



# DEVELOPING A GEOGRAPHICAL INFORMATION SYSTEM FOR THE OUDAYAS KASBAH OF RABAT



**WPI**

Tyler Beaupre  
Dominic Cupo  
Lauren Fraser  
Hayley Poskus

# **Developing a Geographical Information System for the Oudayas Kasbah of Rabat**

An Interactive Qualifying Project (IQP) Proposal submitted to the faculty of  
Worcester Polytechnic Institute (WPI)

In partial fulfillment of the requirements for the Degree of Bachelors of Science  
in cooperation with  
The Prefecture of Rabat

**Submitted by:**

Tyler Beaupre

Dominic Cupo

Lauren Fraser

Hayley Poskus

**Project Advisors:**

Professor Ingrid Shockey

Professor Gbetonmasse Somasse

**Submitted to:**

Mr. Hammadi Houra,  
Sponsor Liaison

Submitted on October 12th, 2016

# **ABSTRACT**

An accurate map of a city is essential for supplementing tourist traffic and management by the local government. The city of Rabat was lacking such a map for the Kasbah of the Oudayas. With the assistance of the Prefecture of Rabat, we created a Geographical Information System (GIS) for that section of the medina using QGIS software. Within this GIS, we mapped the area, added historical landmarks and tourist attractions, and created a walking tour of the Oudayas Kasbah. This prototype remains expandable, allowing the prefecture to extend the system to all the city of Rabat.

# EXECUTIVE SUMMARY

## Introduction

In 2012, the city of Rabat, Morocco was awarded the status of a United Nations Educational, Scientific and Cultural Organization (UNESCO) world heritage site for integrating both Western Modernism and Arabo-Muslim history, creating a unique juxtaposition of cultures (UNESCO, 2016). The Kasbah of the Oudayas, a twelfth century fortress in the city, exemplifies this connection. A view of the Bab Oudaya is shown below in Figure 1. It is a popular tourist attraction and has assisted Rabat in bringing in an average of 500,000 tourists per year (World Bank, 2016).



*Figure 1 – A view of the Kasbah’s beauty (Photo Credit: Prefecture of Rabat)*

Morocco relies on tourism as a primary source of income. In fact, in 2014, tourism accounted for nearly 18% of the total gross domestic product (GDP) of the country and is expected to rise by more than 5% by 2025 (Turner, 2014). For Rabat in particular, the Oudayas is a primary attraction for visitors due to its breathtaking sights and historical atmosphere.

It is for this reason that we worked with the local city government, the Prefecture of Rabat, to map the Oudayas Kasbah using a Geographical Information System (GIS). We looked to merge the idea of displaying the significance of landmarks with a method of condensing information into an easily accessible system. With the detailed maps and tools created, the Kasbah would become a much more accessible place for outsiders. Tourists would be able to discover locations to visit easily and feel more comfortable doing so.

## Methodology

To accomplish our goal, we established three objectives:

- Assess the cultural and historical significance of the Kasbah’s landmarks
- Create a prototype map of the Oudayas Kasbah
- Develop an expandable system using GIS software

### Assess the cultural and historical significance of the Kasbah

The historical impact of the structures in the Oudayas Kasbah was assessed using data such as age or cultural significance to the area. This information was collected by conducting archival research at the Bibliothèque Nationale du Royaume du Maroc and information given to us by the Prefecture. These sources provided us with a basis of information about the Oudayas and its famous structures. All of this information was condensed and inputted into the QGIS system as attribute data.

With assistance from a translator, we spoke to, recorded, and photographed ten residents, workers, and visitors. They were asked to share information about their own experiences in the Oudayas. This information provided us with a deeper understanding of why it is significant to those that come in contact with it. In addition to the interviews, we created a walking tour that highlights popular locations in the Kasbah. We determined the best path for viewing important landmarks and then created a sample pamphlet that could be distributed in the future.

### Creating a prototype map of the Kasbah

In order to establish the physical parameters of the area we used assorted maps of the Oudayas as a foundation. These maps were used to create accurate representations of walls and streets. In addition, we also used satellite imagery from Google to outline structures and topology. Finally, we collected a series of photographs and embedded them into the system to provide a street-side view to any user, as shown in Figure 2.



*Figure 2 - View of the Map Tips Feature (Screenshot from QGIS)*

### Develop an Expandable System

One consideration we made while creating the system was how easily it can be expanded. This means we had to make sure our information was split into a hierarchy of groups, layers and data points in a logical way. The attribute data we gathered for our prototype was split into major

categories: region, type of structure, property boundaries, and so forth. New sections can be added in the future without interfering with the previous data, allowing for simple expansion.

To prepare the Prefecture for future GIS expansion, we created tutorial resources. In order to add to the system, the user must first understand how the software was used to create our GIS. Basic techniques such as the creation of layers, the toggling of their visibility in the Layers Panel, and the installation of plugins are covered to give the user a basic understanding of QGIS.

## **Results and Analysis**

The following presents our results by objective:

### Assessing historical and cultural significance

The ten informal interviews we conducted each resulted in a discussion of the interviewees' love for the area. Each person spoke about the Kasbah's beauty and uniqueness. Many people said that it was unlike anything they had ever seen. Not only did we get a better understanding of the perceptions of the area, we also began to understand the culture as well. The sense of community here is very strong and the people were always kind and helpful.

This information, along with factors such as tourist attraction and historical significance, aided us in determining which landmarks to include in our prototype. We focused on six significant landmarks: The Almohad Walls and Bab Oudaya, the Andalusian Gardens, the Museum of the Oudayas Kasbah, the Jama al Atiq Mosque, the Moorish Café, and the Semaphore Platform.

For the walking tour, we explored the Kasbah multiple times in order to find the simplest route that visitors could take in order to see all of the important landmarks. After doing this, we traced the path on the map we created with QGIS. This map was supplemented with a description of the path as well as close-up images of the landmarks and historical information. We determined that the best way to display this information was in the form of a pamphlet that could be given away at hotels or kiosks near the entrance of the Kasbah.

### Create a prototype map of the Kasbah

In QGIS, all information is contained in layers of different types. These layer types include Raster images, vector shapefiles, satellite information, and an assortment of other specialized layers. In our system, we used various vector layers to represent landmarks such as walls, roads, and structures. In a vector layer, one chooses between lines, polygons, or points for its features and chooses the attributes to associate with each feature. Polygons were used to represent roads and walls while polygons were used for structures.

The individual layers for roads and structures were further broken down using subgroups. This allows the user to toggle the visibility of certain types of roads and buildings or color code them based on material (see Figure 3, below).

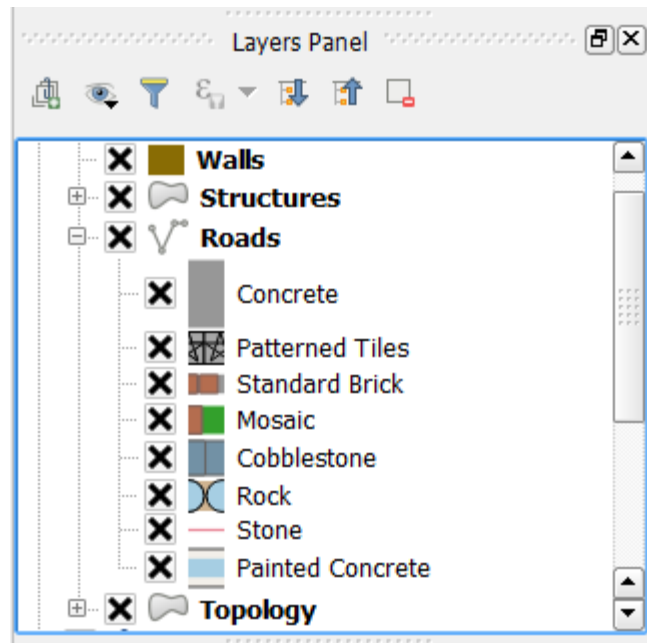


Figure 3 - An example of the Layers panel (Screenshot from QGIS)

### Develop an expandable system using GIS software

We created our GIS with expandability in mind. QGIS works in tandem with a popular embedded database language, called SpatiaLite. It allows the entire database of shapes and layers to be stored on one central file. Users can access each entry by highlighting the corresponding point on the GIS map or by opening up the system and finding the entry manually. This allows the user to edit or add information easily. A new layer can be added at any time. For things such as dumpsters or lights, a similar process could be used with a vector layer of points rather than lines. This is important because the database and GIS need to be able to expand and change as the city evolves.

