as desktop browsers, tablets, and smartphones.
- ii) Tight integration with the Enterprise ArcGIS platforms such as ArcGIS Online

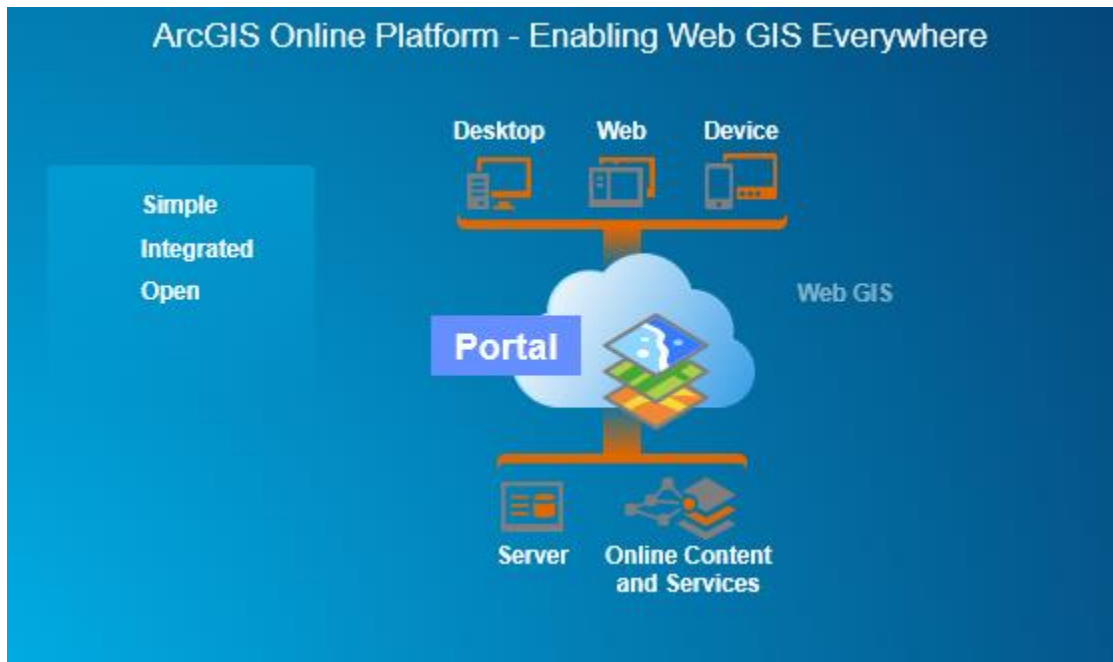
- iii) Ability to build the apps that one needs using ready-to-use widgets and with very little coding.
- iv) Creation of custom app templates.
- v) An extensible framework that allows developers to create widgets and themes.
- vi) Ability to help laymen create apps by configuration.
- vii) Ability to create applications that can be viewed in 3D

The Web AppBuilder for ArcGIS was configured to use services from ArcGIS Online as its query and analysis services.

a) The ArcGIS Online Platform

ArcGIS Online is an open geospatial data platform which allows geographic information to be delivered as simple, intelligent maps and information feeds. With ArcGIS Online users can upload and style geographic data, create web maps, interact with maps on any device and embed maps into websites or into web-based applications (Esri, 2011). ArcGIS Online is completely cloud-based with a collaborative content management system that lets organizations manage their geographic information in a secure and configurable environment. In this way, it is a Web GIS platform that one can use to deliver authoritative maps, geographic information layers, and analytics to wider audiences. Audiences can consume these datasets by using lightweight clients and custom applications on the web and on smart devices, as well as desktops.

ArcGIS Online provides information access using a portal application. The portal is a GIS information catalog and helps in the organization of access to information layers by making maps and geographic information items available to others. The Portal also organizes content into galleries as information items of various kinds. Through these galleries, one has access to personal content items (through the “My Content” page), to one’s organization’s items, and to items that are shared by the broad ArcGIS community. The ArcGIS platform provides diverse technology choices for creating geospatial apps. These options vary in effort depending on personal development experience and preference: It is through this portal that Web AppBuilder for ArcGIS accesses the GIS Service layer for apartments and is able to overlay the service in an application with other GIS data layers.



Source: (Esri Eastern Africa, 2013)

Figure 15: The ArcGIS Online Platform

b) Installing and Configuring the Web AppBuilder for ArcGIS (Developer Edition)

The Web AppBuilder for ArcGIS (Developer Edition) ZIP file was downloaded to a local drive and unzipped.

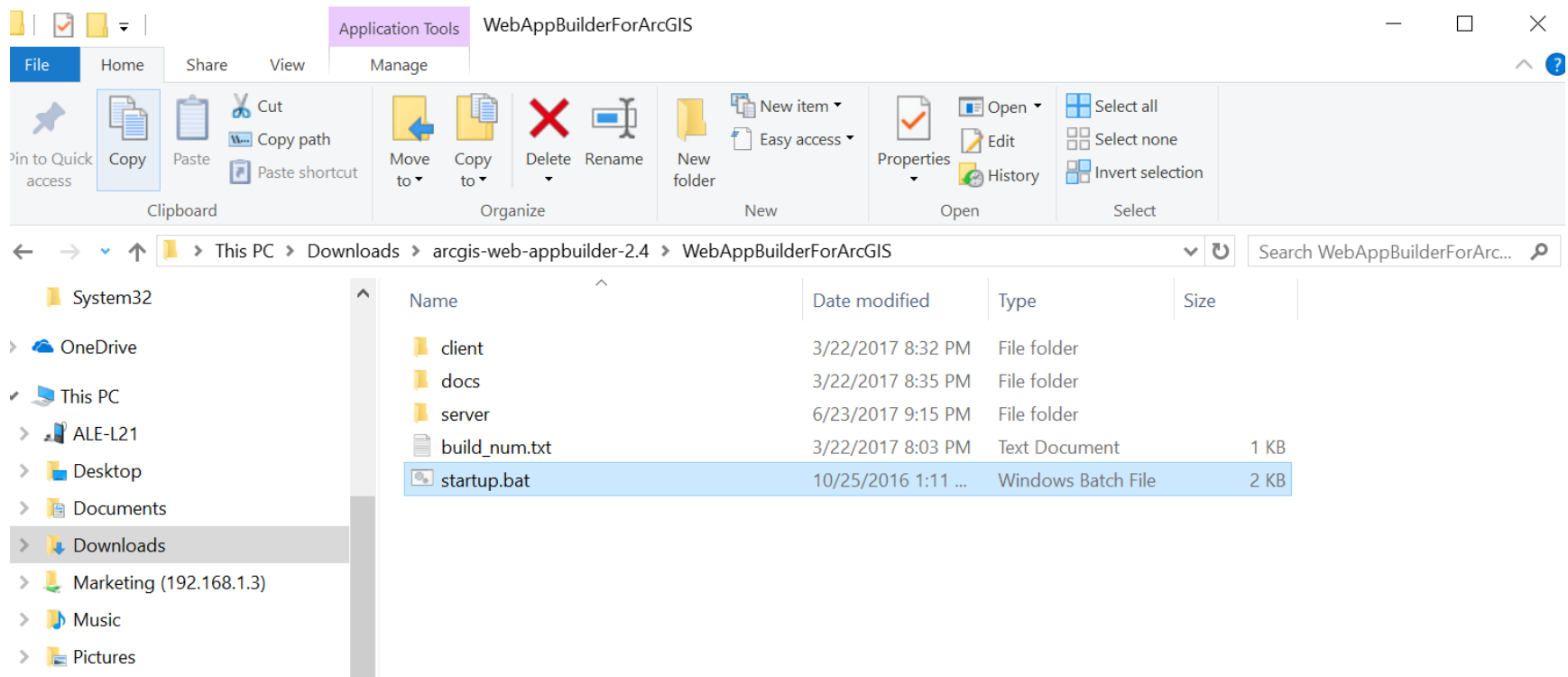


Figure 16: Web App Builder download folder and startup file

```
Web AppBuilder for ArcGIS
[2017-06-23 15:07:58.871] [INFO] repo - insert HTML.ZoomSlider
[2017-06-23 15:07:58.879] [INFO] repo - Read repository items: C:\Users\Laban\Downloads\arcgis-web-appbuilder-2.4\WebApp
BuilderForArcGIS\client\stemapp\themes
[2017-06-23 15:08:03.023] [INFO] repo - insert HTML.BillboardTheme
[2017-06-23 15:08:03.027] [INFO] repo - insert HTML.BoxTheme
[2017-06-23 15:08:03.029] [INFO] repo - insert HTML.DartTheme
[2017-06-23 15:08:03.033] [INFO] repo - insert HTML.FoldableTheme
[2017-06-23 15:08:03.037] [INFO] repo - insert HTML.JewelryBoxTheme
[2017-06-23 15:08:03.039] [INFO] repo - insert HTML.LaunchpadTheme
[2017-06-23 15:08:03.042] [INFO] repo - insert HTML.PlateauTheme
[2017-06-23 15:08:03.047] [INFO] repo - insert HTML.TabTheme
[2017-06-23 15:08:03.049] [INFO] repo - Read repository items: C:\Users\Laban\Downloads\arcgis-web-appbuilder-2.4\WebApp
BuilderForArcGIS\client\stemapp3d\widgets
[2017-06-23 15:08:10.169] [INFO] repo - insert HTML3D.About
[2017-06-23 15:08:10.171] [INFO] repo - insert HTML3D.Compass
[2017-06-23 15:08:10.173] [INFO] repo - insert HTML3D.Coordinate
[2017-06-23 15:08:10.174] [INFO] repo - insert HTML3D.Environment
[2017-06-23 15:08:10.176] [INFO] repo - insert HTML3D.FullScreen
[2017-06-23 15:08:10.180] [INFO] repo - insert HTML3D.Home
[2017-06-23 15:08:10.188] [INFO] repo - insert HTML3D.LayerList
[2017-06-23 15:08:10.192] [INFO] repo - insert HTML3D.3DFx
[2017-06-23 15:08:10.195] [INFO] repo - insert HTML3D.Legend
[2017-06-23 15:08:10.196] [INFO] repo - insert HTML3D.MyLocation
[2017-06-23 15:08:10.198] [INFO] repo - insert HTML3D.Navigate
[2017-06-23 15:08:10.200] [INFO] repo - insert HTML3D.Search
[2017-06-23 15:08:10.204] [INFO] repo - insert HTML3D.Slides
[2017-06-23 15:08:10.206] [INFO] repo - insert HTML3D.Splash
[2017-06-23 15:08:10.207] [INFO] repo - insert HTML3D.ZoomSlider
[2017-06-23 15:08:10.209] [INFO] repo - Read repository items: C:\Users\Laban\Downloads\arcgis-web-appbuilder-2.4\WebApp
BuilderForArcGIS\client\stemapp3d\themes
```

Figure 17: Node JS server running

Within the unzipped folder, there existed a startup.bat file. The file, which is a batch file, is a script that contains a number of commands which do the following:

- Start up the built in Node.js server in a Command Prompt window as shown in Figure 17
- Start-up Web AppBuilder in the default browser with the URL [http://\[yourmachinename\]:3344/webappbuilder](http://[yourmachinename]:3344/webappbuilder) as shown in Figure 18 **Error! Reference source not found.**

Once a link was established to the ArcGIS Online instance from whence the GIS layers would be fetched, the Continue button was pressed to reveal the start page for the Web AppBuilder as shown in Figure 19. The choice of web app (Default 2D application) to be created was chosen as shown in Figure 20.

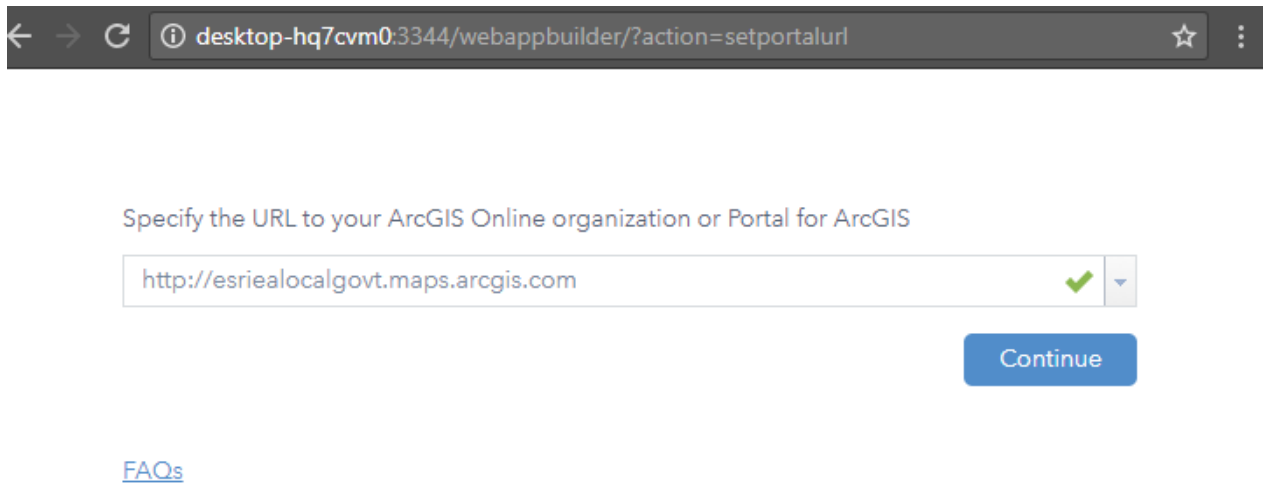


Figure 18: Web App Builder Startup

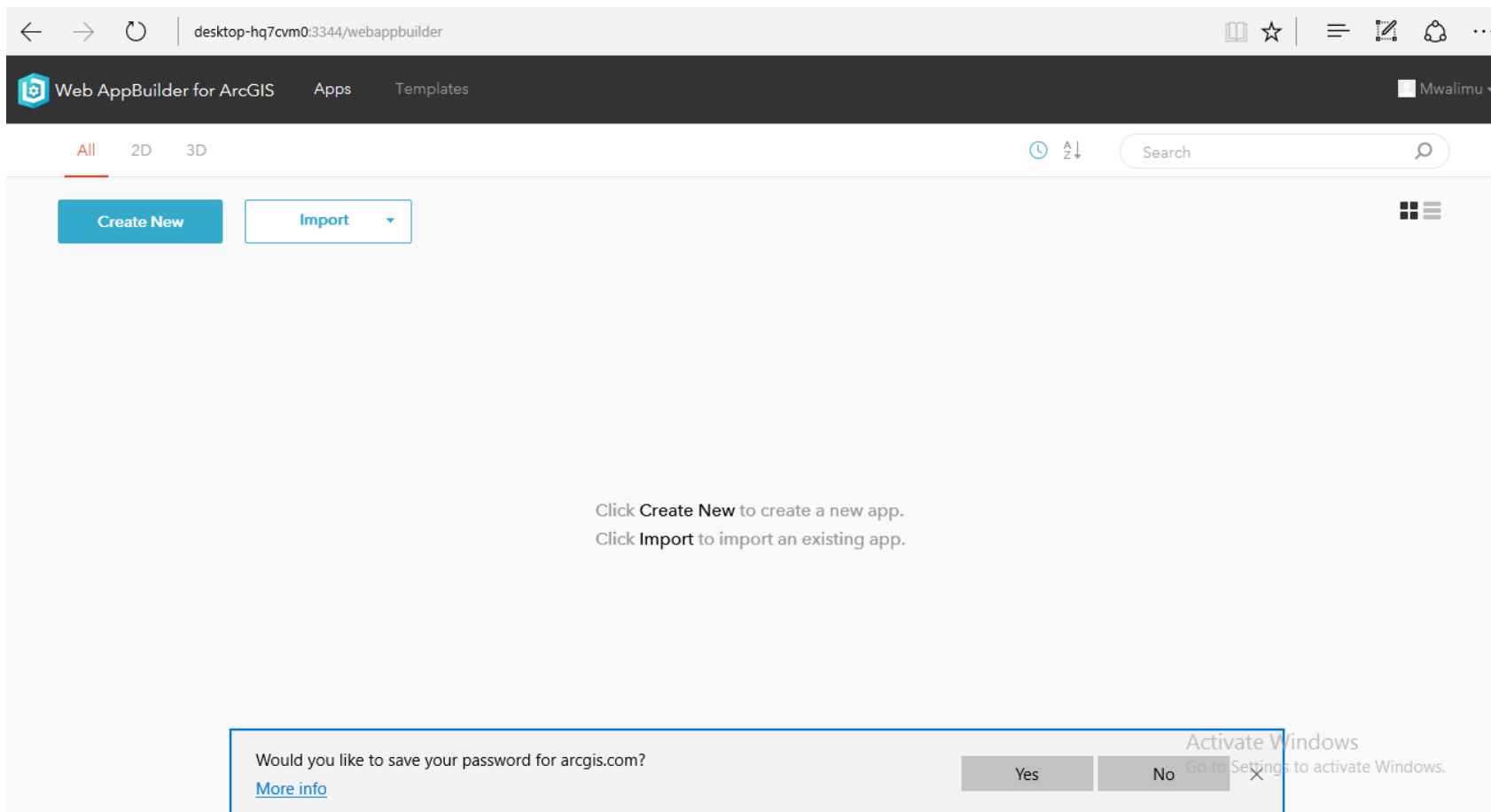


Figure 19: Web AppBuilder Start Page

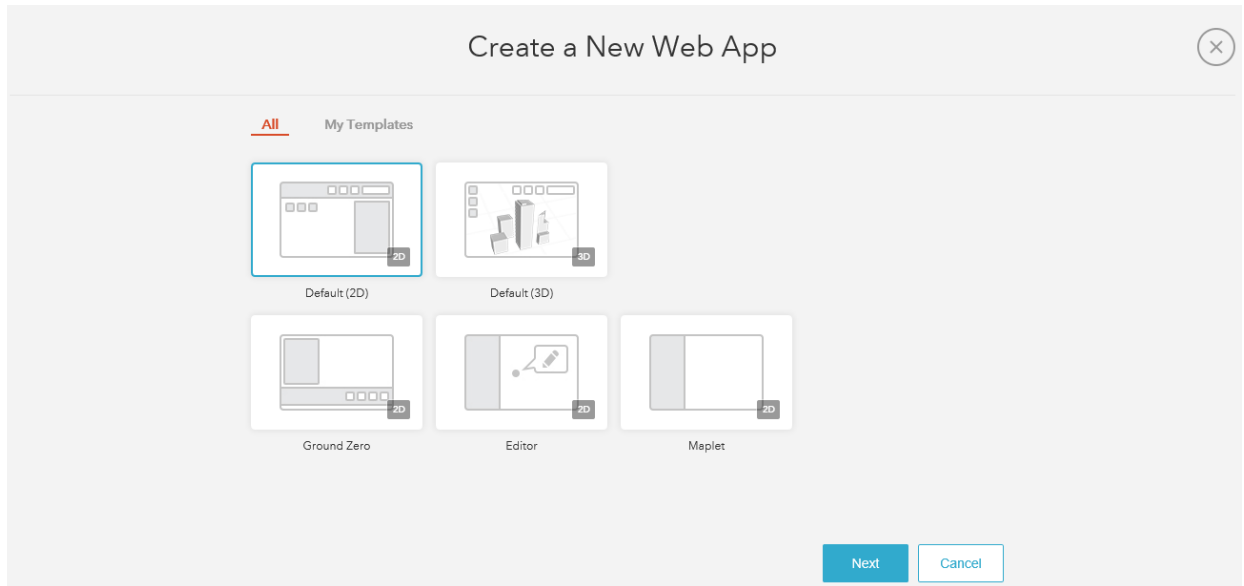


Figure 20: Making a choice of Web AppBuilder

The option to give the application a name and description was then offered as in the following figure:

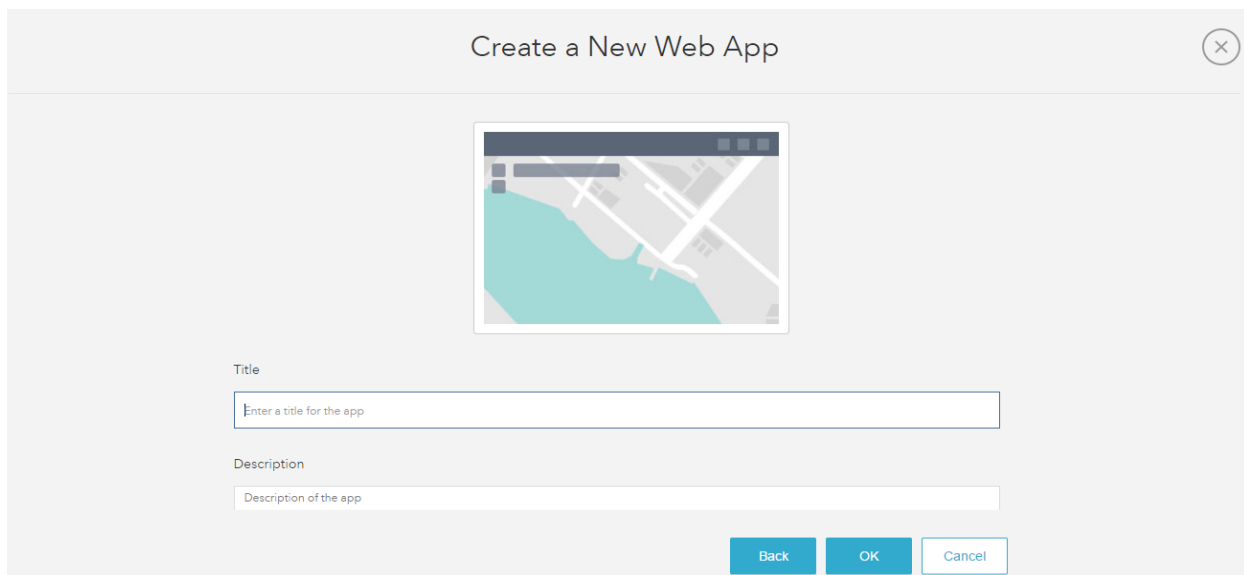


Figure 21: Naming and describing the application

Clicking the OK button catapults the application to a WYSIWYG configuration page from where configuration of the application for use with the previously published datasets would be done.

As shown in Figure 22, the following tabs were used for configuration:

- The 'Themes' tab, to control the look and feel of the application
- The 'Maps' tab, to control the content that would be used in the application
- The 'Widget' tab, to add functionality to the application
- The 'Attribute' tab, to add details and text to the application

The following Widgets were made use of during the Configuration:

- The Bookmark Widget – To save memorable apartment locations for users of the application
- The Query Widget – To assist users to query apartments by their attributes
- The BaseMap Widget – To allow users to switch back and forth between different contextual backgrounds
- The Layer List – To allow users to toggle on and off data layers of interest
- The NearMe Widget – To allow users, once zoned in to an area of interest, to discover the facilities of interest around the area, how far they are from that area and how to get to these facilities

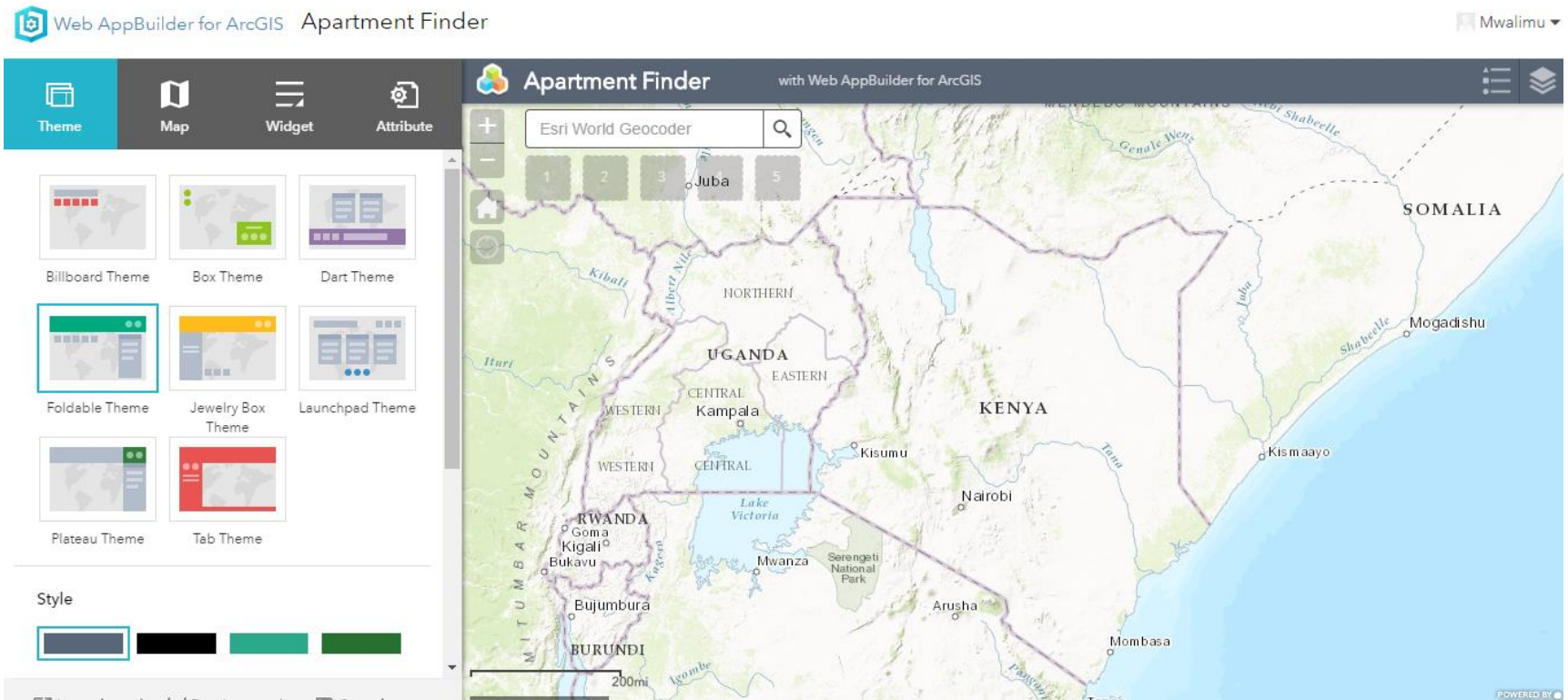


Figure 22: WYSIWYG Configuration Page

CHAPTER 4: RESULTS AND ANALYSIS

The final web applications developed as part of this project are available at:

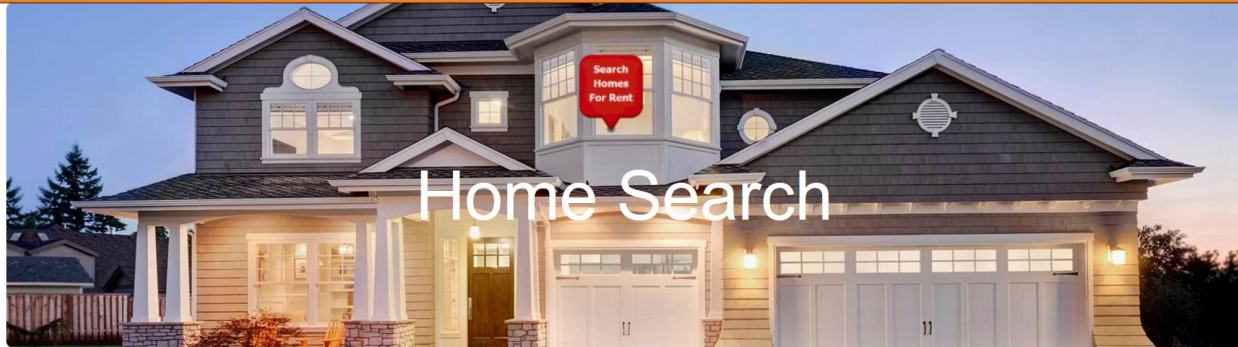
- <http://184.73.188.130/RentManager> - The Real Estate Management application
- <http://184.73.188.130/PataMaskani> - The Public Facing Web application (*Pata Maskani*)

These applications provide users an opportunity to view a sample real estate management and advertising system that could be used to show cooperation between GIS systems and asset management systems without necessarily changing how they work currently. The Real Estate Management application, labelled as Apartment Management System, is a straight forward asset management system that records entries for rental apartments and feeds them simultaneously into the RDBMS-driven Real Estate Database as well as a GIS Platform database. Once in the GIS platform database, which happens to be represented by ArcGIS Online – a Web GIS platform, the various applications available to the platform can be used to augment the data keyed in from the Real Estate Management end. This means that users can collect further data on the sites through smartphones and add data to the database as well as conduct GIS analysis based on the platform.

The front facing public application allows users to make queries on the GIS platform database and use GIS functionality to determine rental apartments that meet their feature as well as lifestyle requirements. Once a user has identified his or her ideal neighbourhood/rental home, the user can look up directions to the venue and print them up, bookmark the location of these properties for later viewing or call the agent who is providing this service for further questioning and possible viewing possibilities.

4.1 A Tour of the Real Estate Manager Application

The Real Estate Management Application, labelled as Apartment Manager System, is a straightforward CRUD (Create-Read-Update-Delete) application. The home page is an entry page to users of the system. From the top right, the realtor running the system can login to the system to begin managing properties. The site is basically an entry to the platform where agents can register themselves and expose properties for sale through the public facing application.



Getting started

The Real Estate Manager is an application that makes it easy to build a network of clients for your real estate properties

[Learn more »](#)

Get more agents

NuGet is a free web extension that makes it easy to add, remove, and update agents from within the platform.

[Learn more »](#)

Web Hosting

You can easily find a web hosting company that offers the right mix of features and price for your applications.

[Learn more »](#)

© 2017 - Rent Management Application

Figure 23: Home page of Real Estate Manager application



Log in.

Use a local account to log in.

Email

Password

Remember me?

[Log in](#)

[Register as a new user](#)

© 2017 - Rent Management Application

Figure 24: Logging into the Real Estate application

Logging in to the platform exposes functionality at the top of the navigation bar as shown below. The Apartments drop-down list exposes functions to add, edit, update or delete any property that has to do with apartments – including the apartment details, the owners of various apartments, the different types of apartments, the people who have rented these apartments as well as the trail of transactions around these apartments (otherwise referred to as an apartment audit trail). The links to the functions for managing the various types of parking spaces being monitored as well as the details of agents that the company deals with are also provided.

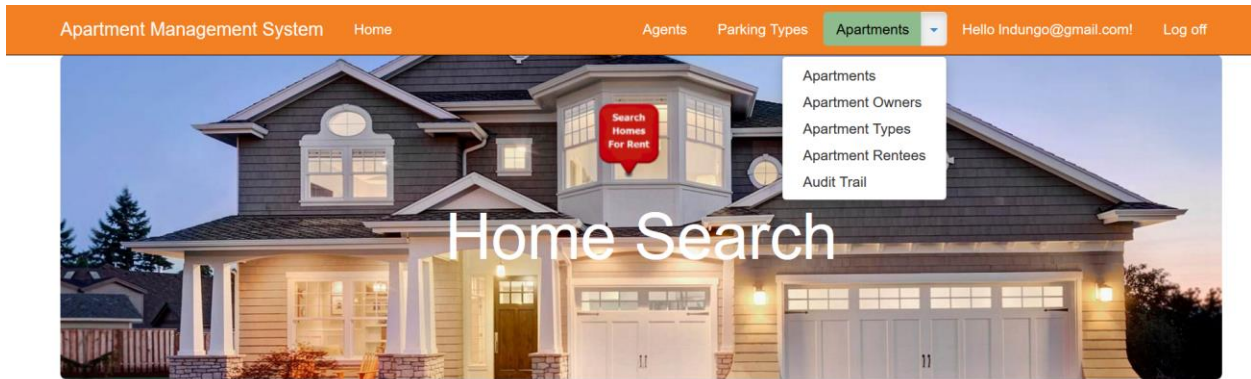


Figure 25: Logged in view of the Home page

4.1.1 General CRUD procedures on the system

Clicking on the Agents link on the Navigation bar opens up a page with details on existing agents. Agents here refers to real estate agents who happen to be selling apartments for rent. Apartment owners liaise with these agents to rent out their apartments and the agents register with this portal and offer apartments for rent under their agency. From this initial page one can add, edit or delete an agent.

Agent Name	Agent Number	
Maximus (Knight Frank)	0721976098	Edit Details Delete
Jude (Lloyd Masika)	0764798076	Edit Details Delete

Figure 26: Agent Details page

These operations occur in simple interfaces such as those which regular system users would be used to as shown in the following figures.

Create

Agent

Agent Name

Agent Number

Create

[Back to List](#)

© 2017 - Rent Management Application

Figure 27: Create operation for Agents

Edit

Agent

Agent Name

Maximus (Knight Frank)

Agent Number

0721976098

Save

[Back to List](#)

© 2017 - Rent Management Application

Figure 28: Edit operation for Agents

Delete

Are you sure you want to delete this?

Agent

Agent Name

Maximus (Knight Frank)

Agent Number

0721976098

Delete

| [Back to List](#)

© 2017 - Rent Management Application

Figure 29: Delete operation for Agents

This format replicates itself throughout much of the functions in the system – each property having the same number of functions available to it and having its template the same as this.

The Apartments property page differs from this in that it is the page that actually connects the GIS to the Real Estate Management system.

4.1.2 Managing Apartments

Clicking on the Apartments link on the Navigation bar opens up a page with details on existing apartments. The details provided provide an easy way of going through the apartments that are on offer.

The screenshot shows the 'Apartment Management System' navigation bar with 'Home', 'Agents', 'Parking Types', and 'Apartments' (selected). The user is logged in as 'Hello Indungo@gmail.com!' with a 'Log off' option. Below the navigation bar is the 'Index' section with a 'Create New' link. A table lists two apartments:

Apartment Name	Location Name	Bedrooms	Bathrooms	Current Price	Apartment Size	Building Complex Name	Apartment Status	
Gracious Apartments Flat	Ruaka	2	1	10000.00	1	Gracious Apartments	<input type="checkbox"/>	Edit Details Delete
Black Privileges Apartment	Runda	3	1	25000.00	3	Black Privilege Flats	<input checked="" type="checkbox"/>	Edit Details Delete

Figure 30: Viewing apartment details

Clicking on the ‘Create New’ link at the top of the page leads the user to the page below, which allows users to key in details of the new apartment being registered. This page relies on information having been fed in from other pages in order to provide options for apartment properties such as parking types, agent names and apartment types. The page is divided into 3 sections:

- Apartment /Basics – Deals with the basic aspects of the apartment in terms of ownership, location and agency
- Apartment Details – Deals with the features that the apartment possesses
- Apartment Location Picker – Based on location given, the person keying in the apartment location can zoom in on a map and set the location for the apartment using a basemap. The action of picking the location on the basemap allows one to add coordinates as attributes on the Real Estate Management database.

Apartment

**Apartment
Owner**

Maina Njagi ▼

**Apartment
Built
Date**

2/22/2001 12:00:00 AM

**Apartment
Status**

**Apartment
Name**

Gracious Apartments Flat

**Apartment
Location**

Ruaka

**Apartment
Floors**

4

**Building
Complex
Name**

Gracious Apartments

Figure 31: Apartment Basics Section

Apartment Details

Number of Bedrooms	<input type="text" value="2"/>
Number of Bathrooms	<input type="text" value="1"/>
Parking Type	<input type="text" value="On Street Parking"/>
Current Price	<input type="text" value="10000.00"/>
Apartment Type	<input type="text" value="Apartment"/>
Apartment Size	<input type="text" value="1"/>
Water Availability	<input checked="" type="checkbox"/>
Electricity Availability	<input checked="" type="checkbox"/>

Figure 32: Apartment Details Section

Apartment Location Picker

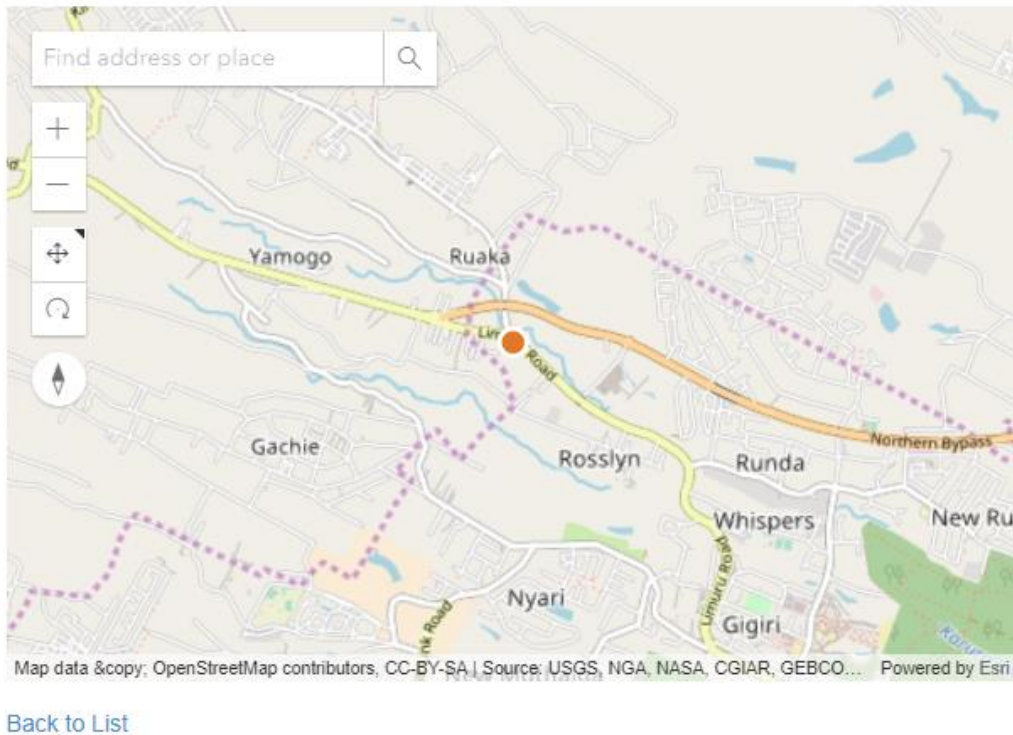


Figure 33: Apartment Location Picker

Clicking on the **Create** button syncs the data added to the web interface with the ArcGIS Online Web GIS platform as well as places the apartment as part of the roster of items within the Real Estate rental apartment database as shown overleaf.

Edits made on apartments go virtually through the same process, only that on opening the page for a particular apartment, the apartment's current details appear in the input textboxes and one has the option to leave them as they are or to edit them and save the changes. Once this addition has been made to the Real Estate platform, one can visit the online Web GIS Platform and view the edit from a map as well.