### **Recommendations**

Based on our results, we produced a set of recommendations for the Prefecture of Rabat. These points include our suggestions for improving historical and cultural data collection and advice for implementing a system of Source Control. These guidelines will support the Prefecture’s plan to further expand the system in the future.

We recommend setting aside a day to combat the issues with litter inside and outside the Kasbah. A clean environment would make the area more welcoming and visually appealing to both tourists and locals.

It is also recommended that the Prefecture either hires an intern or creates a position that focuses on the collection of historical and cultural information. With this position, information can be updated regularly rather than sporadically. This position should create a repository of collected data so that those who work directly on the GIS can easily access information.

With a system such as this, it is important to set up a method that multiple users can work on the same file without overwriting each other’s work. The two most popular systems designed to solve this issue are Git and SubVersion (SVN). We suggest that the Prefecture chooses Git for source control if offline versioning is a high priority. Otherwise SVN should be used, as it is the industry standard for the development of similar systems.

## **Conclusion**

Our research and prototype provide a base for the Prefecture of Rabat's future Geographical Information System for the city of Rabat. The design decisions involved in developing the system were deliberately chosen to allow for further expansion and elaboration. The tutorials and the templates can be expanded upon, giving users a tool for aiding urban management ranging from tourist services to public works projects. With this system in place, users will be able to more comfortably explore the Kasbah, leading to an increase in tourist activity.



# ACKNOWLEDGMENTS

The following individuals deserve many thanks for the assistance they provided:

- Professors Ingrid Shockey and Gbetonmasse Somasse, for countless hours of advice and assistance.
- Our sponsor liaison, Mr. Hammadi Houra, for his input and guidance.
- Mr. Anas Eddik and Mr. Aziz Rafiai, for their assistance with translating.
- The Prefecture of Rabat, for the opportunity to work on this project.

# AUTHORSHIP

<b><u>Chapter/Section</u></b>	<b><u>Author(s)</u></b>	<b><u>Editor(s)</u></b>
<b>Abstract</b>	Dominic Cupo, Hayley Poskus	Hayley Poskus, Dominic Cupo
<b>Introduction</b>	Authored by All	Edited by All
<b>Background</b>	Authored by All	Edited by All
<b>Methodology</b>	Authored by All	Edited by All
<b>Appendices</b>	Authored by All	Edited by All

# TABLE OF CONTENTS

ABSTRACT.....	i
EXECUTIVE SUMMARY .....	ii
Assessing historical and cultural significance .....	iv
Create a prototype map of the Kasbah .....	iv
Develop an expandable system using GIS software .....	v
ACKNOWLEDGMENTS .....	vii
AUTHORSHIP .....	viii
TABLE OF CONTENTS.....	ix
TABLE OF FIGURES .....	xi
1. INTRODUCTION .....	1
2. LITERATURE REVIEW .....	3
2.1 The Prefecture of Rabat and other stakeholders .....	3
2.2 History of Rabat and the Kasbah of the Oudayas .....	3
2.3 Architectural style .....	7
2.4 Economics of tourism in Morocco .....	9
2.5 Applications of technology .....	10
Geographical Information Systems.....	10
GIS software selection .....	11
2.6 Case Studies: Venice and Fes .....	11
Geographical Information Systems in Venice .....	11
Documentation of fondouks in Fes .....	12
2.7 Summary .....	13
3. METHODOLOGY .....	14

3.1 Assess cultural and historical significance of the Kasbah .....	14
3.2 Create a prototype Geographical Information System (GIS) .....	15
3.3 Develop and document an expandable system .....	16
4. RESULTS AND DISCUSSION .....	18
4.1 Historical and cultural significance of landmarks in the Kasbah .....	18
4.2 Implementation of the Geographical Information System (GIS) .....	25
4.3 Expandable system.....	28
4.4 Discussion .....	29
5. RECOMMENDATIONS .....	32
6. CONCLUSION .....	34
REFERENCES .....	35
APPENDICES .....	38
Appendix A: Timeline .....	38
Appendix B: Conversation Guidelines .....	39
<b>Version 1</b> .....	39
<b>Version 2</b> .....	39
Appendix C: Attribute Table .....	40

# TABLE OF FIGURES

Figure 1 – A view of the Kasbah’s beauty (Photo Credit: Prefecture of Rabat) .....	ii
Figure 2 - View of the Map Tips Feature (Screenshot from QGIS) .....	iii
Figure 3 - An example of the Layers panel (Screenshot from QGIS) .....	v
Figure 4- Perimeter of the Oudayas Kasbah in Red (Screenshot from Open Street Map) .....	4
Figure 5 - View from the Semaphore Platform (Photo Credit: Lauren Fraser, 2016) .....	5
Figure 6 - The Hassan Tower in Rabat (Photo Credit: Hayley Poskus, 2016) .....	6
Figure 7 - The Bouregreg Agency building (Photo Credit: Hayley Poskus, 2016) .....	6
Figure 8 - A typical courtyard in a Moroccan home (Photo Credit: Lauren Fraser, 2016) .....	8
Figure 9 - Example walking tour path (Screenshot from QGIS) .....	15
Figure 10 - Kasbah Walls and Bab Oudaya (Photo Credit: Hayley Poskus, 2016) .....	18
Figure 11 - The Andalusian Gardens (Photo Credit: Lauren Fraser, 2016) .....	19
Figure 12 - The Museum of the Oudayas (Photo Credit: Hayley Poskus, 2016) .....	20
Figure 13 - The Moorish Café (Photo Credit: Lauren Fraser, 2016) .....	20
Figure 14 - Entrance to the Jama al Atiq Mosque (Photo Credit: Lauren Fraser, 2016) ..	21
Figure 15 - The Semaphore Platform (Photo Credit: Lauren Fraser, 2016) .....	22
Figure 16 - Informal interviews in the Kasbah (Photo Credit: Hayley Poskus, 2016) .....	22
Figure 17 - Current maps provided for tourists (Photo Credit: Lauren Fraser, 2016) .....	24
Figure 18 – OSM’s map of the Oudayas Kasbah (Screenshot from OSM) .....	26
Figure 19 - Example of the GIS Map (Screenshot from QGIS) .....	27
Figure 20 - An example of subgroups (Screenshot from QGIS) .....	28
Figure 21 - A look at the system structure of QGIS (Screenshot from QGIS) .....	29

# 1. INTRODUCTION

In 2012, the city of Rabat was awarded the status of a UNESCO world heritage site for integrating Western Modernism and Arabo-Muslim history, creating a unique culture that is put on display by the city's excellent design (UNESCO, 2016). The oldest parts of the city, the medina, Mellah, and the Kasbah des Oudayas, are the city's connection to its roots. The Oudayas, which is over nine hundred years old, exemplifies this connection. It is a beautiful vista looking over the ocean that is home to many artists and artisans looking for a source of inspiration. This quarter of the city plays a vital role in Rabat's tourist economy. Its history and beauty bring many visitors each year.

Morocco relies on tourism as a main source of income. In fact, in 2014, tourism accounted for nearly 18% of the total gross domestic product (GDP) of the country and is expected to rise by at least 5% by 2025 (Turner, 2015). Within Rabat, the Oudayas is a primary attraction for visitors due to its beauty and history. It is for this reason that we worked with the local city government, the Prefecture of Rabat, to map the Kasbah while integrating spatial and historical data. With a system such as this, tourists can easily access the history of the many gates, mosques, and other landmarks. With accurate data and a robust framework to present it with, we worked to ensure that this unique combination of Islamic and European cultures showcases itself for future generations to learn from and enjoy.

The goal of our project was to create the framework for a Geographical Information System (GIS) that would help to facilitate the expansion of Moroccan tourism and the preservation of local culture and history. To achieve this goal, we had three main objectives: assess the cultural and historical significance of the Kasbah's landmarks, create a prototype map in GIS, and develop an expandable system.