Index

[Create New](#)

Apartment Name	Location Name	Bedrooms	Bathrooms	Current Price	Apartment Size	Building Complex Name	Apartment Status	
Gracious Apartments Flat	Ruaka	2	1	10000.00	1	Gracious Apartments	<input type="checkbox"/>	Edit Details Delete
Black Privileges Apartment	Runda	3	1	25000.00	3	Black Privilege Flats	<input checked="" type="checkbox"/>	Edit Details Delete
Haile Selassie Apartments flat	Ruiru	3	2	40000.00	1	Haile Selassie Apartments	<input checked="" type="checkbox"/>	Edit Details Delete
Available Flats	Ruaka	3	1	35000.00	3	Kaduas Complex	<input checked="" type="checkbox"/>	Edit Details Delete

© 2017 - Rent Management Application

Figure 34: Apartment Added

Details Add ▾ Edit Basemap Analysis Save ▾ Share Print ▾ Directions Measure Bookmarks Find address or place 🔍

About Content Legend

Contents

- ✓ Apartments
- ▶ Topographic

Map navigation: +, Home, -, Refresh

Map features: LIMURU RD

(3 of 4)

Apartment Layer: Gracious Apartments Flat

Apartment ID	0
Apartment Owner ID	1
Apartment Build Date	2/22/2001, 3:00 AM
Apartment Status	True
Number Of Bedrooms	2
Number Of Bathrooms	1
Apartment Name	Gracious Apartments Flat
ParkingType	1
Location Name	Ruaka

[Zoom to](#) [Edit](#) [Get Directions](#)

Figure 35: Viewing the entry from the Web GIS Platform

The application’s use continues past adding and updating data on the platform. The Apartment Audit Trail page keeps track of all transactions involving the apartments and provides a view through which users can monitor how an apartment has fared in terms of its appeal and how many times it has been rented out as well as to whom.

Start Date	End Date	Agent Name	Rentee Name	Apartment Name	
2/1/2017 12:00:00 AM	6/30/2017 12:00:00 AM	Maximus (Knight Frank)	Laban Karanja	Gracious Apartments Flat	Details

© 2017 - Rent Management Application

Figure 36: Apartment Audit Trail

4.1.3 Managing the apartment from the GIS Platform

Once an apartment entry has been keyed in to the GIS platform, it is now available for operations purely within the GIS platform realm. One of the key operations enabled by an online Web GIS platform such as ArcGIS Online is field data collection. Using ArcGIS out of the box field data collection app, known as Collector for ArcGIS, one can augment the dataset keyed in from the office with on-site photos. Using the Collector for ArcGIS app, a field worker is able to visit the newly keyed in site, navigate to the said site using the GIS platform and add on-site photos to the feature.

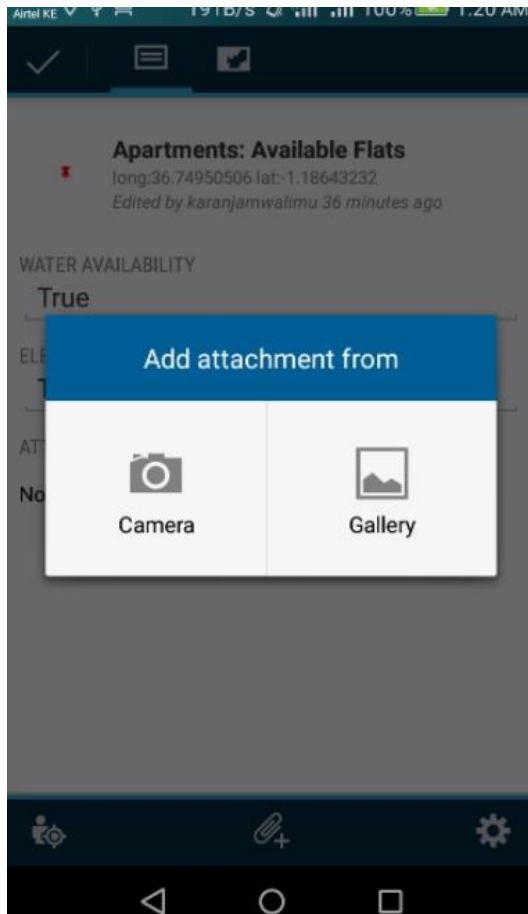


Figure 37: Adding on-site photos and editing details through Collector for ArcGIS

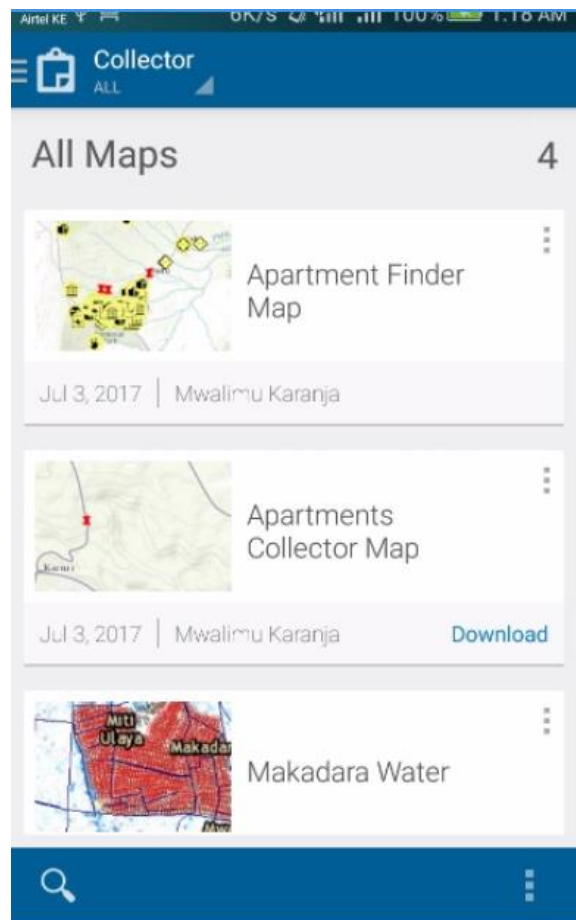


Figure 38: The Collector for ArcGIS app interface

Edits made on this platform end up on the GIS platform and the text elements are also updated on the Real Estate Management Database Platform. GIS personnel can then see the onsite photos on the map as shown below.

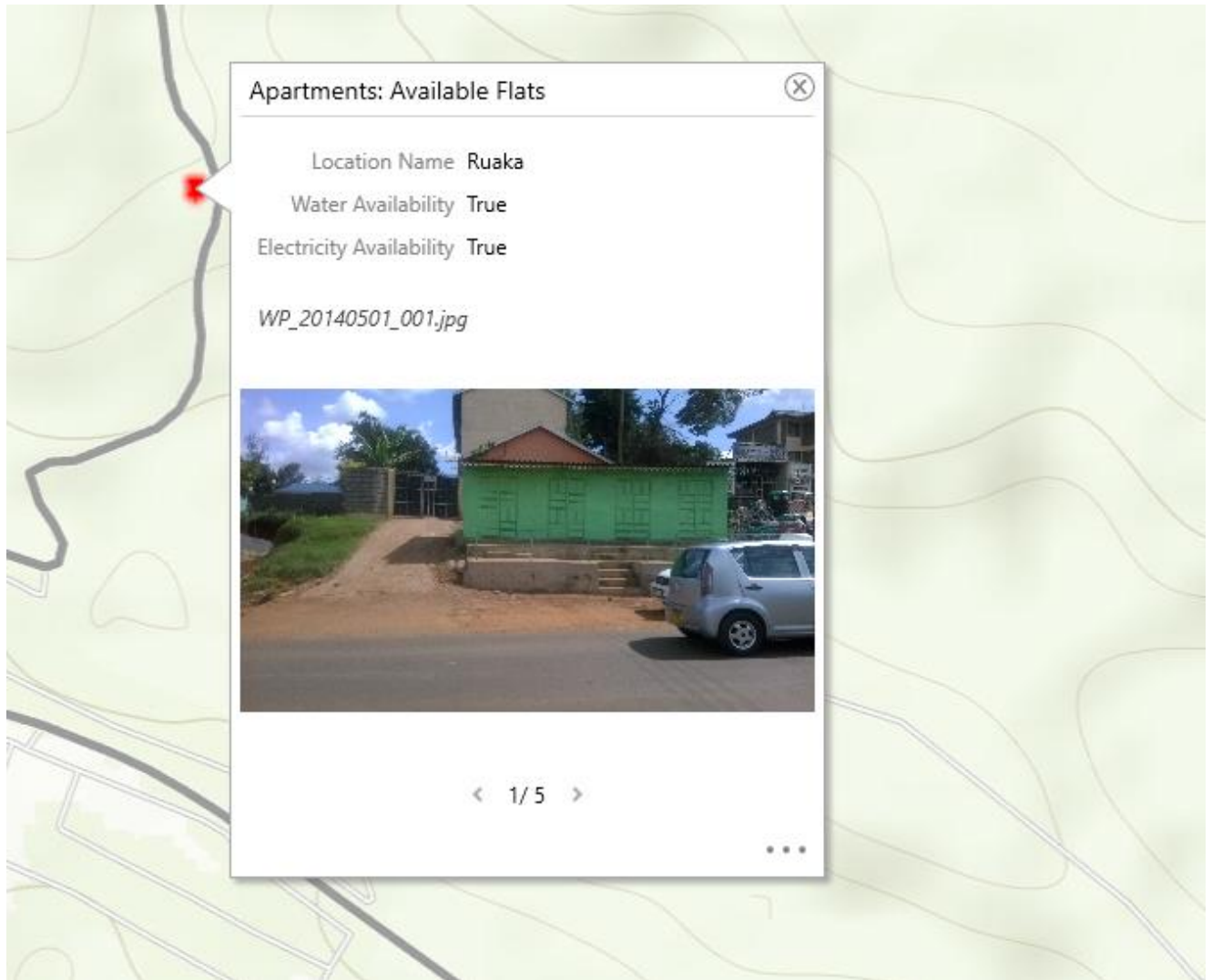


Figure 39: On-site photos attached to GIS feature (Rental Apartment)

4.2 A Tour of the Public Facing Web Application

The Public-facing Web application is the application that will be advertised to home hunters and will be available to the public. Titled *Pata Maskani*, a Swahili phrase for ‘Find a Home’, the browser-based application initially loads a splash screen to introduce the application and provide a disclaimer for users on the validity of information.



Figure 40: Public Facing Application Splash Screen

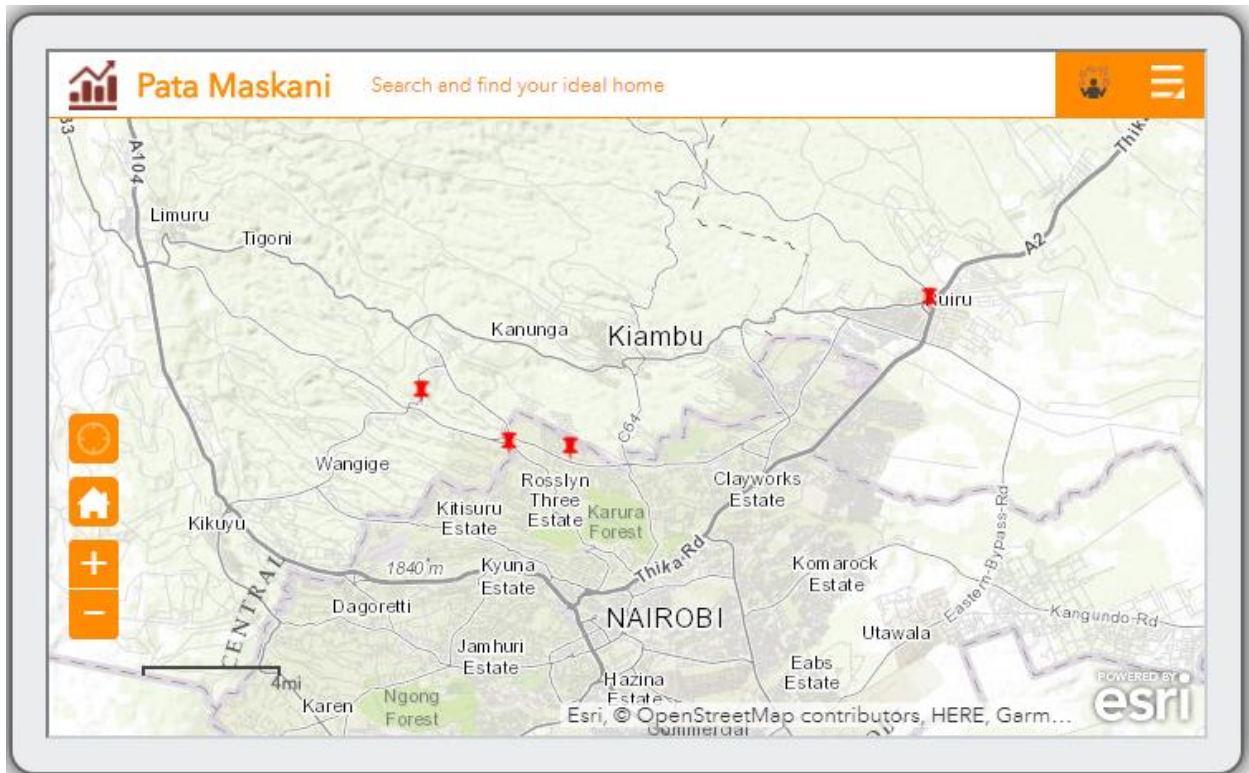


Figure 41: First look at application after the splash screen

Once the disclaimer has been clicked on and read, the user can press the **OK** button, as shown in Figure 40 to continue and access the app. Once the user has checked in, the app displays a map of the study area which is comprised of Kiambu and Nairobi counties as well as the apartments in the said area, as shown in Figure 41.

Users can then do one of two things: begin their home search or review the data overlays on the map. To review the data overlays, one needs to click the button that's second to the top right of the application to reveal a legend of the data available for display. To signify that it is the button that currently has the focus, a white dot appears underneath the button in question. To get back to the map and clear the legend from the screen, one need only click the close button at the top right of the legend to close the panel that the displayed data is shown on.

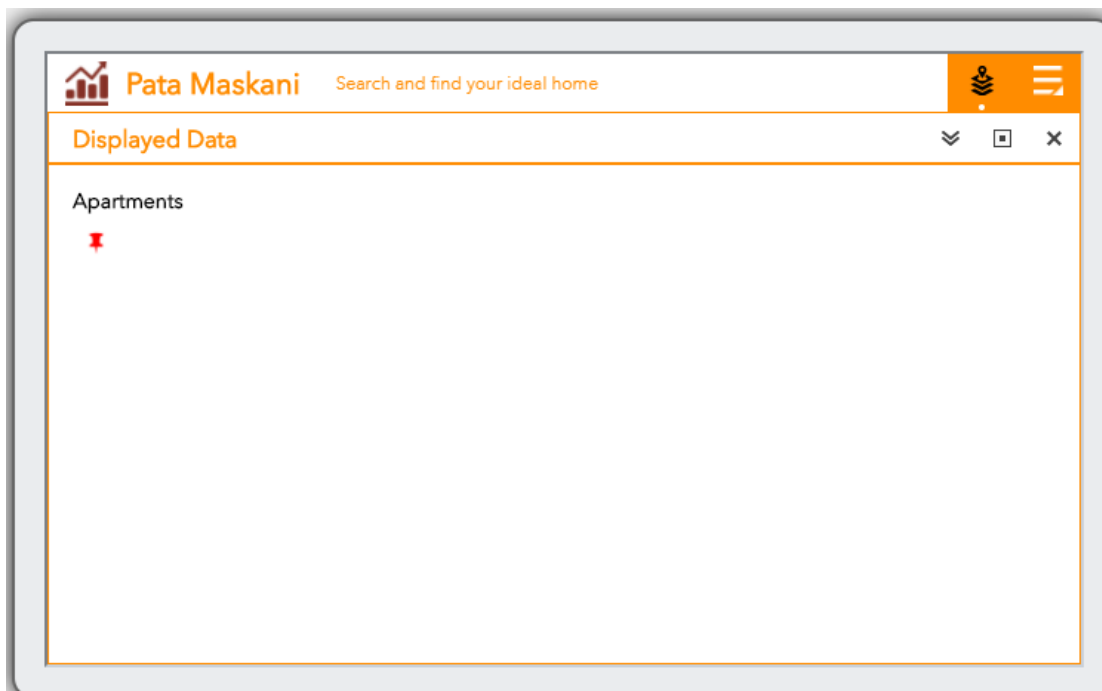


Figure 42: Viewing a legend of displayed data

Clicking the button on the extreme top right reveals a list of operations that can be carried out.

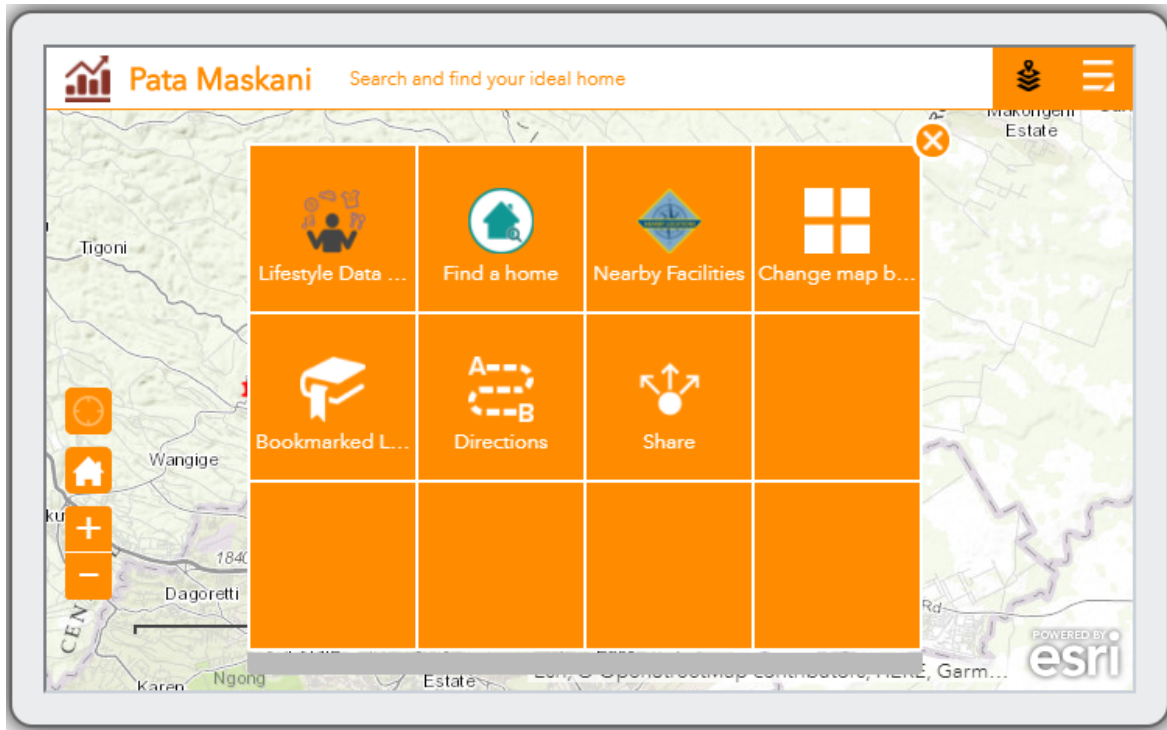


Figure 43: Viewing application options

4.2.1 Lifestyle Data

This option basically shows the various data overlays that one can add to the basemap in form of a Layer List. One can toggle any one of these layers on and off during the course of use of the application. All the layers have scale dependencies due to the volume of data at higher scale levels.

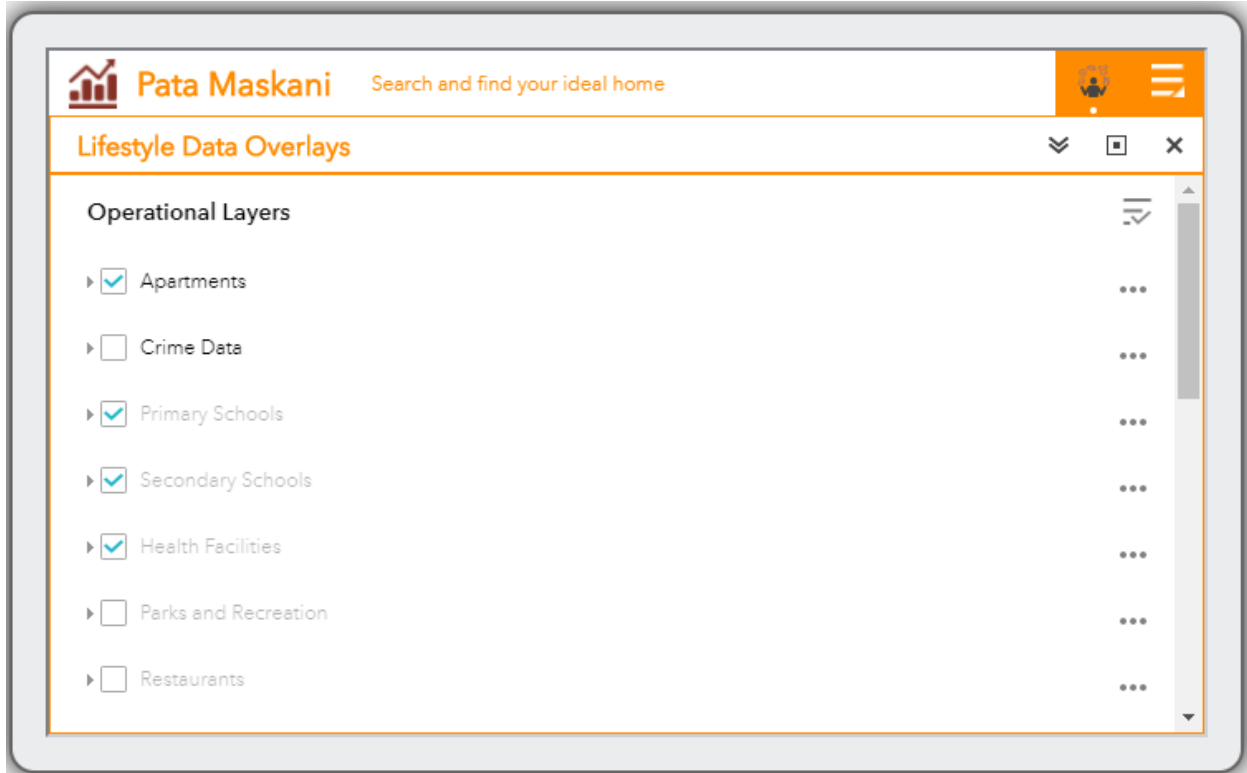


Figure 44: Lifestyle Data Overlays

4.2.2 Find a Home

This option is the one that a user will use to query the GIS platform to for apartment features. Users can query by price, number of rooms and number of bathrooms. Results are displayed on a list with pertinent details on the apartments chosen. The results from the query can be displayed on the map by clicking on a particular result and minimizing the panel. As can be seen from the result details, one is able to directly contact the agent and discuss renting the apartment. The photos of the rental apartment taken by the field personnel also appear as part of the apartment details. This panel thus takes care of apartment search by features.

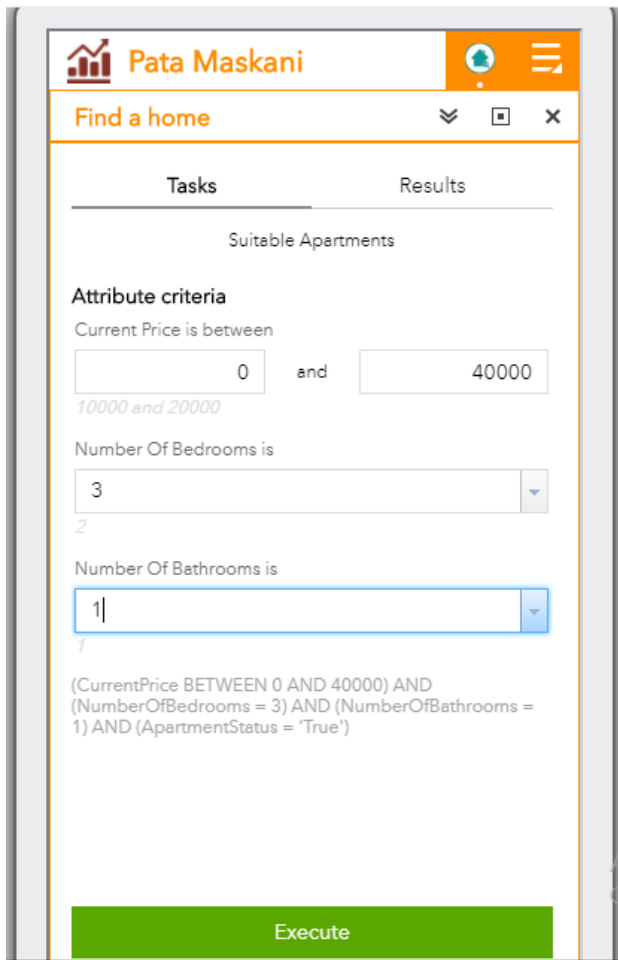


Figure 46: Querying the GIS platform

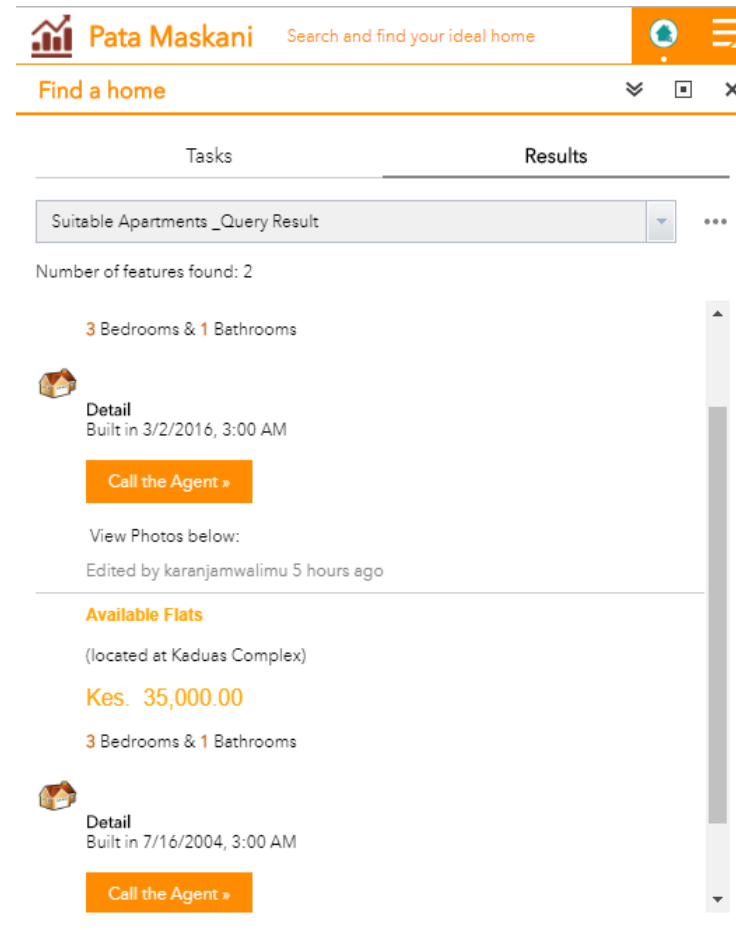


Figure 45: Results from the GIS Query

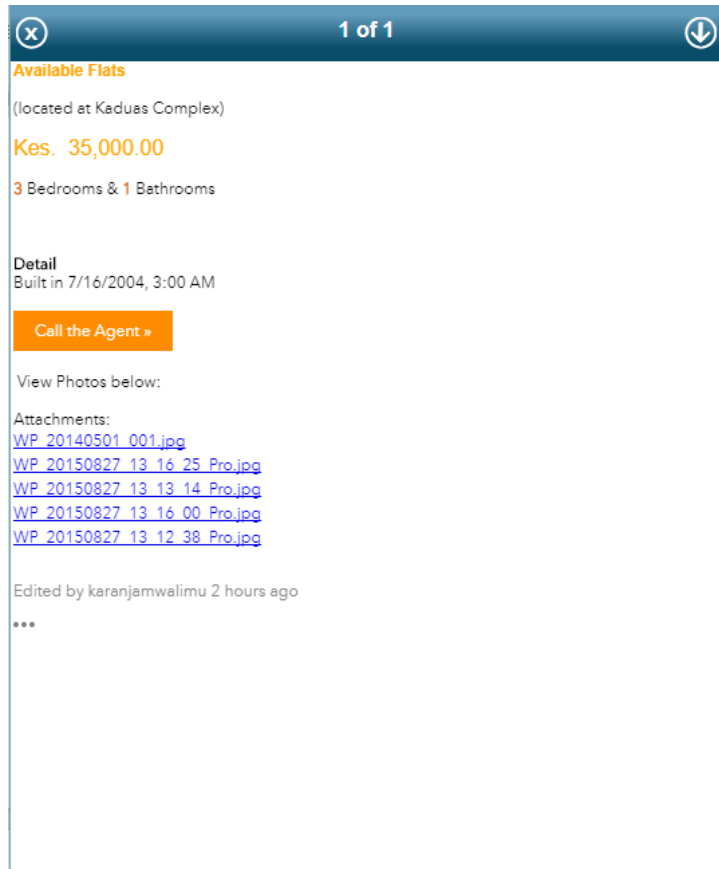


Figure 48: Displaying result detail

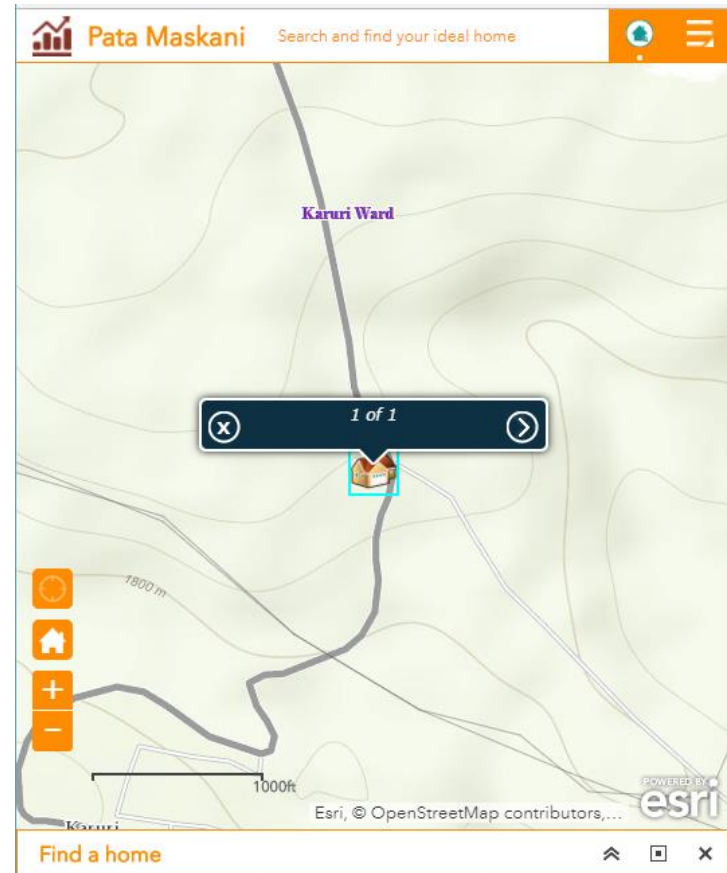


Figure 47: Displaying result on map

4.2.3 Nearby Facilities

This option separates this application from most of the applications in the market. Using this option one is able to find the facilities that are nearest to the desired rental apartment. Once the panel is open, the user is able to define the radius around which he/she wants to find facilities by adjusting the slider to the desired number. Once the user defines the centre of radius (most probably the rental apartment), the panel will then list facilities that meet the distance requirement as well as a count of the features that do so.

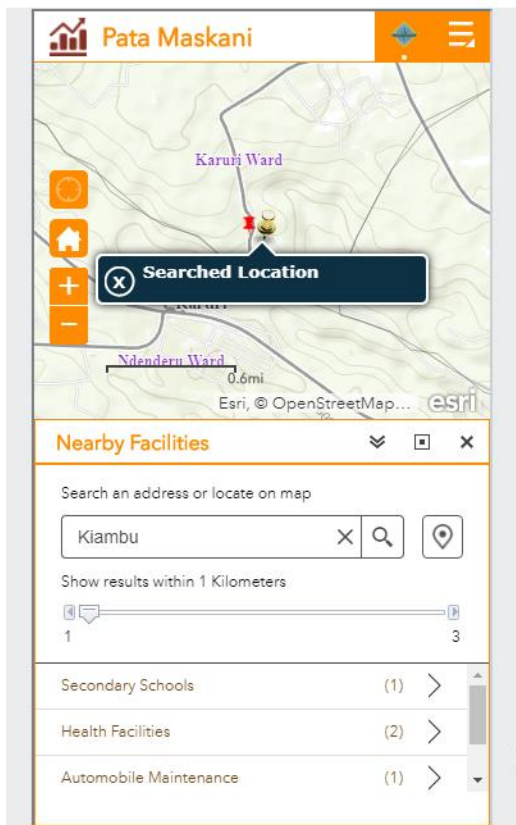


Figure 50: Searching for nearby facilities

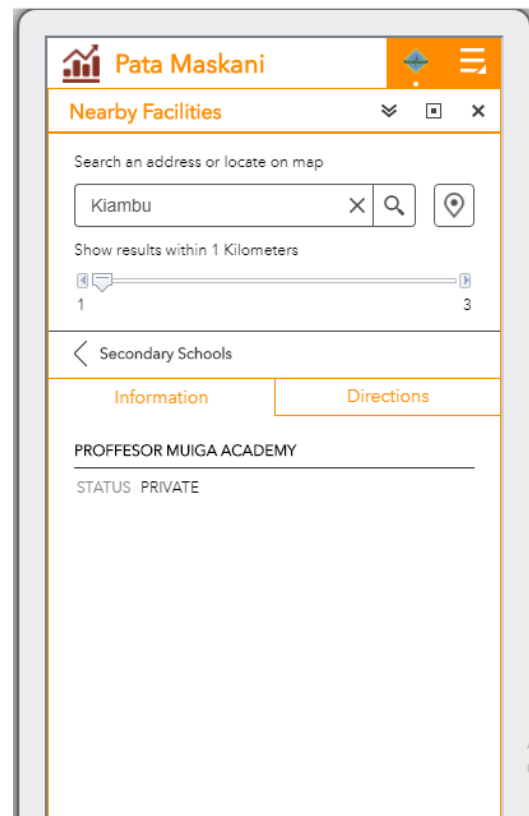


Figure 49: Looking at detail of nearby facilities

For each of the features that meet the proximity requirement, the user is able to look up the facility detail as well as get directions to the facility's location from the desired rental apartment.

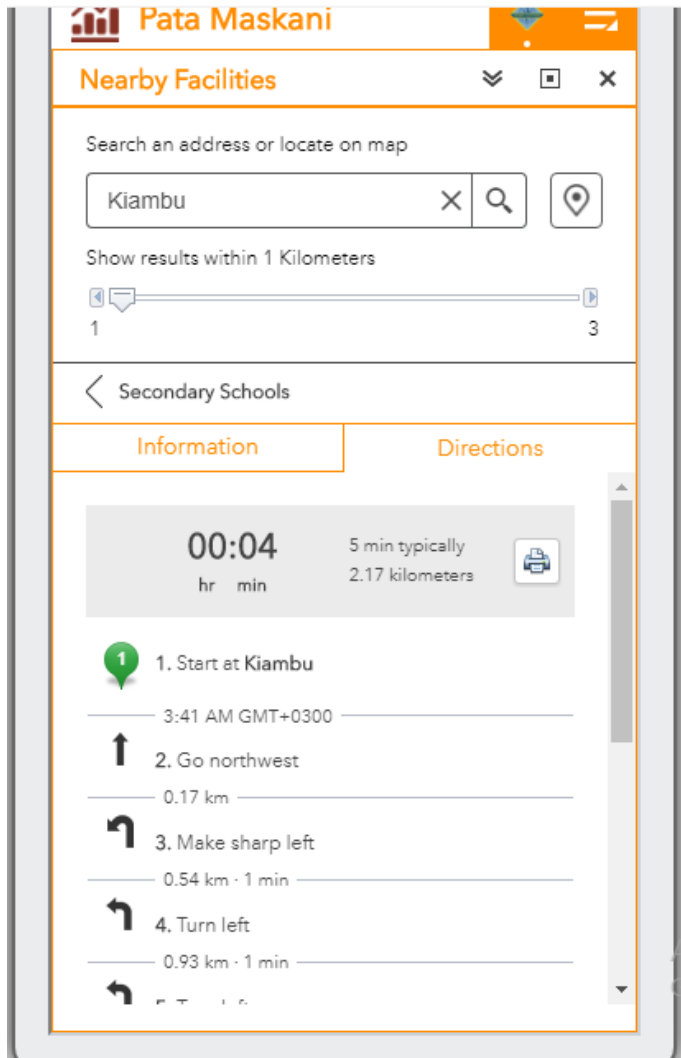


Figure 52: Getting directions to a facility

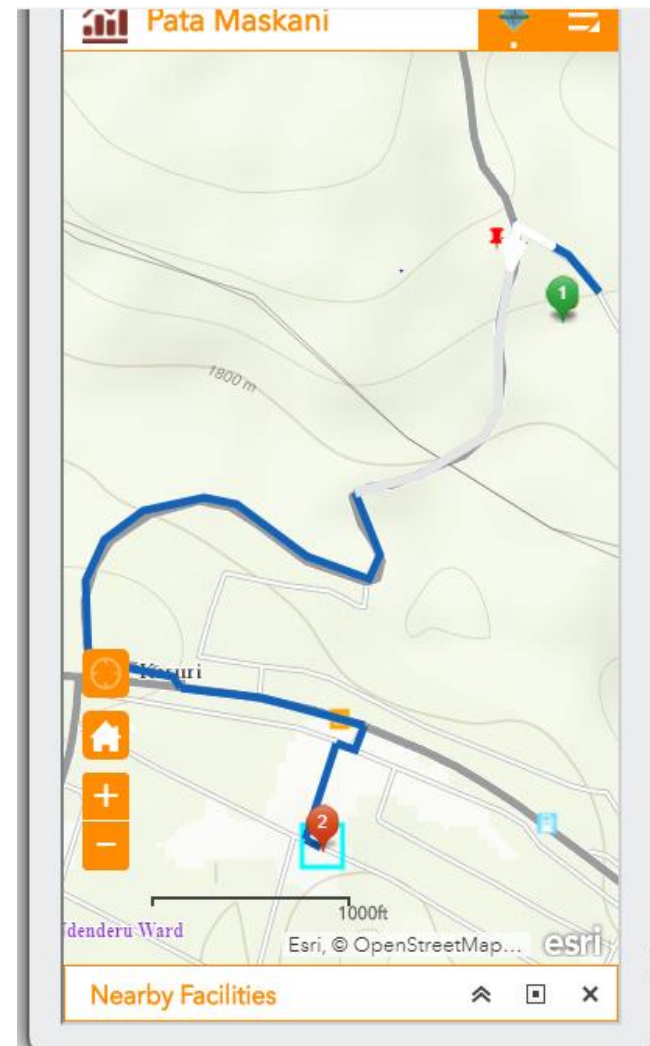


Figure 51: Viewing directions to a facility on the map

4.2.4 Change map background

This option presents a gallery of map backgrounds and allows a user to select one from the gallery as the app's current map background. The map background can be user-defined or from your organization or portal.