In order to evaluate the physical parameters in the area we used assorted maps of the Oudayas as a foundation. After creating a spatial data system, we then added attribute data to our framework. The attribute data included information such as year built, relevant historical information, and other such cultural notes. With this additional information we were then be able to provide an easy, accessible system that residents can use to learn about the history of their neighborhoods.

By completing these objectives, we provided a base for the Prefecture's future Geographical Information System for the city of Rabat. With this template, the Prefecture of Rabat can assist the community by increasing interest in the Kasbah and boosting tourist traffic.

## **2. LITERATURE REVIEW**

This chapter examines the importance of the Rabat medina, which includes the Oudayas Kasbah, and the benefits to tourism it generates. To begin, we describe the history of Rabat and the medina, specifically the Oudayas Kasbah. Next, we discuss tourism's effect on Morocco's economy. Finally, we explain ways in which technology can be used by local governments to benefit residents and visitors alike. To get a better understanding of the strategies for the implementation of technology in tourism and city life, we look to past projects and their utilization of GIS software.

### **2.1 The Prefecture of Rabat and other stakeholders**

There are many stakeholders in this project. The largest is our sponsor, the Prefecture itself. The Prefecture of Rabat is the local city government. They are a branch of the main Moroccan government that focuses primarily on the development of Rabat. One section of this group specifically works toward extensive urban planning and preservation in the city.

The second largest group of stakeholders are the tourists who would use the map. Rabat has brought in an average of 9.5 million tourists per year from all around the world (World Bank, 2016). Though they speak a multitude of languages and reside in many different places, they are welcomed by the people of the Kasbah. These tourists, however, have access to very few resources that detail the region.

Finally, a third set of stakeholders includes the Kasbah's residents, shop owners, and workers. Today, approximately 3,000 people live here. Many use the Kasbah as a place to sell handmade goods including leather, pottery, and paintings to the tourists who wander the streets.

### **2.2 History of Rabat and the Kasbah of the Oudayas**

The Rabat medina, especially the Oudayas Kasbah, is a precious cultural heritage site to the country of Morocco. Rabat, Morocco, once known as Ribat al-Fath, was officially founded in the twelfth century by Abu Yusuf Ya'quab al-Mansur as a fortress to help him extend his



conquests into Spain. Soldiers who went to war with Spanish Christians settled in a small area closest to the ocean. This region became known as the Mehdiya, which gave the medina its name. However, when Rabat began its decline, the medina was temporarily abandoned. Pirates landed in the Mehdiya in the mid-seventeenth century and the region took the name Kasbah Andalusian. In the early 1800s, the tribe of the Oudayas settled in Rabat when they were expelled from Fes. Their settlement in the area spurred another name change, and the Kasbah Andalusian became the Kasbah des Oudayas that is still prevalent within the medina today (Asebriy et al., 2009). The Oudayas Section of the medina is outlined in red below (Figure 4).



Figure 4- Perimeter of the Oudayas Kasbah in Red (Screenshot from Open Street Map)

During this time, the Kasbah became an influential international trading post and boosted Rabat’s economic and social status (Bargach, 2008). Today, the Kasbah is the most peaceful and charming section of the medina. The militaristic walls and watchtowers contrast nicely with the beautiful ocean views that anyone can see (Figure 5).



*Figure 5 - View from the Semaphore Platform (Photo Credit: Lauren Fraser, 2016)*

In 2012, Rabat was distinguished as a UNESCO world heritage site due to its many historical landmarks. They include: the new city of Rabat, the district of Endowments Diour Jamaa, the Test Garden, the Medina, the Mosque of Hassan and the Mohammed V Mausoleum, the ramparts and the Almohad gates, the archaeological site of Chellah, and the Oudayas, and the Oudayas Kasbah. The city displays Morocco's unique combination of Arab and European cultures in many of these locations. For example, the Hassan Tower in the Hassan district of Rabat, as seen in Figure 6, began construction in 1195 and still stands today as the only remaining portion of the unfinished Hassan Mosque (Jechtimi, 2012). This tower was a cornerstone in Muslim culture at the time and still provides a place for worship and spiritual expression.



*Figure 6 - The Hassan Tower in Rabat (Photo Credit: Hayley Poskus, 2016)*

At the same time, Rabat's architecture displays many influences from Spanish culture. For example, the Bouregreg Agency building, as seen in Figure 7, in the same district as the Hassan Tower displays Rabat's Spanish influence. The building's cultural impact on the city is very different than that of the Hassan Tower. However, it is this cross-cultural blending within Rabat that has established the city as historically and culturally valuable (UNESCO, 2014).



*Figure 7 - The Bouregreg Agency building (Photo Credit: Hayley Poskus, 2016)*

In the Kasbah specifically, this juxtaposition of cultures can be seen when looking at the Kasbah Mosque and the Andalusian gardens nearby. The mosque represents Morocco's Arab influences. The Andalusian gardens represents the Spanish influences in Morocco. These two landmarks are quite different in style but both represents Rabat's history equally.

### 2.3 Architectural style

Because of the Kasbah's role as a major tourist attraction, the majority of structures present are small businesses such as cafés and shops with homes interspersed. Most of the Kasbah's residential structures, much like the rest of the medina, follow the traditional layout style with large, central courtyards surrounded by typical indoor areas such as kitchens and bedrooms.

While it is difficult to find the exact ages of the buildings in the Kasbah, as some of them are centuries old, it is interesting to note how the houses of the area vary greatly in engineering quality despite using many similar materials. The lowest tier of homes are small, single-story buildings with walls made from brick or stone and reinforced with earthen materials. These homes generally do not have any concrete or wooden supports. Most commonly, homes in the Kasbah are two to three-story structures with the central courtyard style that is typical of Arab homes (as seen in Figure 8). They have stone or brick walls that are reinforced with lime mortar and wooden columns. The higher end homes are created with reinforced concrete columns and beams with infill of masonry bricks and solid blocks (Omira, 2010).



*Figure 8 - A typical courtyard in a Moroccan home (Photo Credit: Lauren Fraser, 2016)*

Regardless of quality, almost all of these homes are built using the same materials. Stone or brick with lime mortar and a plaster coating were used for internal walls. Wooden beams and columns were implemented in buildings for added support. External walls were typically built using a combination of concrete and clay. (Casadei, 2015). While the concrete and clay walls are strong, inexpensive, and easily installed, they have one large weakness. Capillary action can bring moisture from the ground up through the walls and lead to cracking (Casadei, 2015). Plaster coatings are the most common solution to the issue of cracking due to rising damp, but unless the coating is applied early in the building's life and coats the entirety of the structure, it can lead to worsening of the issue in parts that are not coated (Casadei, 2015).

Besides the underlying architecture of the structures present in the Kasbah, other external factors have led to the condition of the area today. The population growth in Rabat has led to a greater demand for housing and the subdivision of homes. This can lead to neglect of the property because no one is willing to accept responsibility for issues that affect the whole group of houses (Mani, 1998). One of the most common reasons for degradation is the lack of proper repairs due to homeowners' financial difficulties. Many of the supposed fixes for cracks have only led to more issues because most residents do not consider factors such as differences in the thermal expansion coefficients of building materials when attempting to repair damages. If the

coefficients of two materials are different enough, it can lead to the enlargement of cracks and even detachment of the plaster coating from the walls (Mani, 1998).

Our goal with this project is to begin a Geographical Information System that contains information on the many structures of the Oudayas Kasbah including their age and building materials among other attributes. This data could be useful to the Prefecture for future projects focused on the expansion of Moroccan tourism and the preservation of the region.

## 2.4 Economics of tourism in Morocco

As the capital of Morocco and a newly declared UNESCO world heritage site, Rabat has seen increased tourist traffic in recent years. Since the country's boom in popularity, tourism has become a major source of income for Morocco (World Bank 2016). It is also becoming an economic priority of the nation, which is hoping to become an international travel destination and reach a revenue of 140 million dirhams by 2020 (Vision 2020, 2016). Morocco has begun to invest more in tourism by allowing more airlines in, spending more on marketing and promotion, and putting an emphasis on security.