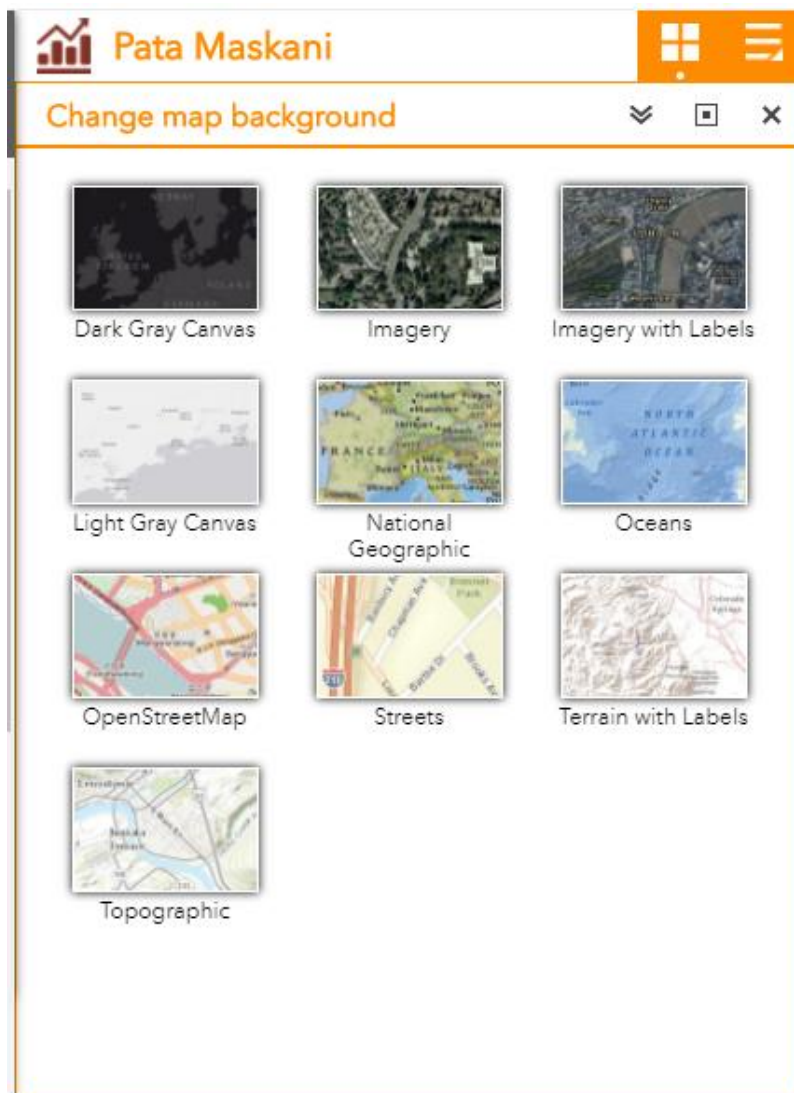


Figure 53: Changing the Map Background

4.2.5 Bookmarked Locations

This option stores a pre-defined collection of map view extents or spatial bookmarks displayed in the app. It also allows users to save a particular map extent, especially if they find a rental apartment they like and would like to come back to it after browsing through other apartments.

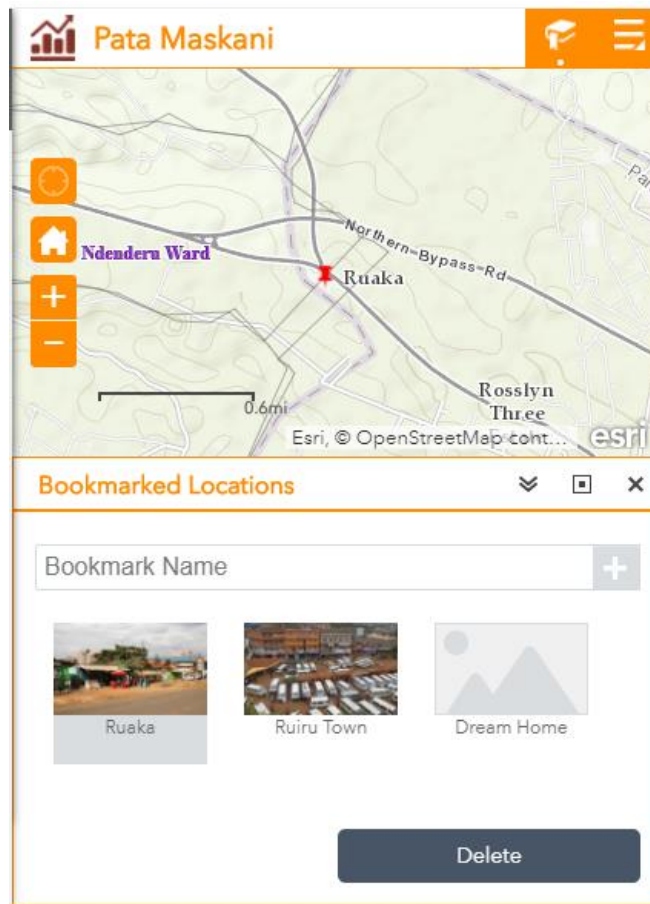


Figure 54: Showing Bookmarked Locations

4.2.6 Directions

The Directions option provides a quick and efficient method of calculating turn-based directions between two or more locations. This option uses both a network route service and a geocoder service to allow the user to get directions from where they are to a potential rental home. The user can choose various travel-modes for the directions such as Driving Distance, driving time and walking modes. Once the two locations have been picked and the **Get Directions** button clicked, the map updates to display the route, and the text directions display in the option panel. Each turn in the directions list is interactive – meaning that clicking a direction text zooms the map to the location described. The route leading to that location also highlights on the map.

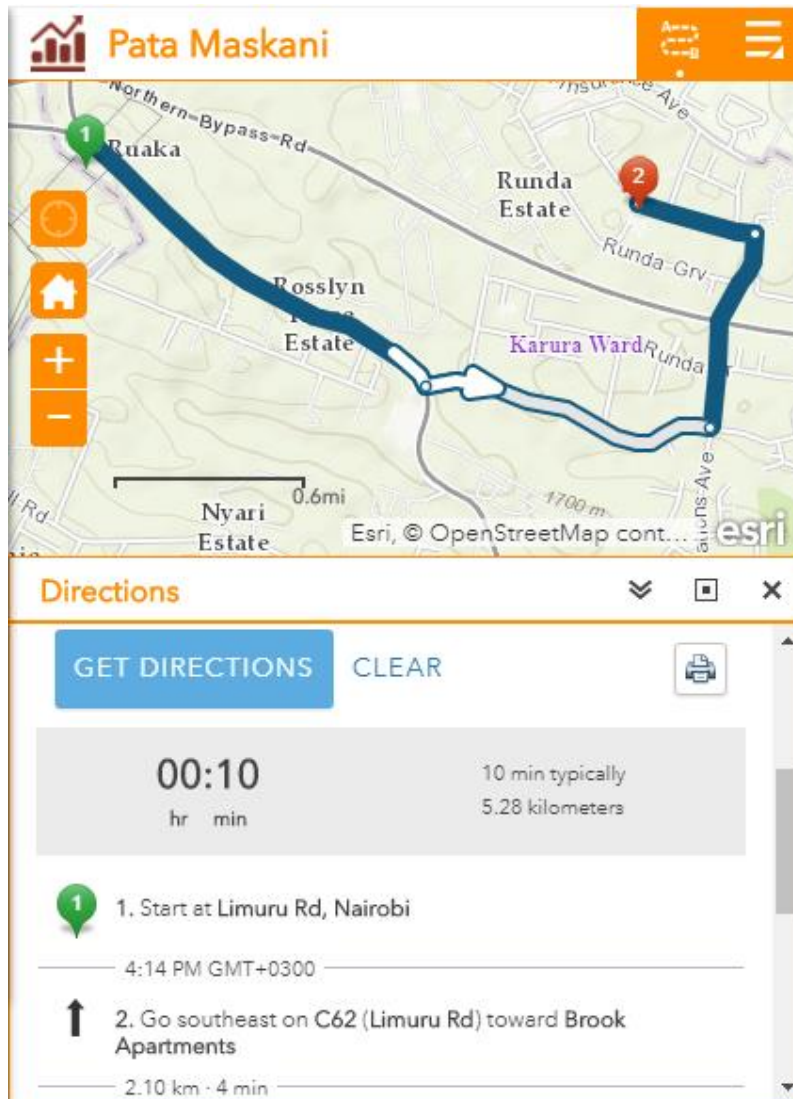


Figure 55: The Directions Panel

4.2.7 Share

The Share option allows a user to share the Apartment Finder app by posting it to one's own social media account, or by sending an email with a link, or embedding it in a website or blog. This provides an easy way for the user to share the application with other people who may be looking for an application that can help them choose a home for themselves.

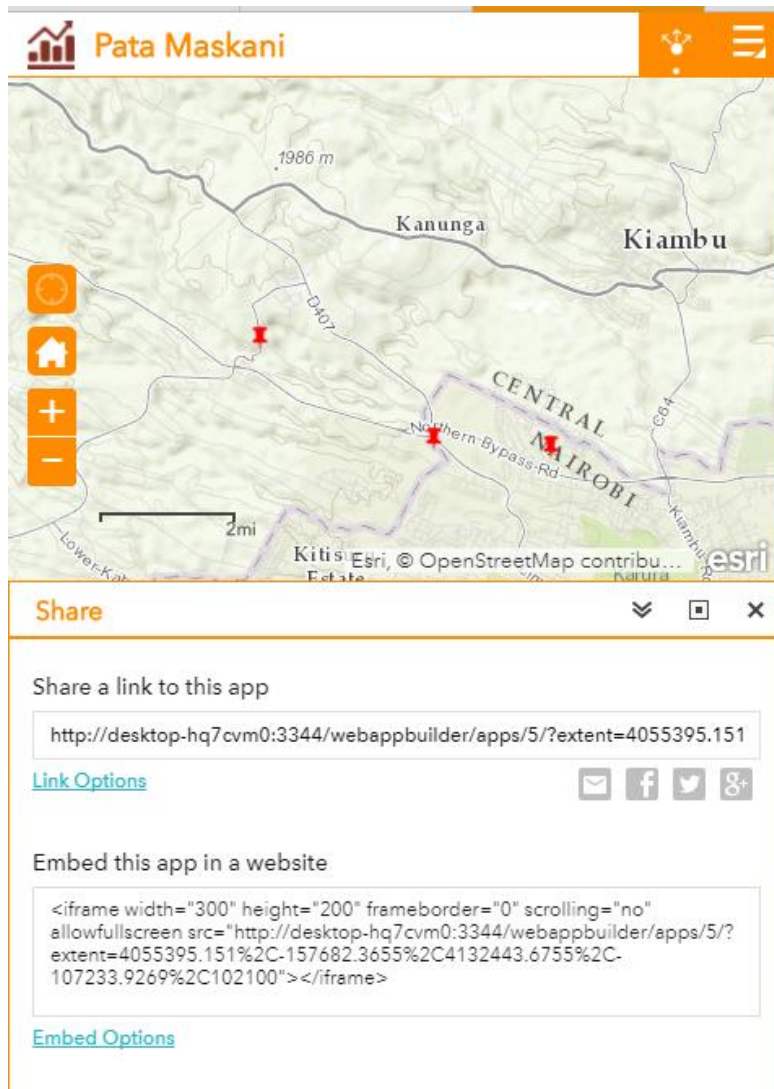


Figure 56: Sharing the application through the share option

4.3 Analysis of Results

The combination of the Real Estate Management Platform and the *Pata Maskani* browser app provide a platform for the management of a real estate property as well as a marketing tool for the properties being managed. By using the Real Estate Management platform, realtors would be able to manage the non-spatial aspects of their rental properties and the agents who handle these properties through a simple web interface that could be accessed on any smart device. The management portion of the platform allows the administrators of the portal to manage their dealings with agents as well as gather important information by maintaining an audit trail. The *Pata Maskani* browser application exposes the available rental properties to the public, who can use the application to browse the properties on offer and contact the agents in charge of these properties without the need to physically search for them. Even though two platforms are being utilized for this solution, careful management of the capabilities of the platforms is exercised to achieve synergy. The details of 30 rental apartments were keyed in as the test entries for the platform. Any search performed on the platform filtered through these entries in order to produce results.

Each platform is used in such a way to capitalize on its strengths. The Real Estate Management platform is best suited for people in the office who may not be too familiar with GIS platforms and thus is primarily a data entry and management type of platform. The workers in the field who collect data on the apartments need a simple tool to collect data with and the GIS platform – ArcGIS Online - provides for this through a field data collection smartphone app named Collector for ArcGIS. The public-facing web application is interactive and responsive for users on the go. The application, powered by the Web GIS platform, is used to create an interactive platform through which users can search for and find rental homes for use. All they need to have is a web browser and access to the internet to access the site and carry out their searches. The *Pata Maskani* web application is not affiliated with any particular agency and does not position itself as a realtor's site. It functions as a realty advisor site in that the core goal of the application is to assist the public in choosing a rental home in convenient surroundings. Nairobi residents are known to spend a large portion of their monthly earnings, over 40%, on housing (Business Daily, 2015) and thus every rental purchase should be value for money. The application achieves this by offering to incorporate many sources of surrounding data, such as road data, crime data and

nearby facilities to assist the user in making a choice on the rental home that will suit him or her. This assists the administrators of the portal and the real estate management solution to endear themselves to the public as a trusted brand and legitimizes other real estate related services or products that they may have to offer.

The public web application allows users to search by their preferred apartment features (such as number of bedrooms, bathrooms, price and availability of amenities) but also goes a step further and allows the user to investigate the surroundings of the apartments that meet his or her criteria. Though the application attempts to be extensive in the type of data overlays it provides for the user, there does not currently exist a substitute for visiting a potential home to experience the house for oneself. To cater for this, the contacts of the required agent are provided in order for the user to connect with the agent who is selling the desired property. Even so, the visualization of data both spatial and non-spatial about rental apartments on the web platform underscores the importance of spatial details when choosing an apartment.

The deployment of the public facing web tool on a cloud platform provides for a more stable hosting platform especially as concerns capability for high availability and scalability of the application. Public facing systems are known to fail when faced with an avalanche of users in a short period of time (Shaw, 2013). Cloud platforms provide for solutions to scale in and out depending on usage. Additionally, due to the use of redundant and distributed virtual cloud servers, the effect of downtimes prevalent in systems that host applications/solutions on premise is minimized greatly.

4.4 Challenges Encountered

A number of impediments affected the outcome of this project. These impediments may be categorised as follows:

4.4.1 Challenges in simulating a Real Estate Management platform

The Real Estate Management platform was the first application to be embarked on. The initial intention had been to make use of an existing Real Estate Management application and link it to a Web GIS platform. Unfortunately, none was forthcoming and thus the decision was made to

create a simulation of the same. The author was not well versed in the creation of ASP.NET MVC applications and thus a steep learning curve was encountered while creating the platform.

4.4.1 Challenges in obtaining Lifestyle Data Overlay data

The Lifestyle Overlay data that users of the public facing web application use to inform their choices proved to be quite difficult to obtain – especially crime data which appears to be top on the list of information which many rental home seekers would like to have about a potential purchase. The crime data that was eventually put on display was sparse and not able to give a nuanced visualization, such as a surface, for the desired areas. The application currently displays dated point data as a simulation of how crime data can be used to help inform home seekers of the surroundings of their prospective home choices.

4.4.2 Challenges in creation of the Public Facing Web application

The Public Web Application was created from a configurable template provided by the ArcGIS Online and thus did not pose a problem at the creation stage. It however posed a problem as concerns the theming. This involved the need for knowledge about the use of HTML and CSS in web application development and necessitated the use of time and effort to get it right, or at the very least – to an expectable standard.

There also arose challenges in the use of map popups in the public facing application. The logic used to create the pop ups on the Web GIS platform did not always translate well on the web application and thus adjustments had to be made to accommodate these discrepancies. Hosting of both the Real Estate Management and Public Facing applications also was an issue but was solved by the use of an already existing cloud server that was made available for use.

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

This project used two web applications – a Real Estate Management application and a Web GIS powered public facing web application to conceptualize how GIS and Real Estate Management Systems could be integrated to market and manage facilities on the web. Through the Real Estate Management System, managers of the portal are able to maintain a database of rental properties, the features that dominate these properties, the agents who are selling these properties as well as an audit trail of transactions regarding these properties. The same system also proved that the data housed within such a RDBMS system could be synchronized with a Web GIS platform to allow field operatives to keep up to date and verified records on the rental properties. The Web GIS platform allowed users to make use of geospatial functions without necessarily exposing its complexities to the users.

The project was also able to demonstrate that a Front Facing Public Web GIS powered application that emphasizes neighbourhood features in addition to desired home amenities is a viable approach to home buying/renting. Through this web application, the public can browse through a complete and comprehensive inventory of all the rental properties as exposed to them through a user-friendly Web GIS interface. This allows visual interpretation of the environment around an apartment in the form of a map and consequently better-informed decision making. The results of this project confirm that the inclusion of Web GIS is indeed cutting-edge technology in the management and marketing of real estate and as its full potential is realized, the real estate market will move to higher levels of efficiency which will enhance the Kenyan experience as concerns house hunting. However, it is only through integration with currently existing systems that this can happen.

The current landscape of real estate marketing sites consists of interfaces which show an assortment of photographs and a checklist of home amenities. With applications such as the ones discussed in this project, realtors and real estate web programmers can focus on providing unique experiences for prospective homebuyers. Data on neighbourhoods could be augmented by

incorporating census data, linking news reports, and integrating social media posts. Including such options in home searches will act as an invaluable tool for realtors – in terms of analysing home buying trends as a means of market research; and home seekers - by enhancing the home search process.

5.2 Recommendations

The applications that were created as a result of this project were designed as simulations of interfaces to dynamic real estate and Web GIS databases. As more Kenyans turn to online real estate listings to perform home searches, the following are recommendations for future work that could be done to provide more rewarding experiences for prospective homebuyers online:

- i) The Real Estate Management platform could provide an interface for agents to upload details on available properties and provide options for agents to access visitor statistics for their properties and respond to email enquiries.
- ii) The Public Facing Web platform could be enhanced to allow users to create profiles when visiting the site. Registered users could key in their preferred search criteria and receive email alerts when rental properties that fit their tastes are placed on the portal. The portal could also be enhanced to add a ‘Favourites’ section that shortlists apartments which are similar to the apartments that a user has shown interest in before.
- iii) The Public Facing Web platform could be re-invented as a native mobile application that could be downloaded on any platform. This would ensure that users need not remember the URL of the map application’s site and can launch the app whenever need be
- iv) The Public Facing Web application could also make use of virtual tours with 360-degree 3D views of properties in order to immerse the user in the most realistic virtual house hunting experience
- v) Data overlays on the Public Facing Web application, such as crime data, needs to be up to date and regularly refreshed to provide a more accurate depiction of conditions on the ground
- vi) Though the scope of the project was limited to Nairobi and Kiambu Counties, both these applications can be scaled to work for a global or country-wide dataset. The applications

could also be used for other types of asset management and tweaked to fit different datasets.

References

- Alexa.com. (2017, January 31). *Top Sites in Kenya - Alexa*. Retrieved July 14, 2017, from Alexa.com: <http://www.alexa.com/topsites/countries/KE>
- Anderson, R. (2013, October 17). *Adding a Controller*. Retrieved July 18, 2017, from docs.microsoft.com: <https://docs.microsoft.com/en-us/aspnet/mvc/overview/getting-started/introduction/adding-a-controller>
- Benjamin, J. D. (2005). Technology and Real Estate Brokerage Firm Financial Performance. *The Journal of Real Estate Research* 27, 409-426.
- Blower, J. (2010). *GIS in the cloud: implementing a Web Map Service on Google App Engine*. Reading: University of Reading. Retrieved June 17, 2017
- Business Daily. (2015, March 17). *Business Daily: Economy*. Retrieved July 18, 2017, from Business Daily: <http://www.businessdailyafrica.com/news/City-residents-spend-40pc-of-income-on-rent/539546-2655694-cocq01z/index.html>
- Business Daily. (2015, April 9). *Kenya rural birth rates defy family planning drive*. Retrieved from Business Daily: <http://www.businessdailyafrica.com/Kenya-s-poor-households-in-child-bearing-rat-race/-/539546/2679794/-/y3ojx3z/-/index.html>
- CAK. (2014, October). *Quarterly Sector Statistics Report: First Quarter of the Financial Year 2014/15*. Retrieved July 12, 2017, from CAK: <http://www.ca.go.ke/images/downloads/STATISTICS/Sector%20Statistics%20Report%20Q1%202014-2015.pdf>
- Canaan, P. (2017, March 4). *8 Things To Consider When Renting A House/Apartment In Kenya*. Retrieved from Canaan Properties: <http://www.canaanproperties.co.ke/blog/47-8-things-to-consider-when-renting-a-house-apartment-in-kenya>
- Cytonn Investments. (2016, April 25). *Cytonn Investments*. Retrieved from <http://www.cytonn.com>: http://www.cytonn.com/download/Residential_Research.pdf
- Dafe, F. (2009). *No Business Like Slum Business? The Political Economy of the Continued Existence of the Slums: Case Study of Nairobi*. London: Development Studies Institute, London School of Economics.
- DeMeritt, M. (2009). *Pleasing Bosses and Customers*. Retrieved from ArcUser Online: <http://www.esri.com/news/arcuser/0609/aspnetmvc.html>
- DiNucci, D. (1999). Fragmented Future. *PRINT*, p. 32.

- Dojo. (2017). *Dojo Toolkit*. Retrieved August 25, 2017, from Dojo Toolkit:
<https://dojotoolkit.org/>
- Donlon, K. (2007). Using GIS to Improve the Services of a Real Estate Company. *Volume 10: Papers in Resource Analysis*, 11.
- Dowling, J. N. (2014). *Finding Your Best-Fit Neighborhood: A Web GIS Application for Online Residential Property Searches for Anchorage, Alaska*. Alaska: University of Southern California. Retrieved July 18, 2017
- Esri. (2006). *ESRI Brings The Geographic Advantage to Real Estate*. Retrieved June 14, 2017, from Esri: <http://www.esri.com/library/brochures/pdfs/esri-real-estate.pdf>
- Esri. (2007). *GIS in Real Estate: Best Practices*. Retrieved July 18, 2017, from esri.com: <http://www.esri.com/library/bestpractices/real-estate.pdf>
- Esri. (2011). *Intelligent Web Maps and ArcGIS Online*. Retrieved from ArcNews: <http://www.esri.com/news/arcnews/summer11/articles/intelligent-web-maps-and-arcgis-online.html>
- Esri. (2013). *ArcGIS Server REST API - Overview*. Retrieved July 18, 2017, from ArcGIS Server REST API: <http://resources.arcgis.com/en/help/rest/apiref/>
- Esri Eastern Africa. (2013). Esri Eastern Africa Profile.
- Fu, P., & Sun, J. (2011). *Web GIS principles and applications*. Redlands, California: Esri Press. Retrieved January 24, 2017
- Government of Kenya. (2013, March 18). *Vision 2030 - Vision*. Retrieved from www.vision2030.go.ke: <http://www.vision2030.go.ke/index.php/vision>
- Hagey, P. (2014, March 03). *Zillow, Trulia, realtor.com now capturing 1 in 3 desktop visits in real estate category*. Retrieved July 14, 2017, from InMan.com: <http://www.inman.com/2014/03/03/zillow-trulia-realtor-com-now-capturing-1-in-3-desktop-visits-in-real-estate-category/>
- Keja Hunt*. (2016). Retrieved January 23, 2017, from Keja Hunt: <http://kejahunt.com/>
- KNBS. (2010). *Kenya 2009 Population and Housing Census*. Nairobi: Government Printer.
- KNBS. (2010). *Kenya 2009 Population and Housing Census*. Nairobi: Government Printer.
- KNBS. (2014). *Kenya National Housing Survey 2012/2013*. Retrieved from <http://statistics.knbs.or.ke>: <http://statistics.knbs.or.ke/nada/index.php/catalog/83/download/520>

- KNBS. (2015, December). *Kenya Demographic and Health Survey 2014*. Retrieved July 20, 2017, from Kenya National Bureau of Statistics:
<https://dhsprogram.com/pubs/pdf/fr308/fr308.pdf>
- Kouyoumjian, V. (2010, January 15). *The New Age of Cloud Computing and GIS*. Retrieved June 6, 2017, from Esri ArcWatch January 2010:
<http://www.esri.com/news/arcwatch/0110/feature.html>
- Law, D. (2014, January). Portal for ArcGIS 101. *ArcUser*. Retrieved June 14, 2017
- Lazauskas, J. (2013, June 4). *How The Cloud Is Empowering Developing Nations*. Retrieved July 2, 2017, from Forbes: <http://www.forbes.com/sites/centurylink/2013/06/04/how-the-cloud-is-empowering-developing-nations/>
- Maguire, D. J. (2008). GeoWeb 2.0 and its implications for geographic information science and technology. *Proceedings of the Geospatial Information and Technology Association Conference*. Seattle. Retrieved June 6, 2017
- Microsoft. (2017). *ASP.NET*. Retrieved July 18, 2017, from The ASP.NET Site:
<https://www.asp.net/>
- MLPP. (2016, April 20). *HOUSING SITUATION IN KENYA*. Retrieved June 5, 2017, from Ministry of Lands and Physical Planning: <http://www.ardhi.go.ke/?p=121>
- Musyoka, P. K. (2012). *Demand for Housing in Urban Kenya: The Case of Households in Nairobi and Mombasa Counties*. Retrieved July 24, 2017, from The Kenya Institute for Public Policy Research and Analysis:
http://kippra.or.ke/index.php?option=com_docman&task=doc_view&gid=278&Itemid=
- MySpace Properties Kenya*. (2017). Retrieved July 15, 2017, from
<http://myspacepropertieskenya.com/>
- National Geographic. (2006). *Map*. Retrieved August 29, 2017, from National Geographic:
<https://www.nationalgeographic.org/encyclopedia/map/>
- NIST. (2011, September). The NIST Definition of Cloud Computing. Gaithersberg, Maryland, United States of America: National Institute of Standards and Technology (NIST). Retrieved June 20, 2017
- O'Reilly, T. (2005, 09 30). *What Is Web 2.0?* Retrieved July 2, 2017, from O'Reilly Media:
<http://www.oreilly.com/pub/a/web2/archive/what-is-web-20.html>

- Oxford Business Group. (2016, February 12). *Kenya's retail sector ranks as second-most formalised in Africa*. Retrieved July 14, 2017, from Oxford Business Group: <https://www.oxfordbusinessgroup.com/news/kenya%E2%80%99s-retail-sector-ranks-second-most-formalised-africa>
- Oxford Business Group. (2016, February 12). *The Report: Kenya 2016*. Retrieved July 14, 2017, from Oxford Business Group: <https://www.oxfordbusinessgroup.com/kenya-2016>
- Piyush Tiwari, J. P. (1997). Demand for housing in the Bombay Metropolitan Region. *Journal of Policy Modeling Volume 19, Issue 3*, <http://www.sciencedirect.com/science/article/pii/S0161893896000531>. Retrieved June 10, 2017
- Preston, V. I. (2013). *Factors influencing choice of rental houses among middle class residents of Nairobi county Kenya*. Nairobi: University of Nairobi. Retrieved July 19, 2017
- Ryden International. (2017). Retrieved July 16, 2017, from <http://www.ryden.co.ke/>
- Shaw, A. (2013, July 4). *Jay-Z's 'Magna Carter Holy Grail' Samsung app crashes at midnight: Twitter reacts*. Retrieved July 21, 2017, from [rollingout.com](http://rollingout.com/2013/07/04/jay-zs-magna-carter-holy-grail-samsung-app-crashes-at-midnight-twitter-reacts/): <http://rollingout.com/2013/07/04/jay-zs-magna-carter-holy-grail-samsung-app-crashes-at-midnight-twitter-reacts/>
- Smith, L. R. (1988). Recent Developments in Economic Models of Housing Markets. *Journal of Economic Literature XXVI*, 29-64.
- SoftKenya.com. (2016). *Property and Real Estate Companies in Kenya*. Retrieved July 27, 2017, from SoftKenya.com: <https://softkenya.com/directory/property-companies-in-kenya/>
- Thompson, H. (2011, March 14). *Matching Your Home To Your Lifestyle*. Retrieved July 18, 2017, from Esri Insider: <https://blogs.esri.com/esri/esri-insider/2011/03/14/matching-your-home-to-your-lifestyle/>
- WHO. (1989). *Health Principles of Housing*. Geneva: WHO.
- Wikipedia. (2016). *.NET Framework*. Retrieved July 18, 2017, from Wikipedia.com: https://en.wikipedia.org/wiki/.NET_Framework
- World Bank. (2011). *Kenya Economic Update: Turning the Tide in Turbulent Times*. Poverty Reduction and Economic Management Unit Africa Region.

APPENDICES

Appendix A

The process of publishing a feature GIS Service

(Only one service publishing instance is shown since the process remains the same for any service)

Once your map is created on ArcMap, sign into the GIS portal into which the layer will be published.

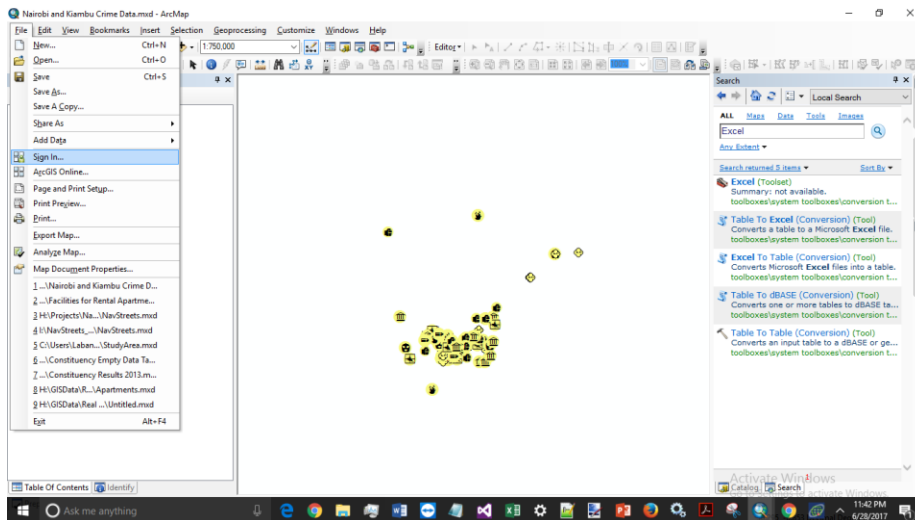


Figure 57: Signing into GIS Platform

ArcGIS Desktop wants to access your ArcGIS Online account information

Sign In **esri**

Username

Password

SIGN IN **CANCEL**


[Forgot password?](#) [Forgot username?](#)

OR

Sign in with ENTERPRISE ACCOUNT

Sign in with

ArcGIS Desktop developed by:



Esri

Esri publishes a set of ready-to-use maps and apps that are available as part of ArcGIS. ArcGIS is a mapping platform that enables you to create interactive maps and apps to share within your organization or publicly.

Sign me in automatically

Figure 58: Signing in Page

Once signed in, from the File menu, point to **Share As**, and then click Service:

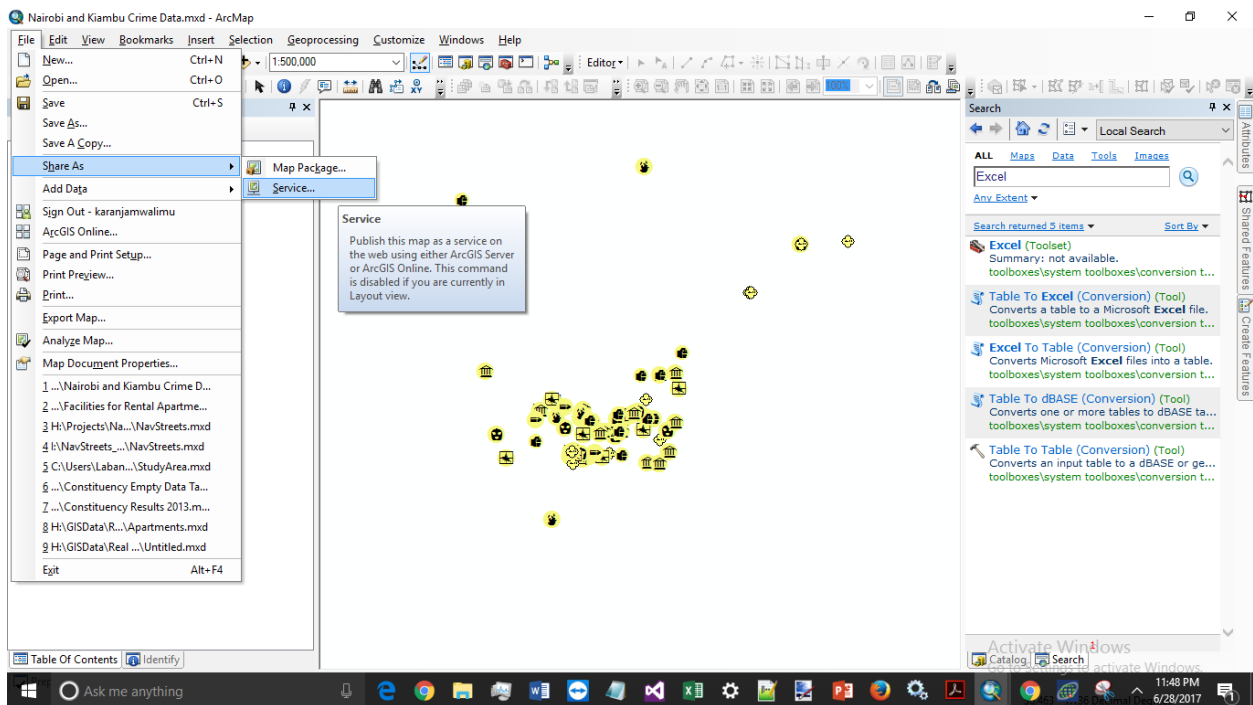


Figure 59: Sharing as a Service

The following dialog appears. A service is being published, so the default choice is accepted and **Next** is clicked.

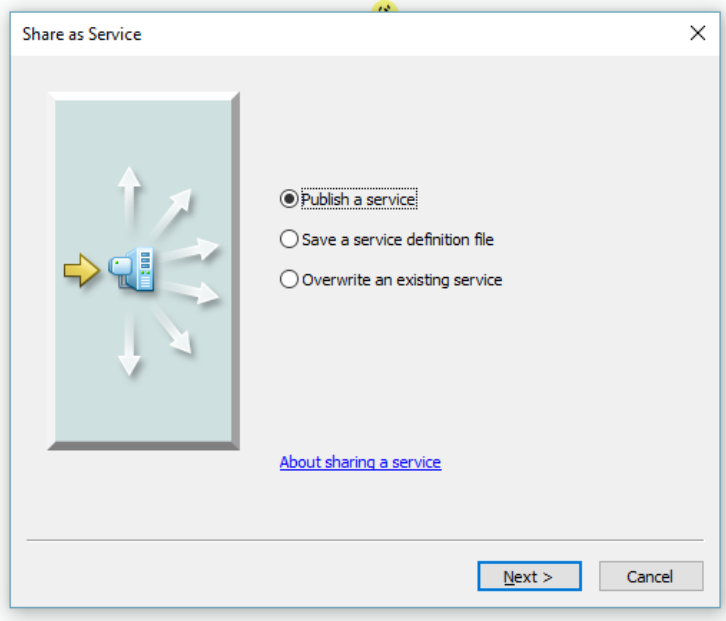


Figure 60: Choosing the Publish option

Below **Choose A Connection**, the publisher connection is selected. For the Service Name, the appropriate name is typed and then **Continue** is clicked:

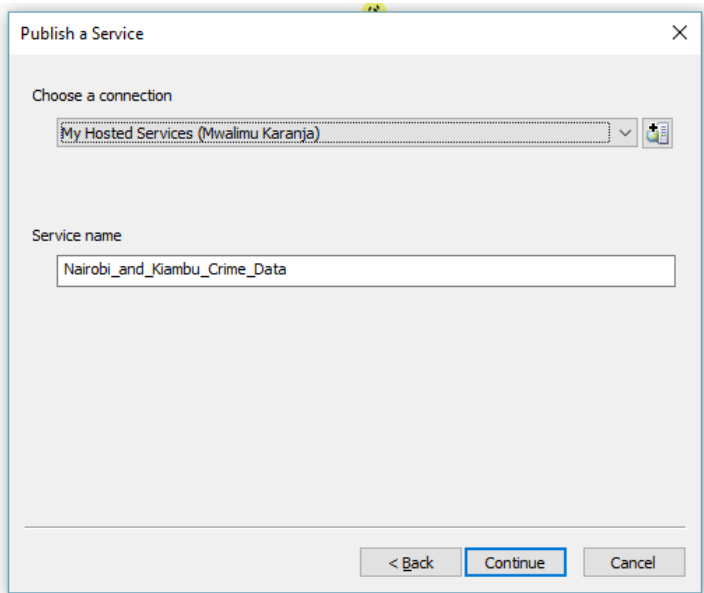


Figure 61: Publish Dialog

The Service Editor opens, which allows one to set properties for a new service. The first thing done is verification that **Feature Access** is selected and **Tiled Mapping** is cleared.