When Mohammed VI ascended to the throne as the King of Morocco in 1999, he expressed his belief that increasing tourism could assist the country's economy. In 2001, he implemented a new tourist policy known as the "2010 Vision." This plan based its strategies on three pillars: territorial development, new governance framework regarding tourism, and integration of sustainable development. The volume of foreign tourism increased from around 3 million people in 2000 to 9.3 million in 2010 (Bouzahzah & Menyari, 2013). With the help of tourism, the economy has continued to increase every year and it is expected that by 2025 the GDP direct from tourism and travel will rise another 5.5% (Turner, 2015).

After the success of the "2010 Vision," Mohammed VI and his governing body created the "2020 Vision," which will attempt to double the number of foreign tourists to 18 million by the year 2020. The plan is set to strengthen Morocco's tourist industry so that it may become one of the top tourist destinations in the world (Bouzahzah & Menyari, 2013).

Along with both the 2010 and 2020 visions, Mohammed VI also created Plan Azur. The plan's main goal was to develop six large resorts along the coast that would provide tourists with new opportunities to stay for an extended amount of time. When Plan Azur was finished in 2009,

it created more than 70,000 beds for visitors and further increased the flow of tourists into the country (“Embassy of Morocco,” 2016).

In 2013, travel and tourism accounted for nearly 7% of Morocco’s gross domestic product (GDP) and after one year it grew to nearly 18%. Between 1980 and 2010, GDP per capita rose from \$1,019 U.S. Dollars to \$1,841 (Bouzahzah & Menyari, 2013). These significant jumps in GDP show how Morocco’s history and culture have caused the country to become a valid destination for more tourists each year.

## 2.5 Applications of technology

Modern day technology has greatly helped with urban planning and rehabilitation efforts. Geographical Information Systems make it simpler to view information on a map, while computer-aided design (CAD) allows users to view buildings or objects without needing to take a trip to its location. We explored software options that could support the needs of the Prefecture.

### Geographical Information Systems

Geographical Information Systems (GIS) are information systems that allow users to take a series of attribute and spatial data, and visualize it. Attribute data is information that describes an object. Spatial data describes the physical relationships between locations relative to a fixed origin or to other objects in the system. This system can be as simple or complex as its purpose calls for it to be (Gregory & Ell, 2007). As an example of the capabilities of GIS, imagine a system designed for Rabat. A GIS system could be created that combines the locations of each of the mosques in the city with information about the heights of their minarets, ages, daily traffic, and other data. Using that information, one could create an interactive map of the mosques or use it to create a guided tour based on user locations. The power of the software is in the quality of the data you reference within it (Gregory & Ell, 2007).

GIS has been used with great success in restoration efforts as well. When Hurricane Katrina hit New Orleans in 2005, GIS maps were used in both emergency response and recovery. First responders were able to match addresses from 911 calls to physical GPS coordinates; an important feature considering many streets were underwater and signs were unreadable. Later, transportation workers were able to use the GIS map of all roadways to create alternate routes

around the city, avoiding demolished areas and alleviating traffic where they could (Pennington & Melikian, 2006). It is important to understand that different GIS styles work better for different tasks. Because of this, we carefully weighed the benefits and drawbacks of each software package in order to choose the one that was best suited for our work.

## GIS software selection

When choosing the right software package to use for a job, one must consider many different factors including ease of use, cost, software features, and the availability of educational resources. When creating a system that is designed to be used and expanded on, usability and resource availability are priorities. Because of this, we looked for well-established and stable software packages that have large user bases and plenty of tutorials. This led us to a choice between ArcGIS, the most popular commercial GIS software, and QGIS, its free, open-source competitor. While ArcGIS boasts more consistent results and greater capabilities, QGIS can easily be expanded with plugins that are either downloaded or written ourselves, giving it comparable functionality. ArcGIS is a Windows exclusive software while QGIS is available on all platforms.

## 2.6 Case Studies: Venice and Fes

We examined two case studies where previous project groups have used GIS to help with city planning. In order to better understand how best to utilize GIS, we looked at a project completed in Venice, Italy, which focused on mapping the city's history into an online map. To gain a better understanding of Morocco's architecture, we studied a project that focused on mapping three famous fondouks in the medina of Fes.

### Geographical Information Systems in Venice

The WPI Venetian Project Center focuses heavily on utilizing GIS for the restoration of Venice by mapping the locations of various landmarks. Fountains, churches, canals and statues are mapped precisely with GPS. Ancient maps of Venice are digitized and show detailed information about the locations marked when you highlight them. By having all this information



digitized, the Venetian government has been able to plan restoration projects much more efficiently. A recent project, *The Evolution of Venice Through Mapping Technology*, combined 25 years of GIS data that WPI had compiled about Venice and connected it with the *Atlante della Laguna* (Atlas of the Lagoon). This Atlas is used heavily by local city government to make informed decisions relating to infrastructure and similar issues. The WPI database contains many smaller data sets relating to key architectural features and artwork. The group updated data sets containing the locations of fountains, islands and historical maps. They created a website that allows users to view maps of Venice from different eras and highlight certain churches or other features. Clicking on a feature allows the user to see it marked on the map and brings up information about that location (Chhim, et al, 2014). Finally, a map of modern day Venice was created. On this map, the viewer can choose what specific items they wish to see. An overlay would appear marking every instance of that item within Venice. Clicking on a feature would bring up additional information about it, and multiple characteristic types could be shown on the map concurrently.

### Documentation of fondouks in Fes

Fondouks (inns or hotels in Arabic) are an important part of Moroccan heritage. They have served both as the nightly accommodation for travelling merchants, as well as the marketplace from which those merchants sold their goods. Now they are used for everything from housing, to manufacturing shops or white collar businesses.

A previous research project evaluated the structural stability of three fondouks and the efforts to rehabilitate them. The group utilized computer-aided design in order to recreate the fondouks as 3D models. These models allowed them to look at structural issues without having to visit the locations. It also allowed some simulations of potential fixes. The advances in CAD let the group do all their work digitally. This allowed them to flesh out the details of their plans without intruding on the occupants of the fondouks (Hernandez, et al, 2015).

Creating CAD models allows builders and architects to view the house they are working on without having to venture out to the location. This allows them to work quicker, cheaper, and on more houses in the same amount of time. These CAD models can be housed in a database, with correspondence to the locations in the GIS map. A user could click on the house in the map,

and immediately pull up the relevant CAD model to aid in their planning. Alternatively, these models can be used to take a virtual tour of the city. Each landmark will be shown as a model that the user can look around, and relevant information about the architecture, history, and other aspects can be shown to educate the user.

## 2.7 Summary

The literature review presented here discusses the main background information needed to complete this undertaking. First, we examined the history and cultural context of Rabat and the Kasbah as it relates to our project. Second, we discussed Morocco's reliance on tourism for economics. Third, it was determined that by using a GIS software, QGIS, we could create a system to provide the Prefecture with a simple way to access information about the area, starting with the Kasbah. Finally, we looked at similar past projects and how technology like Geographical Information Systems were implemented.

### 3. METHODOLOGY

The goal of our project was to work with the Prefecture of Rabat to create the framework for a Geographical Information System (GIS) for the Oudayas Kasbah. To accomplish our goal, we established the following objectives:

- Assess the cultural and historical significance of the Kasbah's landmarks
- Create a prototype Geographical Information System (GIS)
- Develop and document an expandable system to work alongside our GIS

To keep us on track, a timetable was created to reference when certain events needed to be completed. This is included in Appendix A.

#### 3.1 Assess cultural and historical significance of the Kasbah

The historical impact of the structures in the Oudayas Kasbah was assessed using data including age, past rehabilitation efforts, and cultural significance to the area. Information was collected by conducting archival research in the local geographical history section at the Bibliothèque Nationale du Royaume du Maroc, as well as reviewing information given to us directly from the Prefecture. These sources provided us with a basis of information about the Oudayas and the famous buildings, walls, and gates it contains.

Important landmarks and locations such as the Bab Oudaya and the Andalusian gardens were observed and photographed on multiple occasions in order to provide accurate, up-to-date visual references for information collected. These photos, along with the historical information, were condensed and inputted into the QGIS system as attribute data.