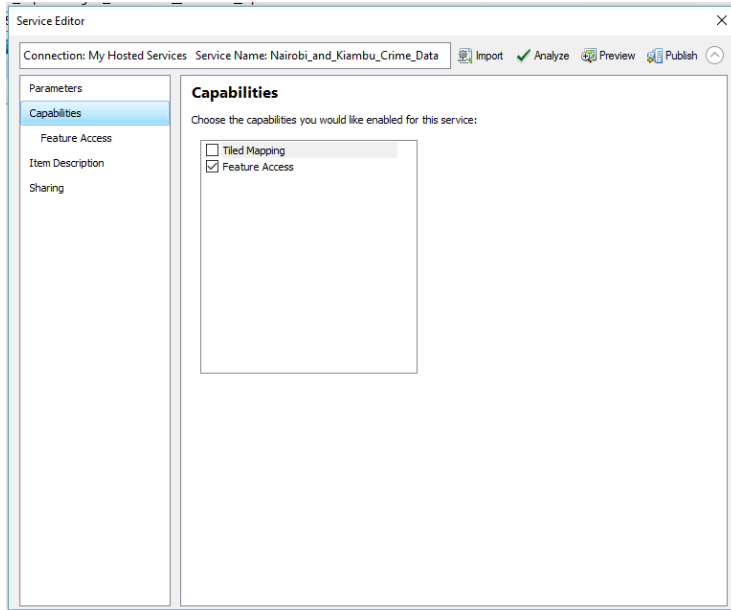


Figure 62: Service Editor Dialog

On the left side of the dialog box, the **Item Description** is clicked and a **Summary** of what the layer represents is typed and **Tags** added. Tags are added to allow people to search for the service easily on the ArcGIS Online GIS Portal. Your summary and tags are included in the **Item Description** of the new map service.

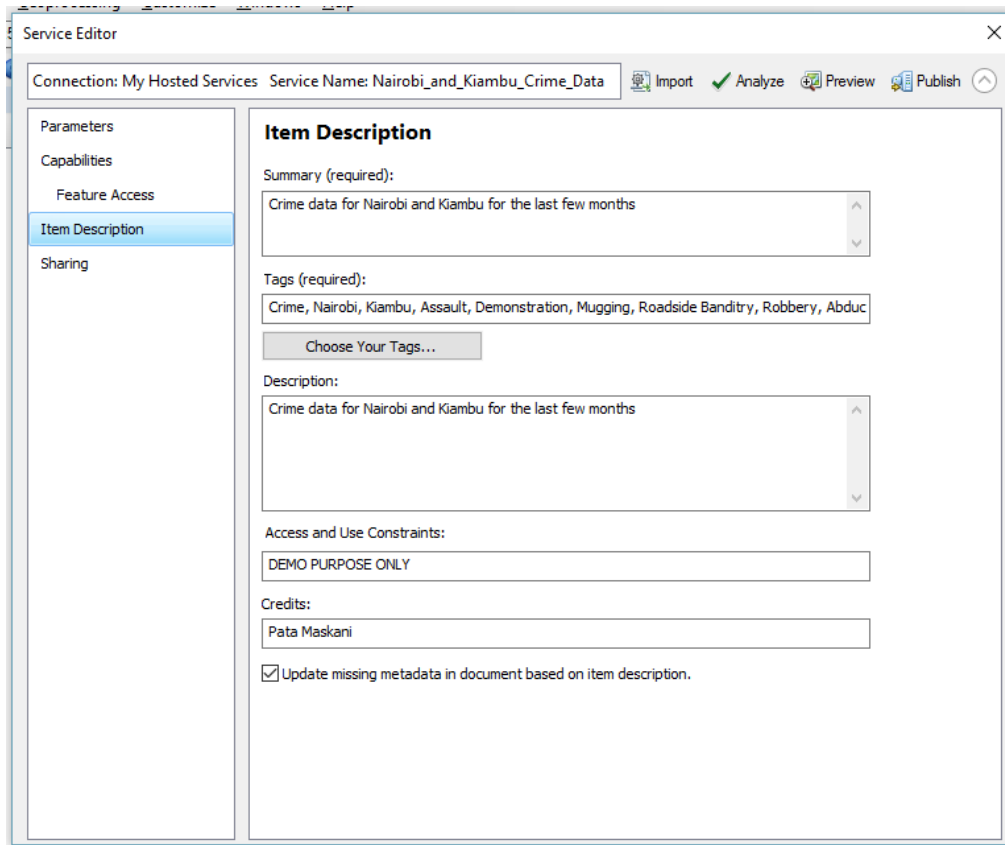


Figure 63: Adding Item Descriptions

The **Sharing** tab is then clicked, and the check box selected for the option to share with whichever group of people one might want to share the service with. Once this is done, the **Publish** button is then clicked.

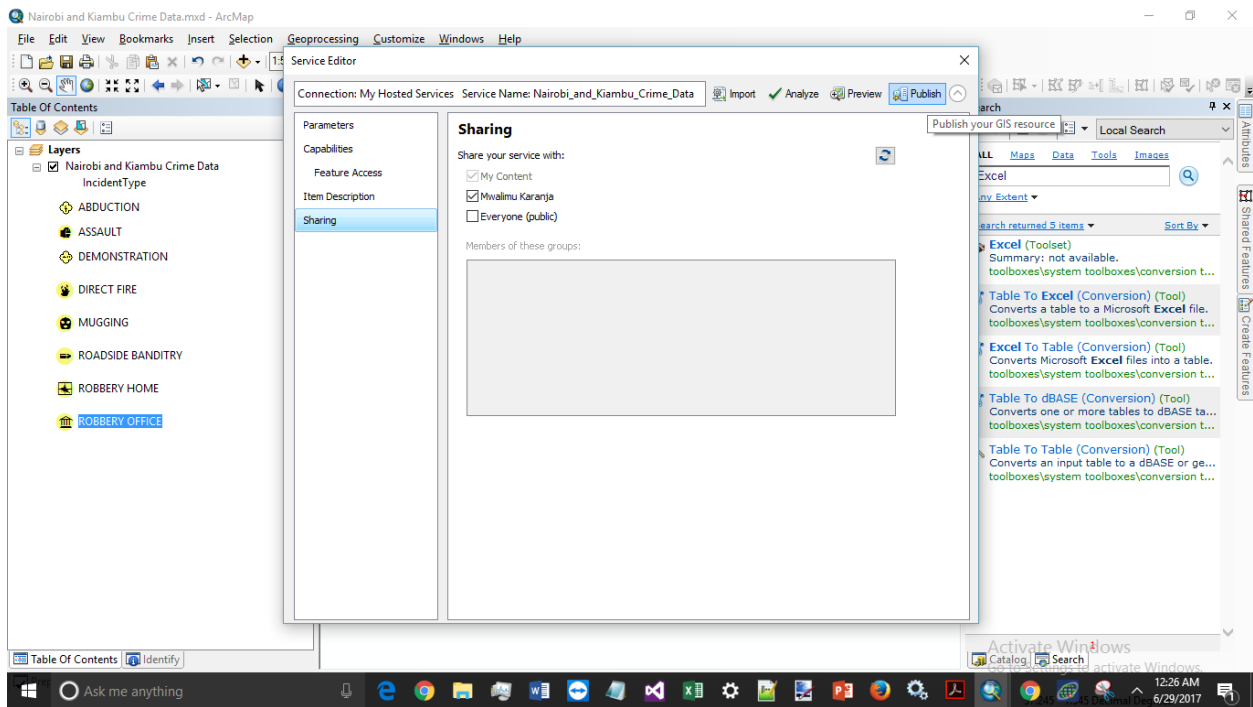


Figure 64: Sharing Options

When the Service Publishing Result message notifies one that the service has successfully published, the **OK** button is clicked.

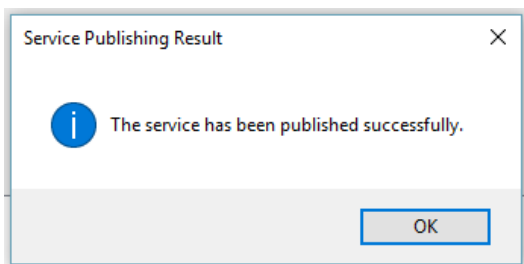


Figure 65: Successful Publish

This procedure ensures that the map is now published as a GIS Service Layer. To see the service layer, one needs to log on to the online platform on a browser by visiting ArcGIS.com, entering one's credentials and signing in. Once signed in, one can search for the dataset by typing in one of the tags placed in the Tag section in the search box and pressing enter. The dataset will be displayed as follows:

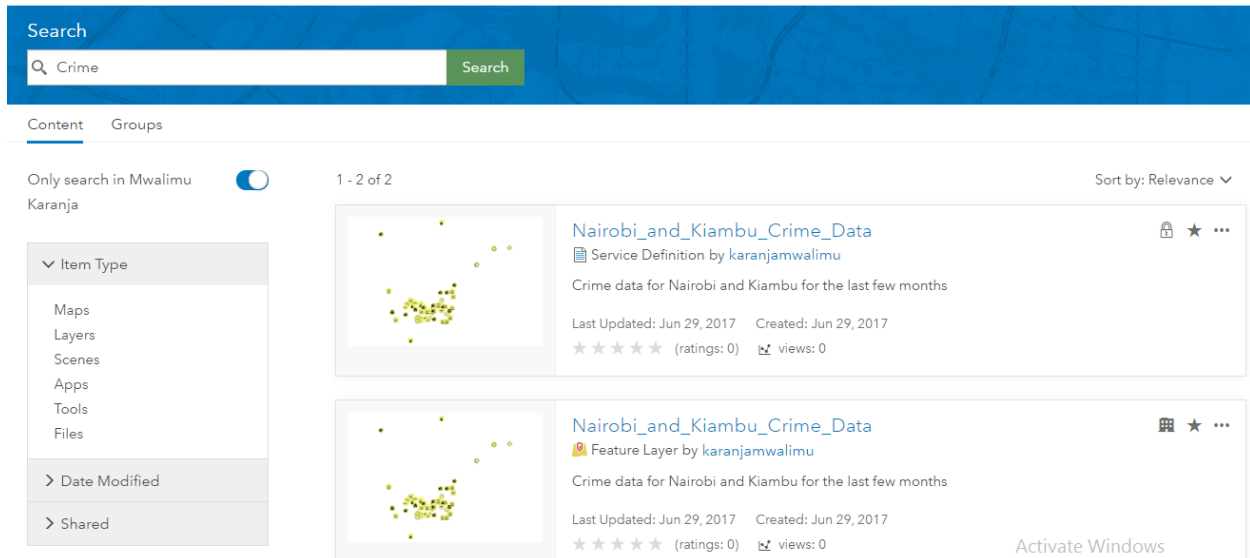


Figure 66: Web Application Development Published Service

Appendix B

Creation of Real Estate Management RDBMS in SQL Server Express 2016

```

USE [master]
GO
/***** Object: Database [RentManagement]    Script Date: 6/26/2017 10:18:35 PM *****/
CREATE DATABASE [RentManagement]
    CONTAINMENT = NONE
    ON PRIMARY
( NAME = N'RentManagement', FILENAME = N'C:\Program Files\Microsoft SQL
Server\MSSQL13.MSSQLSERVER\MSSQL\DATA\RentManagement.mdf' , SIZE = 8192KB , MAXSIZE =
UNLIMITED, FILEGROWTH = 65536KB )
    LOG ON
( NAME = N'RentManagement_log', FILENAME = N'C:\Program Files\Microsoft SQL
Server\MSSQL13.MSSQLSERVER\MSSQL\DATA\RentManagement_log.ldf' , SIZE = 8192KB , MAXSIZE =
2048GB , FILEGROWTH = 65536KB )
GO
ALTER DATABASE [RentManagement] SET COMPATIBILITY_LEVEL = 130
GO
IF (1 = FULLTEXTSERVICEPROPERTY('IsFullTextInstalled'))
begin
EXEC [RentManagement].[dbo].[sp_fulltext_database] @action = 'enable'
end
GO
ALTER DATABASE [RentManagement] SET ANSI_NULL_DEFAULT OFF
GO
ALTER DATABASE [RentManagement] SET ANSI_NULLS OFF
GO
ALTER DATABASE [RentManagement] SET ANSI_PADDING OFF
GO
ALTER DATABASE [RentManagement] SET ANSI_WARNINGS OFF
GO

```

```

ALTER DATABASE [RentManagement] SET ARITHABORT OFF
GO
ALTER DATABASE [RentManagement] SET AUTO_CLOSE OFF
GO
ALTER DATABASE [RentManagement] SET AUTO_SHRINK OFF
GO
ALTER DATABASE [RentManagement] SET AUTO_UPDATE_STATISTICS ON
GO
ALTER DATABASE [RentManagement] SET CURSOR_CLOSE_ON_COMMIT OFF
GO
ALTER DATABASE [RentManagement] SET CURSOR_DEFAULT GLOBAL
GO
ALTER DATABASE [RentManagement] SET CONCAT_NULL_YIELDS_NULL OFF
GO
ALTER DATABASE [RentManagement] SET NUMERIC_ROUNDABORT OFF
GO
ALTER DATABASE [RentManagement] SET QUOTED_IDENTIFIER OFF
GO
ALTER DATABASE [RentManagement] SET RECURSIVE_TRIGGERS OFF
GO
ALTER DATABASE [RentManagement] SET DISABLE_BROKER
GO
ALTER DATABASE [RentManagement] SET AUTO_UPDATE_STATISTICS_ASYNC OFF
GO
ALTER DATABASE [RentManagement] SET DATE_CORRELATION_OPTIMIZATION OFF
GO
ALTER DATABASE [RentManagement] SET TRUSTWORTHY OFF
GO
ALTER DATABASE [RentManagement] SET ALLOW_SNAPSHOT_ISOLATION OFF
GO
ALTER DATABASE [RentManagement] SET PARAMETERIZATION SIMPLE
GO
ALTER DATABASE [RentManagement] SET READ_COMMITTED_SNAPSHOT OFF
GO
ALTER DATABASE [RentManagement] SET HONOR_BROKER_PRIORITY OFF
GO
ALTER DATABASE [RentManagement] SET RECOVERY FULL
GO
ALTER DATABASE [RentManagement] SET MULTI_USER
GO
ALTER DATABASE [RentManagement] SET PAGE_VERIFY CHECKSUM
GO
ALTER DATABASE [RentManagement] SET DB_CHAINING OFF
GO
ALTER DATABASE [RentManagement] SET FILESTREAM( NON_TRANSACTED_ACCESS = OFF )
GO
ALTER DATABASE [RentManagement] SET TARGET_RECOVERY_TIME = 60 SECONDS
GO
ALTER DATABASE [RentManagement] SET DELAYED_DURABILITY = DISABLED
GO
EXEC sys.sp_db_vardecimal_storage_format N'RentManagement', N'ON'
GO

```

Appendix C

SQL commands that created the database schema / skeleton

```
USE [RentManagement]
```

```

GO
/***** Object: Table [dbo].[Agents]    Script Date: 6/26/2017 10:18:36 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[Agents](
    [AgentID] [bigint] IDENTITY(1,1) NOT NULL,
    [AgentName] [varchar](100) NOT NULL,
    [AgentNumber] [varchar](20) NOT NULL,
    CONSTRAINT [PK_Agents] PRIMARY KEY CLUSTERED
(
    [AgentID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[ApartmentOwners]    Script Date: 6/26/2017 10:18:36 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[ApartmentOwners](
    [ApartmentOwnerID] [bigint] IDENTITY(1,1) NOT NULL,
    [ApartmentOwnerName] [varchar](100) NOT NULL,
    [ApartmentOwnerNumber] [varchar](15) NOT NULL,
    [OwnerStartDate] [datetime] NOT NULL,
    [OwnerEndDate] [datetime] NULL,
    CONSTRAINT [PK_ApartmentOwners] PRIMARY KEY CLUSTERED
(
    [ApartmentOwnerID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[ApartmentRentees]    Script Date: 6/26/2017 10:18:36 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[ApartmentRentees](
    [ApartmentRenteeID] [bigint] IDENTITY(1,1) NOT NULL,
    [ApartmentRenteeName] [varchar](200) NOT NULL,
    [ApartmentRenteeNumber] [varchar](20) NOT NULL,

```

```

        [ApartmentRenterIDNumber] [varchar](50) NOT NULL,
        [DateOfRegistration] [datetime] NOT NULL,
    CONSTRAINT [PK_ApartmentRentees] PRIMARY KEY CLUSTERED
    (
        [ApartmentRenteeID] ASC
    )WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
    ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
    ) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[Apartments]    Script Date: 6/26/2017 10:18:36 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[Apartments](
    [ApartmentID] [bigint] IDENTITY(1,1) NOT NULL,
    [ApartmentOwnerID] [bigint] NOT NULL,
    [ApartmentBuildDate] [datetime] NOT NULL,
    [ApartmentStatus] [bit] NOT NULL,
    [NumberOfBedrooms] [int] NOT NULL,
    [NumberOfBathrooms] [int] NOT NULL,
    [ApartmentName] [varchar](200) NOT NULL,
    [ParkingType] [int] NOT NULL,
    [LocationName] [varchar](100) NOT NULL,
    [CurrentPrice] [money] NOT NULL,
    [ApartmentType] [int] NOT NULL,
    [ApartmentSize] [int] NOT NULL,
    [WaterAvailability] [bit] NOT NULL,
    [ElectricityAvailability] [bit] NOT NULL,
    [Latitude] [float] NULL,
    [Longitude] [float] NULL,
    [Floor] [int] NULL,
    [BuildingFloors] [int] NOT NULL,
    [BuildingComplexName] [varchar](100) NULL,
    CONSTRAINT [PK_Apartments] PRIMARY KEY CLUSTERED
    (
        [ApartmentID] ASC
    )WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
    ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
    ) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[ApartmentStatusTrail]    Script Date: 6/26/2017 10:18:36 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
CREATE TABLE [dbo].[ApartmentStatusTrail](
    [ApartmentStatusTrailID] [int] IDENTITY(1,1) NOT NULL,
    [ApartmentID] [bigint] NOT NULL,

```

```

    [ApartmentRenteeID] [bigint] NOT NULL,
    [AgentInvolved] [bigint] NOT NULL,
    [StartDate] [datetime] NOT NULL,
    [EndDate] [datetime] NOT NULL,
    CONSTRAINT [PK_ApartmentStatusTrail] PRIMARY KEY CLUSTERED
(
    [ApartmentStatusTrailID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
/***** Object: Table [dbo].[ApartmentType]    Script Date: 6/26/2017 10:18:36 PM
*****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[ApartmentType](
    [ApartmentTypeID] [int] IDENTITY(1,1) NOT NULL,
    [ApartmentTypeName] [varchar](100) NOT NULL,
    [ApartmentTypeDescription] [varchar](250) NOT NULL,
    CONSTRAINT [PK_ApartmentType] PRIMARY KEY CLUSTERED
(
    [ApartmentTypeID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[ParkingTypes]    Script Date: 6/26/2017 10:18:37 PM *****/
SET ANSI_NULLS ON
GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[ParkingTypes](
    [ParkingTypeID] [int] IDENTITY(1,1) NOT NULL,
    [ParkingTypeName] [varchar](200) NOT NULL,
    [ParkingSpots] [int] NOT NULL,
    [ParkingSecurity] [varchar](20) NOT NULL,
    CONSTRAINT [PK_ParkingTypes] PRIMARY KEY CLUSTERED
(
    [ParkingTypeID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
/***** Object: Table [dbo].[Photos]    Script Date: 6/26/2017 10:18:37 PM *****/
SET ANSI_NULLS ON

```

```

GO
SET QUOTED_IDENTIFIER ON
GO
SET ANSI_PADDING ON
GO
CREATE TABLE [dbo].[Photos](
    [PhotoID] [bigint] IDENTITY(1,1) NOT NULL,
    [PhotoName] [varchar](200) NOT NULL,
    [ApartmentID] [bigint] NOT NULL,
    [PhotoSection] [varchar](50) NOT NULL,
    CONSTRAINT [PK_Photos] PRIMARY KEY CLUSTERED
(
    [PhotoID] ASC
)WITH (PAD_INDEX = OFF, STATISTICS_NORECOMPUTE = OFF, IGNORE_DUP_KEY = OFF,
ALLOW_ROW_LOCKS = ON, ALLOW_PAGE_LOCKS = ON) ON [PRIMARY]
) ON [PRIMARY]

GO
SET ANSI_PADDING OFF
GO
ALTER TABLE [dbo].[Apartments] ADD CONSTRAINT [DF_Apartments_WaterAvailability] DEFAULT
('True') FOR [WaterAvailability]
GO
ALTER TABLE [dbo].[Apartments] ADD CONSTRAINT [DF_Apartments_ElectricityAvailability]
DEFAULT ('False') FOR [ElectricityAvailability]
GO
ALTER TABLE [dbo].[Apartments] WITH CHECK ADD CONSTRAINT
[FK_Apartments_ApartmentOwnerID] FOREIGN KEY([ApartmentOwnerID])
REFERENCES [dbo].[ApartmentOwners] ([ApartmentOwnerID])
GO
ALTER TABLE [dbo].[Apartments] CHECK CONSTRAINT [FK_Apartments_ApartmentOwnerID]
GO
ALTER TABLE [dbo].[Apartments] WITH CHECK ADD CONSTRAINT [FK_Apartments_ApartmentType]
FOREIGN KEY([ApartmentType])
REFERENCES [dbo].[ApartmentType] ([ApartmentTypeID])
GO
ALTER TABLE [dbo].[Apartments] CHECK CONSTRAINT [FK_Apartments_ApartmentType]
GO
ALTER TABLE [dbo].[Apartments] WITH CHECK ADD CONSTRAINT [FK_Apartments_ParkingType]
FOREIGN KEY([ParkingType])
REFERENCES [dbo].[ParkingTypes] ([ParkingTypeID])
GO
ALTER TABLE [dbo].[Apartments] CHECK CONSTRAINT [FK_Apartments_ParkingType]
GO
ALTER TABLE [dbo].[ApartmentStatusTrail] WITH CHECK ADD CONSTRAINT
[FK_ApartmentStatusTrail_AgentInvolved] FOREIGN KEY([AgentInvolved])
REFERENCES [dbo].[Agents] ([AgentID])
GO
ALTER TABLE [dbo].[ApartmentStatusTrail] CHECK CONSTRAINT
[FK_ApartmentStatusTrail_AgentInvolved]
GO
ALTER TABLE [dbo].[ApartmentStatusTrail] WITH CHECK ADD CONSTRAINT
[FK_ApartmentStatusTrail_ApartmentID] FOREIGN KEY([ApartmentID])
REFERENCES [dbo].[Apartments] ([ApartmentID])
GO
ALTER TABLE [dbo].[ApartmentStatusTrail] CHECK CONSTRAINT
[FK_ApartmentStatusTrail_ApartmentID]
GO

```



```

ALTER TABLE [dbo].[ApartmentStatusTrail] WITH CHECK ADD CONSTRAINT
[FK_ApartmentStatusTrail_ApartmentRenteeID] FOREIGN KEY([ApartmentRenteeID])
REFERENCES [dbo].[ApartmentRentees] ([ApartmentRenteeID])
GO
ALTER TABLE [dbo].[ApartmentStatusTrail] CHECK CONSTRAINT
[FK_ApartmentStatusTrail_ApartmentRenteeID]
GO
ALTER TABLE [dbo].[Photos] WITH CHECK ADD CONSTRAINT [FK_Photos_ApartmentID] FOREIGN
KEY([ApartmentID])
REFERENCES [dbo].[Apartments] ([ApartmentID])
GO
ALTER TABLE [dbo].[Photos] CHECK CONSTRAINT [FK_Photos_ApartmentID]
GO
USE [master]
GO
ALTER DATABASE [RentManagement] SET READ_WRITE
GO

```

Appendix D

Schema of the Rental Apartment/Real Estate Management Database

RentApartment Database Documentation

ApartmentOwners

This table houses details of people who own apartments

Field	Description	Type	Default	Other
ApartmentOwnerID	Identifying number of Apartment Owner	bigint		PK
ApartmentOwnerName	Name of apartment owner	string		
ApartmentOwnerNumber	Mobile phone number of apartment owner	varchar(15)		
OwnerStartDate	When did the owner of the apartment register with the service?	date		
OwnerEndDate	When did the owner of the apartment deregister with the service?	date		NULLABLE

Apartments

Field	Description	Type	Default	Other
ApartmentID	Identifying number of Apartment	bigint		PK
ApartmentOwnerID	Relating the Apartment with the owner table	bigint		FK
ApartmentBuildDate	When was the apartment built?	date		
ApartmentStatus	Is the apartment rented or nah?	bit		

Field	Description	Type	Default	Other
NumberOfBedrooms	How many bedrooms does the apartment possess?	int		
NumberOfBathrooms	How many bathrooms does the apartment possess?	int		
ApartmentName	Name of the apartment	varchar(200)		
ParkingType	What type of parking is available for the owner of the apartment?	int		FK
LocationName	Name of the apartment's location	varchar(100)		
CurrentPrice	What is the current price of the aptment?	money		
ApartmentType	Relating Apartment with the type table	int		FK
ApartmentSize	Size of the apartment	int		

ApartmentType

Field	Description	Type	Default	Other
ApartmentTypeID	Identifying Apartment type	int		PK
ApartmentTypeName	Name of Apartment Type	varchar(100)		
ApartmentTypeDescription	Description of the Apartment Type	varchar((250)		

ParkingTypes

Field	Description	Type	Default	Other
ParkingTypeID	Identifying number of the Parking type	int		PK
ParkingTypeName	Name of the Parking type	varchar(200)		
ParkingSpots	Number of Parking Spaces per apartment	int		
ParkingSecurity	Public or private parking	varchar(20)		

ApartmentStatusTrail

Field	Description	Type	Default	Other
ApartmentStatusTrailID	Identifying number of Apartment Status trail	int		PK
ApartmentID	Relating Apartment with the status trail	bigint		FK
ApartmentRenteelID	Relating Status trail with the person who rented the apartment	bigint		FK
AgentInvolved	Identifying agent involved in transaction	bigint		FK
StartDate	Date of renting apartment	date		

Field	Description	Type	Default	Other
EndDate	End date of aparting rent	date		

ApartmentRentees

Field	Description	Type	Default	Other
ApartmentRenteeID	Identifying the ID of a renting person	bigint		PK
ApartmentRenteeName	What's the renting entity's name?	varchar(200)		
ApartmentRenteeNumber	What's the renting entity's pphone number?	varchar(20)		
ApartmentRenterIDNumber	What's the renting entity's ID Number?	varchar(50)		
DateOfRegistration	Date of apartment rent registration	date		

Agents

Field	Description	Type	Default	Other
AgentID	Identifying the Agent who sold an apartment	bigint		PK
AgentName	What's the agent's name?	varchar(100)		
AgentNumber	What's the agent's phone number?	varchar(20)		

Photos

Field	Description	Type	Default	Other
PhotoID	Identifying a particular photo for an apartment	bigint		PK
PhotoName	Name of the photo of the apartment	varchar(200)		
ApartmentID	Relating with the apartment	bigint		FK
PhotoSection	Identifying the section of the photo for an apartment	varchar(50)		

Appendix E

A method to add data to a GIS web service using an ASP.NET MVC Controller action

The method below adds an apartment to the database but only if it is added to the GIS database first – ensuring both systems are kept in sync.

```
// POST: Apartments/Create
// To protect from overposting attacks, please enable the specific properties you
want to bind to, for
// more details see http://go.microsoft.com/fwlink/?LinkId=317598.
[HttpPost]
```

```

[ValidateAntiForgeryToken]
public ActionResult Create([Bind(Include =
"ApartmentID,ApartmentOwnerID,ApartmentBuildDate,ApartmentStatus,NumberOfBedrooms,NumberO
fBathrooms,ApartmentName,ParkingType,LocationName,CurrentPrice,ApartmentType,ApartmentSiz
e,WaterAvailability,ElectricityAvailability,Latitude,Longitude,Floor,BuildingFloors,Build
ingComplexName")] Apartment apartment)
{
    if (ModelState.IsValid)
    {
        //Add to GIS Database
        if (!GetWithParams("karanjamwalimu", "Arc90ln!",
apartment).resultCode.Equals("Result Code: 0000"))
        {
            //Add to database
            dbApartments.Add(apartment);
            db.SaveChanges();
            return RedirectToAction("Index");
        }
        else
        {
            return HttpNotFound();
        }
    }

    ViewBag.ApartmentOwnerID = new SelectList(db.ApartmentOwners,
"ApartmentOwnerID", "ApartmentOwnerName", apartment.ApartmentOwnerID);
    ViewBag.ApartmentType = new SelectList(db.ApartmentTypes, "ApartmentTypeID",
"ApartmentTypeName", apartment.ApartmentType);
    ViewBag.ParkingType = new SelectList(db.ParkingTypes, "ParkingTypeID",
"ParkingTypeName", apartment.ParkingType);
    return View(apartment);
}

```

The following method (GetWithParams) is the actual method that keys in data to the GIS database (hosted online on ArcGIS Online)

```

public Result GetWithParams(string username, string password, Apartment apart)
{
    try
    {
        //Get the Portal in question
        AGOL currentPortal = new AGOL(username, password);

        //define the feature service in question
        var featureServiceURL =
"http://services.arcgis.com/p2yM6iU800nr9nEC/arcgis/rest/services/Apartment
s/FeatureServer";

        //define the URL for querying the feature service based on the plot number
        var queryURL = featureServiceURL + "/0/query";

        //define the URL for adding a feature in the Feature Service

```

```

var updateURL = featureServiceURL + "/0/addFeatures";

var tokenz = currentPortal.Token;

//Create Features Name Value Collection

var updateData = new NameValueCollection();
updateData["token"] = tokenz;
updateData["f"] = "json";

long currentID = dbApartments.Max(v => v.ApartmentID) + 1;

string jsonf = "[{'geometry':{'x':" + apart.Longitude.ToString() + ","
+ "y':" + apart.Latitude.ToString() + "},"
+ "'attributes': {'ApartmentID': " + currentID.ToString() +
+ "'ApartmentOwnerID': " + apart.ApartmentOwnerID.ToString() +
+ "'ApartmentBuildDate': '" + apart.ApartmentBuildDate.ToShortDateString() +
+ "', 'ApartmentStatus': '" + apart.ApartmentStatus.ToString() +
+ "', 'NumberOfBedrooms': " + apart.NumberOfBedrooms.ToString() +
+ "', 'NumberOfBathrooms': " + apart.NumberOfBathrooms.ToString() +
+ "', 'ApartmentName': '" + apart.ApartmentName +
+ "', 'ParkingType': " + apart.ParkingType.ToString() +
+ "', 'LocationName': '" + apart.LocationName +
+ "', 'CurrentPrice': " + apart.CurrentPrice.ToString() +
+ "', 'ApartmentType': '" + apart.ApartmentType.ToString() +
+ "', 'ApartmentSize': " + apart.ApartmentSize.ToString() +
+ "', 'WaterAvailability': '" + apart.WaterAvailability.ToString() +
+ "',
+ "          'ElectricityAvailability': " +
+ apart.ElectricityAvailability.ToString() +
+ "', 'Floor': " + apart.Floor.ToString() +
+ "', 'BuildingFloors': " + apart.BuildingFloors.ToString() +
+ "', 'BuildingComplexName': '" + apart.BuildingComplexName +
+ "', 'FromDatabase': " + "'Y'" + "},"
+ "'spatialReference': {"
+ "'wkid' : '4326'"
+ "}}]";

updateData["features"] = jsonf;

string updateResult = @getQueryResponse(updateData, updateURL);

//Report back on the feature - whether added or not
var uObj = JsonConvert.DeserializeObject(updateResult) as JObject;

if ((JArray)uObj["updateResults"] != null)
{
JArray ufeatures = (JArray)uObj["updateResults"];

string boolResult = ((JObject)ufeatures[0])["success"].ToString();

response.resultText = updateResult;

if (boolResult == "True")

```

```

        {
            response.resultCode = "Result Code: 0000";
            response.resultText = "OK! Feature number " +
                ((JObject)ufeatures[0])["objectId"].ToString() + " successfully
            updated";
        }
        else
        {
            response.resultCode = "Result Code: 0001";
            response.resultText = updateResult + ". Contact Administrator";
        }
    }
    else
    {
        response.resultCode = "Result Code: 0003";
        response.resultText = updateResult + ". Contact Administrator";
    }
}
}
catch (Exception ef)
{
    response.resultCode = "Result Code: 0003";
    response.resultText = ef.Message + ". Contact Administrator";
}
}
return response;
}

```

Appendix F

A method to edit a GIS web service using an ASP.NET MVC Controller action

The method below adds an apartment to the database but only if it is added to the GIS database first – ensuring both systems are kept in sync.

```

public ActionResult Edit(long? id)
{
    if (id == null)
    {
        return new HttpStatusCodeResult(HttpStatusCode.BadRequest);
    }
    Apartment apartment = db.Apartments.Find(id);
    if (apartment == null)
    {
        return HttpNotFound();
    }
    ViewBag.ApartmentOwnerID = new SelectList(db.ApartmentOwners,
"ApartmentOwnerID", "ApartmentOwnerName", apartment.ApartmentOwnerID);
    ViewBag.ApartmentType = new SelectList(db.ApartmentTypes, "ApartmentTypeID",
"ApartmentTypeName", apartment.ApartmentType);
    ViewBag.ParkingType = new SelectList(db.ParkingTypes, "ParkingTypeID",
"ParkingTypeName", apartment.ParkingType);
    return View(apartment);
}

```

The following method (GetWithParams) is the actual method that keys in data to the GIS database (hosted online on ArcGIS Online)

```
public Result GetWithParams(string username, string password, Apartment apart)
{
    try
    {
        //Get the Portal in question
        AGOL currentPortal = new AGOL(username, password);

        //define the feature service in question
        var featureServiceURL = "http://services.arcgis.com/p2yM6iU800nr9nEC/arcgis/rest/services/Apartment/FeatureServer";

        //define the URL for querying the feature service based on the plot number
        var queryURL = featureServiceURL + "/0/query";

        //define the URL for updating a feature in the Feature Service
        var updateURL = featureServiceURL + "/0/updateFeatures";

        //get token from GIS portal
        var tokenz = currentPortal.Token;

        var queryData = new NameValueCollection();
        queryData["where"] = "ApartmentID = '" + id + "'";
        queryData["outFields"] = "*";
        queryData["token"] = tokenz;
        queryData["f"] = "json";

        string queryResult = @getQueryResponse(queryData, queryURL);

        var jsonObj = JsonConvert.DeserializeObject(queryResult) as JObject;
        JSONArray features = (JSONArray)jsonObj["features"];

        if(features == null)
        {
            response.resultCode = "Result Code: 0004";
            response.resultText = jsonObj["error"]["details"].ToString().Replace("\r\n", string.Empty);
            return response;
        }

        if (features.Count == 0)
        {
            response.resultCode = "Result Code: 0002";
            response.resultText = "ApartmentID " + id + " not present in the rental GIS database";
            return response;
        }
        string jsonGeom = ((JObject)features[0])["geometry"].ToString();

        //Create Features Name Value Collection
    }
}
```

```

var updateData = new NameValueCollection();
updateData["token"] = tokenz;
updateData["f"] = "json";

long currentID = id;

string jsonf = "[{'geometry':{'x':" + apart.Longitude.ToString() + ","
+ "y':" + apart.Latitude.ToString() + "},"
+'attributes': {'ApartmentID': " + currentID.ToString() +
", 'ApartmentOwnerID': " + apart.ApartmentOwnerID.ToString() +
", 'ApartmentBuildDate': '" + apart.ApartmentBuildDate.ToShortDateString() +
", 'ApartmentStatus': '" + apart.ApartmentStatus.ToString() +
", 'NumberOfBedrooms': " + apart.NumberOfBedrooms.ToString() +
", 'NumberOfBathrooms': " + apart.NumberOfBathrooms.ToString() +
", 'ApartmentName': '" + apart.ApartmentName +
", 'ParkingType': " + apart.ParkingType.ToString() +
", 'LocationName': '" + apart.LocationName +
", 'CurrentPrice': " + apart.CurrentPrice.ToString() +
", 'ApartmentType': '" + apart.ApartmentType.ToString() +
", 'ApartmentSize': " + apart.ApartmentSize.ToString() +
", 'WaterAvailability': '" + apart.WaterAvailability.ToString() +
", 'ElectricityAvailability': '" +
apart.ElectricityAvailability.ToString() +
", 'Floor': " + apart.Floor.ToString() +
", 'BuildingFloors': " + apart.BuildingFloors.ToString() +
", 'BuildingComplexName': '" + apart.BuildingComplexName +
", 'FromDatabase': " + "'Y'" + "},"
+'spatialReference': {"
+'wkid': '4326'"
+'}'}]";

updateData["features"] = jsonf;

string updateResult = @getQueryResponse(updateData, updateURL);

//Report back on the feature - whether added or not
var uObj = JsonConvert.DeserializeObject(updateResult) as JObject;

if ((JArray)uObj["updateResults"] != null)
{
    JArray ufeatures = (JArray)uObj["updateResults"];

    string boolResult = ((JObject)ufeatures[0])["success"].ToString();

    response.resultText = updateResult;

    if (boolResult == "True")
    {
        response.resultCode = "Result Code: 0000";
        response.resultText = "OK! Feature number " +
            ((JObject)ufeatures[0])["objectId"].ToString() + " successfully
            updated";
    }
}

```



```

        else
        {
            response.resultCode = "Result Code: 0001";
            response.resultText = updateResult + ". Contact Administrator";
        }
    }
    else
    {
        response.resultCode = "Result Code: 0003";
        response.resultText = updateResult + ". Contact Administrator";
    }
}
catch (Exception ef)
{
    response.resultCode = "Result Code: 0003";
    response.resultText = ef.Message + ". Contact Administrator";
}
return response;
}

```

Appendix G

Attached with the project report is a DVD that contains the web based geo-visualization resources that were instrumental in the creation of the Real Estate Management and the Public-Facing web applications. At the root directory is a folder named **MSc Project** organized into three sub directories;

- docs
- GIS
- Code

The folder **docs** contains the project report. The **GIS** folder contains geospatial resources such as the geodatabases and shapefiles that were used in authoring and publishing map services in the Esri ArcGIS Online platform.

The folder **Code** is a repository containing all the programming source code for both the Real Estate Management application and the Public Facing web application. A copy of the repository containing the Real Estate Management application is hosted in GitHub (<https://github.com/>) and can be accessed from the link - <https://github.com/sowanch/Real-Estate-Management-Solution-with-Web-GIS-ASP.NET-MVC-and-EF-5>. This code repository will continuously be maintained until it reaches maturity.