To gain a better understanding of the cultural significance of the landmarks, we engaged in conversations with locals. With assistance from a translator, conversations with residents, workers, and visitors were recorded, and some participants were photographed. Each conversation followed a set of questions we created, shown in Appendix B. We asked questions in order to gather information about personal feelings toward the Kasbah. Residents also shared information about their own experiences, which allowed us to get a deeper understanding of why people love the Kasbah.

In order to consolidate this information and make it easily accessible and visible for visitors, we created a walking tour that highlights popular locations in the Kasbah. We decided to walk through the Kasbah in order to determine the best path to take to see the important landmarks, as seen in Figure 9 below. We compiled the map we developed, photos that we took of important structures, and historical information about each location, to create an easy to read and follow tour.



*Figure 9 - Example walking tour path (Screenshot from QGIS)*

### 3.2 Create a prototype Geographical Information System (GIS)

Before we could begin creating our system we needed to determine a base to use. This base would need to be a map or aerial image that shows the Kasbah in detail. We looked at many possible sources including both Google and Bing Maps, as well as Google Earth imagery. This base map was inputted into QGIS and became the main layer of the system. Streets, walls, and topology were traced out on the map so that they could be showcased, independent of the map background.

To illustrate the benefits of our system and also test for possible issues, we created a prototype GIS detailing six important landmarks. We selected these landmarks according to their significance based on our own personal experience touring the Oudayas Kasbah. By adding this information to the GIS, we were able to start a detailed attribute data table, which can be filled out for individual features as they are added.

### 3.3 Develop and document an expandable system

One consideration we made while creating the system was how easily the GIS system could be expanded. New issues can be solved by expanding this system to include other data. Other issues in expansion arise if the original data was not arranged in such a way as to allow new information. A primary reason we selected QGIS was its ability to accept new data types and information by use of plug-ins. While the software allows us to accept new types of information, the way we set up our attribute data determines how well it will fit. This means making sure our information is split into a system of groups, layers and data points in a way that starts broad and ends specific. We made sure that the information was grouped correctly so that similar information was together and the sections were logical.

The layer system we have implemented is intuitive, but it is covered in detail to ensure understanding. The base map layer is a polygon vector layer. It has a categorization system for the different types of geography. By drawing polygons and labeling it with its type, the shape takes on a specified color. This layer serves as a base and holds no attribute data. The Structures layer is quite similar, but its categorization system shows different colors depended upon the purpose of the structure. There are also a number of attributes that describe the structures.

The Walls and Roads layers are similar, but their features are polylines instead of polygons. Rather than a type, they require information such as name, age, and material. The Roads layer has a more advanced categorization system than the base layer that takes into account the different materials and adjusts the line width according to the width attribute.

To create a perfect fit, the attribute data we gathered in our pilot study was split into major categories: region, type of structure, property boundaries, and so forth. Each major category was split into minor categories such as building materials or color. Entries also included detailed information about the history and importance of each structure in categorized text labels

on the maps. By keeping things in separate categories and subcategories, new sections can be added without interfering with the previous data, allowing expansion.

The Prefecture has plans to expand our prototype GIS. To ease this process, we created tutorial resources. In order to add to the system, the user must first gain a basic understanding of QGIS and how we used the software. Learning QGIS can be done with just the resources online. We compiled a list of useful websites for learning the basics. These basic techniques include the creation of layers, the toggling of their visibility in the Layers Panel, and the installation of plugins. After these basic lessons are completed, one will have the necessary base of knowledge. After, our specialized tutorials may be used to learn how to add to the system developed. We included a written tutorial that explains the role of each of the different layers, shows how HTML tips were used, and the techniques for adding in features. The tutorial also covers how a layer can be added, edited and expanded.

Finally, we show how to use tips to display relevant information. QGIS includes a feature called Map Tips, which, when toggled, displays the information of your choosing above the feature your mouse is hovering over. For more advanced users, these tips can be programmed in HTML. This functionality is used to display structure names and their images in the popup tips.

## 4. RESULTS AND DISCUSSION

In this section, we present our findings and discuss how they relate to the objectives that we previously identified. We will provide additional cultural and historical background on the Kasbah and describe the Geographical Information System and its expandability.

### 4.1 Historical and cultural significance of landmarks in the Kasbah

Our findings concerning the history and culture of the Kasbah meant many hours researching Rabat's past. At the *Bibliothèque Nationale du Royaume du Maroc*, we consulted many sources and collected historical information about key sites in the Oudayas Kasbah. These sites include: The Kasbah walls and Bab Oudaya, the Andalusian Gardens, the Museum of the Oudayas, the Moorish Café, the Jama al atiq Mosque, and the Semaphore Platform.

Our initial site assessment and research revealed beautiful cultural and historical landmarks that have withstood many centuries. We learned that the Kasbah Walls and the Bab Oudaya, *Bab Oudaia*, seen in Figure 10 below, were built in the 12th century by Yacoub el Mansour (Voir & Hatchett, 2002). The walls that surround the Kasbah were built in order to protect the city due to its role as a military fortress.



Figure 10 - Kasbah Walls and Bab Oudaya (Photo Credit: Hayley Poskus, 2016)

Through the Bab Oudaya, visitors enter the Andalusian Gardens, *Le jardin andalou*, as seen in Figure 11. Designed in the early 12<sup>th</sup> century by a French landscape architect, the garden was built as a secluded park for many visitors and local residents to get fresh air and tranquility. In addition to its array of 650 species of greenery, the garden has a variety of water features and fountains that were inspired by Andalucia, which is Islamic Spain. (ANSAMED, 2016). The main feature is the traditional water wheel that is located in the middle of the garden. Immediately next to the garden is a gift shop where tourists can purchase postcards and other souvenirs.



*Figure 11 - The Andalusian Gardens (Photo Credit: Lauren Fraser, 2016)*

Looking over the gardens, stands the Museum of the Oudayas, *Le musee des Oudaia* (Figure 12), which was originally built in the 17<sup>th</sup> century by Moulay Ismail (Voir & Hatchett, 2002). Initially built to serve as a luxury mansion for the former ruler, Moulay Ismail, it is now used as a museum for arts and popular traditions. It is known for its spectacular sights and antique interior that is crafted in authentic fashion. A former living room was turned into a traditional bedroom with sofas covered in beautiful silk fabric and gold imported from Fes. To keep the ancient Moroccan culture, they have a collection of handmade rugs and carpets. Additionally, the Oudayas Museum has a wide variety of pottery, musical instruments, and Amazigh jewelry.





*Figure 12 - The Museum of the Oudayas (Photo Credit: Hayley Poskus, 2016)*

After exiting the gardens, guests come across the Moorish Café. This café, also known as *Le Café Maure*, is another major location in the Kasbah. To arrive at this café, you have to walk through the Alley of Kasbah, *Ruelle de la Kasbah*, which has blue and white walls that date all the way back to the era of the first Alawite ruler (Voir & Hatchett, 2002). Once arriving at the café, you are able to see the medina of Salé, the Atlantic Ocean, the Bouregreg River, and the doors of the Andalusian Garden (Figure 13).



*Figure 13 - The Moorish Café (Photo Credit: Lauren Fraser, 2016)*

After exploring the Kasbah a bit, visitors will come across the Jama al Atiq Mosque (Figure 14). Built in 1150, it still stands as the oldest mosque in Rabat. It was initially built under the supervision of Sultan Abd el-Moumen but was later reconstructed in the 18th century due to structural degradation. The interior contains galleries and dining rooms, all surrounding a

centralized prayer hall (Berrada, 2012). This mosque is a sacred area and is exclusively open to Muslims.



*Figure 14 - Entrance to the Jama al Atiq Mosque (Photo Credit: Lauren Fraser, 2016)*

Finally, the Semaphore Platform, *Place du Semaphore*, as seen in Figure 15, is the outermost point of the Oudayas Kasbah. The platform along with the three watchtowers were built in the late 18th century under the sultan Mohammed ben Abdallah. It overlooks the Atlantic Ocean and the Bouregreg River that runs between Rabat and Salé. Because of this easy access to the waterways of Rabat, the Semaphore Platform was used to communicate with vessels that wished to enter the port (Berrada, 2012).



*Figure 15 - The Semaphore Platform (Photo Credit: Lauren Fraser, 2016)*

The library provided a lot of the historical information but we still needed to learn more about the cultural effects of the Kasbah. To get a better understanding of the effects, informal interviews were conducted throughout the Kasbah using a sample of convenience. With assistance from a translator, Aziz, we conversed with different people in the area in order to get an understanding about their experiences and feelings about the Oudayas Kasbah (Figure 16).

An interview with a 72-year-old Moroccan male visiting the Kasbah provided us with information about how interesting and unique the area was. Though it was only his first visit, he already loved the atmosphere found in the gardens because it reminded him of the beauty found in the mountains of Morocco. He stated that the Kasbah is extremely unique and is unlike anything you would find anywhere else.



*Figure 16 - Informal interviews in the Kasbah (Photo Credit: Hayley Poskus, 2016)*

Another conversation with a male college student in a painting shop revealed what it was like to live in the Kasbah. He stated that he was born in the Kasbah and has lived there all his life. The cleanliness and the safety of the Kasbah and the easily accessible medina just down the road has made him love the area. He expressed that because of these factors, the Kasbah is a popular location for tourists, especially in the summer.

We had the good fortune to meet a resident that had lived in the Kasbah for 62 years and once worked as a security guard here. He explained to us that he has always loved the Kasbah and its unique combination of beautiful views, nature, and historical monuments. However, he stated that the area has changed recently, and that the sense of community has decreased over time. Homeowners would always have their doors open and people were welcoming, but now people are much more reserved.

On October 4th, we went to the Kasbah to begin our walking tour. We walked through the Kasbah multiple times in order to find the easiest route that visitors could take in order to see all of the important landmarks. After doing this, we traced the path on the map we created with QGIS. This map was supplemented with a description of the path as well as close-up images of the landmarks and historical information. We determined that the best way to display this information was in the form of a pamphlet that could be given away at hotels or kiosks near the entrance of the Kasbah.

While creating this tour, we were approached by many curious locals and tourists. During this time, we conversed with 5 different people.

When we first arrived in the Kasbah, we were greeted by a middle aged male who was standing at the entrance. He was extremely interested in why we were at the Kasbah and provided us with historical information that has been used in our walking tour. Interesting information such as the meaning behind the blue and white walls and the current number of residence in the Kasbah were shared. The blue in the walls represents water and sky and the white represents peace. Besides providing interesting facts, he also showed us construction projects that are currently in progress. They are currently in the process of reconstructing the walls and they are expected to be done in November of 2016. Additionally, he was able to show us how to get to specific areas of the Kasbah and even introduced us to the man that owns the Moorish Café.

We also talked with two women from Australia who were in Rabat for three days. They expressed their excitement to walk around and explore the Kasbah. After discussing our reasons for being there, they were very interested in the idea of a detailed map for tourists because they were having troubles finding their way around. They showed us a map that their hotel had provided. It was an extremely hard to read, black and white photocopy of a map of Rabat taken from a book (Figure 17).



*Figure 17 - Current maps provided for tourists (Photo Credit: Lauren Fraser, 2016)*

While taking photos of the Andalusian Gardens, a young Moroccan man approached us because he noticed that we spoke English. When we first met, he immediately stated that he was excited to talk to us because his English was not good and he had to pay translators to speak with him in English. We jokingly assured him that payment would not be necessary. He shared with us that though he lives 20 minutes away, he comes to the Kasbah often. His favorite location was the café because he loved looking at the view of the ocean.

Finally, we had the opportunity to meet a male resident that has lived in the Kasbah for many years with his family. When he realized we were American, he explained how he has hosted American students for the past four years and invited us to tour his home. While in his

home, he introduced us to his entire family and brought us to the living room to take pictures of the Atlantic Ocean.

## 4.2 Implementation of the Geographical Information System (GIS)

In order to display the cultural and historical information that was collected in a visual manner, we created a mapped representation of the Kasbah utilizing GIS software. In this section, we discuss mapping techniques and GIS functions that were used in order to develop this system.

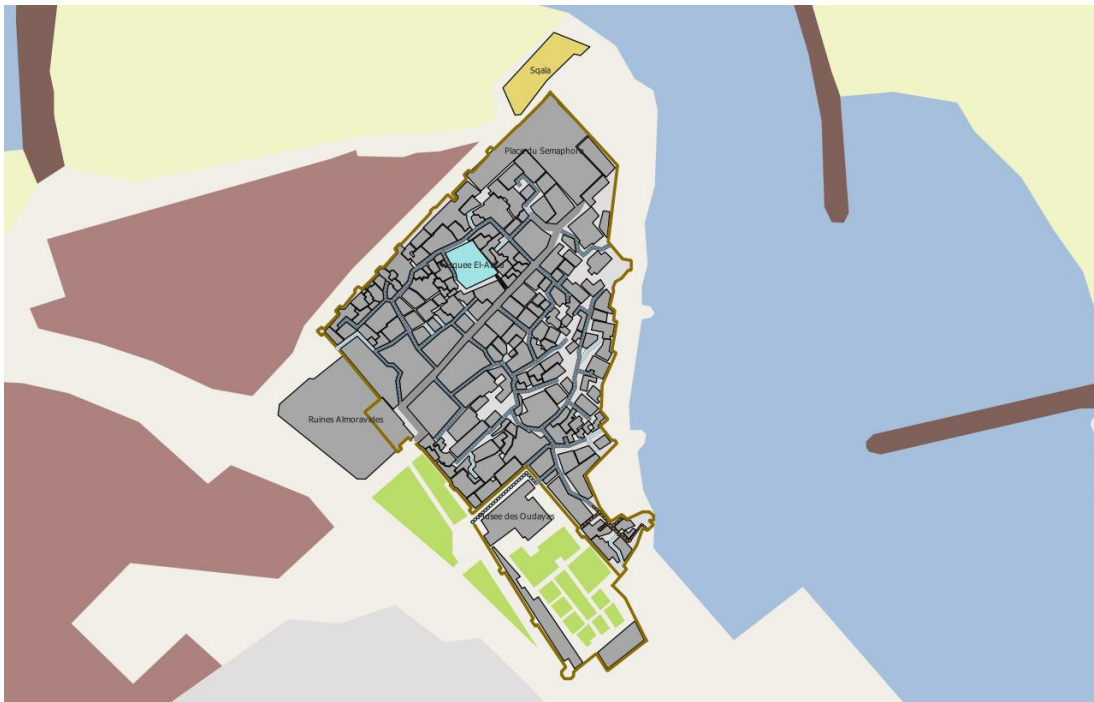
After doing some experimentation with QGIS, we discovered Open Street Map (OSM), which is a crowd-sourced project aimed at creating a free map of the world. The map of the Oudayas Kasbah that OSM provided, shown below in Figure 18, included most streets and details down to small alleys and walkways. It also imported a number of landmarks and key points automatically. This supplemented our system with information we would not have thought to add, such as the locations of benches, fountains and handicap accessible locations. This import served as a base that we could test different prototype builds of our GIS map and a system for us to expand with our own attribute data.



Figure 18 – OSM's map of the Oudayas Kasbah (Screenshot from OSM)

Once we had a map base, we could create the rest of the system. In QGIS, the information is contained in layers of different types. Vector layers can hold many different kinds of information. There are simple shapes like points, lines, or polygons. They can also contain raster images with data stored as individual pixels. Finally, they can include data pulled from online sources such as Google, Bing, or OSM. For our GIS, a vector layer was created which used polylines to represent roads and, in a separate layer, walls. Rather than outlining the entire road to create a polygon, a line was placed down the center and a thickness was proportional to an attribute. Thickness could be changed to denote width of the road or density of traffic, thereby giving a visual showing of a certain attribute. While mechanical errors can occur with this strategy, QGIS allows for the movement of individual points in the polyline at any time allowing us to increase the accuracy of our geometry. A unique entry was created for each named road. The roads can hold data fields including name, total length, average number of lanes, and amount of traffic. Walls are created the exact same way. However, the walls hold attributes such as thickness, height, and year built.

In GIS, polygons are used to represent structures. Points in combination with these polygons are used to denote the exact locations of entrances for greater details. Our strategy for creating polygons was to trace over satellite images from Google Earth and Bing Maps and add attribute data for those features into our system, the complete list of attributes can be found in Appendix C. The results can be seen below in Figure 19.



*Figure 19 - Example of the GIS Map (Screenshot from QGIS)*

With the ability to form new layers, we can develop a structured system that showcases the attributes of all important walls, gates, and streets with ease. The individual layers for roads and structures were further broken down using subgroups, as shown below in Figure 20. This grouping of data allowed us to color code polygons based on structure type and change color or thickness for different types of roadways. The group system allowed the user to toggle the visibility of certain types of roads or buildings.



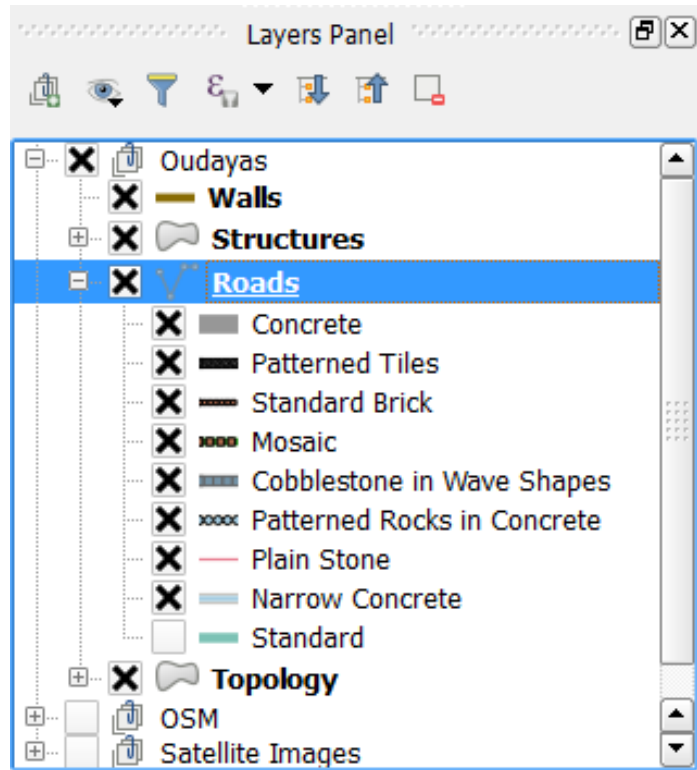


Figure 20 - An example of subgroups (Screenshot from QGIS)

### 4.3 Expandable system

QGIS works in tandem with a version of SQLite, a popular embedded database language, called SpatiaLite. It is a central core of information that is designed to be accessed and edited by multiple users. SpatiaLite extends the core of SQLite to support fully fledged spatial capabilities. It allows the entire system of spatial dots, polylines or polygons to be stored on one central file. Each feature in the GIS has a unique ID number and different attributes can be assigned within multiple categories. You can access each entry by highlighting the corresponding point on the GIS map or by opening up the system and finding the entry manually. An example of the system can be shown below in Figure 21.

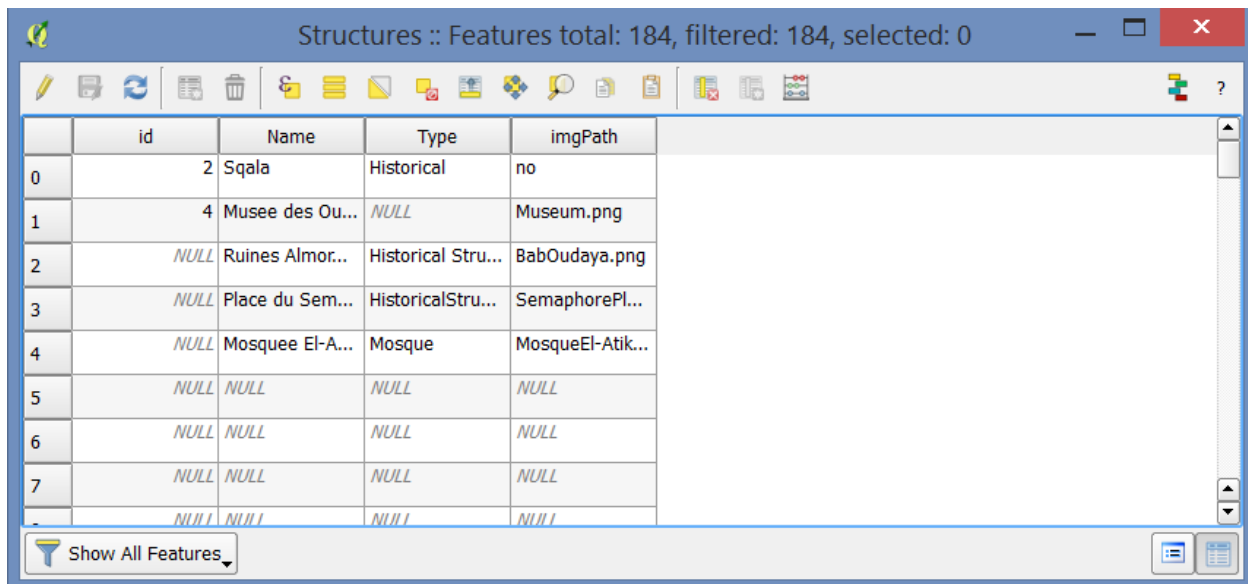


Figure 21 - A look at the system structure of QGIS (Screenshot from QGIS)

We have created our GIS with expandability in mind. A new layer can be added at any time. If the Prefecture would like to include electrical infrastructure data to the map they need only add a vector layer of lines and add features wherever powerlines are. For things such as dumpsters or lights, a similar process is used with a vector layer of points rather than lines. The process for adding a layer to the GIS is described in the Tutorial.

#### 4.4 Discussion

Though many different structures in the Kasbah are important, we chose which to include in the prototype GIS by considering factors such as tourist attraction and historical significance. There are four historical landmarks we focused on and two more that are more tourist oriented. The historical landmarks are the Almohad Walls and Gates, the Andalusian Gardens, the Museum of the Oudayas Kasbah, and the Jama al Atiq Mosque. The tourist locations are the Café and the Semaphore Platform. Today, many of these landmarks carry a huge piece of Moroccan history and many people visit here each year.

When we looked at the responses from the informal interviews, it was clear that all participants had the same perceptions of the Oudayas Kasbah. All responses included positive descriptors. Words regarding the beauty, uniqueness, safety, and cleanliness, were used in every

interview. With these words we were able to identify a trend of love for the Kasbah from its visitors and residents. Despite the difference in ages of the two people we interviewed who lived in the Oudayas (18 and 62), they both spoke about how they felt safe in their homes, loved how beautiful the Kasbah is, and had no plans on leaving. This shows how impactful the Kasbah is on the impressions and feelings of those that interact with it. The fact that even first time visitors love the area shows how significant it is as a whole.

During the five random interactions, we saw there was a notable sense of kindness in the community. Though people may be more reserved than they were in the past, they were still very kind and compassionate. We were approached many times and held multiple conversations despite the language barrier. Every conversation with the local residents made it very clear they are proud of their city and they are very welcoming towards others.

Though many people live, work, and visit the Kasbah every day, there was still no detailed map that we could use to base our GIS on. We had hoped that the Prefecture might supply us with a street map or satellite map, but they did not. In the end, we decided to use OSM's map because it contained a far more detailed road-map of the Oudayas than Google Maps or Bing Maps. This was not the perfect solution though. It is only a topological base that we expanded on.

While the data from OSM was a good starting point, we quickly discovered some issues with it. For one, OSM's points of interest were all singular points. This was not a major issue for gates, benches, or lookouts, but other feature types would work better in certain situations. Polygons would allow us to better show the area occupied by a building. Representing an oddly shaped building with multiple entrances using a single point might be confusing to users. A polygon however, makes it clear that the building stretches across a certain space and multiple paths connect to it. The other big issue was that none of the roads were selectable entities. By creating our own layers for roads and structures, we are able to add in any streets that are not already included in the base map.

We discussed earlier that we have broken our structure and road layers into subgroups according to different categories. Optimization of layers and groups will make the system robust, powerful, and adaptable to the user's needs. For example, if a user was driving a car and could not go down dirt roads, they could turn off the visibility of the group representing dirt roads.

While we were creating our prototype GIS we realized that we would need a system to input our data into. There are a few factors to consider when implementing a system such as where it is located or the number of users. The fact that SpatiaLite uses a monolithic database file is nice for single users looking to contain their work locally, but not optimal for groups of people remotely working on the same database. Some other type of online database or some form of source control would be ideal for a system like this.

In summary, we discovered the following:

- Many sites in the Oudayas Kasbah are historically and culturally significant to Rabat.
- Specifically, sites such as the Kasbah Walls, Bab Oudaya, Andalusian Gardens, Museum of the Kasbah, Moorish Café, Jama al- Atiq Mosque, and the Semaphore Platform resonate with people the most.
- Generally, people love the atmosphere in the Oudayas Kasbah and feel very safe and secure.
- The Kasbah has a very welcoming and kind community.
- Many residents and tourist were interested in the idea of a walking tour and were extremely helpful in providing historical information.
- OSM is a perfect base for a GIS such as this.
- Ordering like information into layers and sublayers helps to organize a city's information into a cohesive and logical system.
- By having an expandable system, multiple users can add information at the same time without having to pass a file between them.

## 5. RECOMMENDATIONS

Based on the results of the pilot study on the six buildings, the informal interviews, and the initial GIS system, we determined some recommendations that could assist in the Prefecture's plans to further widen the scope of the Geographical Information System.

We recommend that the Prefecture clean the litter inside and outside the Kasbah. This will make the area more visually appealing and welcoming to visitors traveling here.

It is also recommended that the Prefecture either hires an intern or create a position that focuses on the collection of historical and cultural information. With this position, information can be updated periodically than sporadically. This person should develop an archive or repository that can store all information that has been collected. This way, the information that will be used in the GIS's system will be easily accessible for those directly working on the GIS system.

It is very important to set up a method by which multiple users can work on the same file without overwriting each other's work. The two most popular systems designed to solve this issue are Git and SubVersion (SVN). Both have their benefits and drawbacks.

Git is very good for decentralized work. This means that it allows you to commit, or save a version, of your project without needing to be connected to the internet. SVN on the other hand needs an internet connection as it stores all its data in a central system. While you can still work locally and then commit the data later, you will not have the same version control as you would with Git. With Git you can save multiple versions locally, but with SVN you can only save one version when you work without internet. While Git has this extra capability, it also makes it a bit more complicated in use. There are two ways to save, committing (locally) and pushing (to the server), as well as two ways to copy information from the server.

The choice between the two depends on whether offline source control is more important than ease of access and a monolithic repository. We recommend that the Prefecture chooses Git for source control if offline work is a priority, but otherwise recommend SVN as it is the industry standard for the development of systems such as this.

When it comes to the addition and expansion of layers in the system, we suggest that utilities are included. Knowing the exact locations of each electrical line, gas line and water main

is imperative for safe digging and underground work. While there may be separate maps that have the locations of each utility on it, having one singular source would improve the speed and ease of future public works projects.

Additional research could be conducted in order to aid the Prefecture in adapting this system for use in the rest of the Medina and Rabat. Future projects could create an atlas of the city, condensing all the history of the area into one easily accessible location. Another project could be to adapt that atlas to automatically feed into a Geographical Information System that encompasses a larger area with more detail.

## 6. CONCLUSION

The research we have conducted and prototype created have provided a base for the Prefecture of Rabat's future Geographical Information System of the city. The design decisions involved in developing the system were deliberately chosen to allow for further expansion and elaboration. Therefore, if the tutorials we have created are used and the templates we developed are expanded upon, the Prefecture could potentially have a very powerful tool for tourism and public works at their disposal. With regular maintenance, updates, and the correct data inputted, our system is robust and adaptable enough to fit many requirements. We hope that with this system in place, users will be able to more easily find locations to explore and feel comfortable while going there, leading to an increase in tourist activity. The GIS we have created could stand as a case for universally available information and the importance of creating a well-structured system.

## REFERENCES

Anonymous. (25, June 2016). Andalusian gardens unveiled in Rabat's historic centre. Retrieved from [http://www.ansamed.info/ansamed/en/news/nations/spain/2013/06/25/Andalusian-gardens-unveiled-Rabat-historic-centre\\_8923295.html](http://www.ansamed.info/ansamed/en/news/nations/spain/2013/06/25/Andalusian-gardens-unveiled-Rabat-historic-centre_8923295.html)

Anonymous. (2016). Rabat, Mordern Capital and Historical City: a Shared Heritage. Retrieved from:  
<http://whc.unesco.org/en/list/1401>

Asebriy, L, Cherkaoui, T. E., El Hassani, I. E. E. A., Franchi, R., Guerrero, F., Martín-Martín, M., & Alcalá, F. J. (2009). Deterioration processes on archaeological sites of Chellah and Oudayas (world cultural heritage, Rabat, Morocco): restoration test and recommendations. *Bollettino della Società geologica italiana*, 128(1), 157-171.

Bargach, J. (2008). Rabat: from capital to global metropolis. *The Evolving Arab City: Tradition, Modernity and Urban Development*, 99-117.

Berrada, H., & Couplet, X. (2012). *Rabat-Salé de bab en bab: Villes et région, 14 promenades guidées*. Marsam.

Bouzahzah, M., & Menyari, Y. E. (2013, September 18). *The Journal of North African Studies*. Retrieved September 19, 2016, from:  
<http://www.tandfonline.com/doi/full/10.1080/13629387.2013.836321>

Casadei, D. (2015). TRADITION AND TECHNOLOGY IN THE RESTORATION AND REUSE. THE DAR DGIRA IN RABAT, MOROCCO. *Esempi di Architettura*.

Chhim, S., Hoctor, T., Pryor, J., & Sadowski, B. (2014). *The Evolution of Venice Through Mapping Technology*. Worcester Polytechnic Institute. Retrieved from:



[http://www.wpi.edu/Pubs/E-project/Available/E-project-121914-112605/unrestricted/VE14-Atlas\\_Report.pdf](http://www.wpi.edu/Pubs/E-project/Available/E-project-121914-112605/unrestricted/VE14-Atlas_Report.pdf)

Embassy of the kingdom of morocco in the USA. (n.d.). Retrieved September 19, 2016, from: <http://www.embassyofmorocco.us/tourism.htm>

Gregory, I. N., & Ell, P. S. (2007). *Historical GIS: technologies, methodologies, and scholarship* (Vol. 39). Cambridge University Press.

Hernandez, A. C., Krupnick, J. T., & Peglow, E. R. (2015). *Repairing and Repurposing the Foundouks of Rabat's Medina*. Worcester, MA: Worcester Polytechnic Institute.

International Tourism, Number of Arrivals [Chart]. (n.d.). In *The World Bank*. Retrieved September 19, 2016, from: <http://data.worldbank.org/indicator/ST.INT.ARVL?end=2014&locations=MA&start=1995&view=chart>

Jechtimi, A. E. (2012). *Hassan Tower, a look at Morocco's 12th C. architecture*. Retrieved September 19, 2016, from: <https://www.moroccoworldnews.com/2012/02/29105/hassan-tower-a-look-at-moroccos-12th-c-architecture/>

Mani, M. S. (1998). *The future of the past: on conserving the Mellah of Rabat, Morocco* (Doctoral dissertation, Massachusetts Institute of Technology).

Omira, R., et al. "Tsunami vulnerability assessment of Casablanca-Morocco using numerical modelling and GIS tools." *Natural hazards* 54.1 (2010): 75-95.

Pennington, D., & Melikian, G. (2006). *GIS Use in the Hurricane Katrina Response and Recovery Efforts*. University of Wisconsin-Madison.

Strategy of the sector of tourism: Vision 2020. (n.d.). Retrieved September 19, 2016, from:  
<https://www.finances.gov.ma/en/pages/stratégies/stratégie-du-secteur-du-tourisme--la-vision-2020.aspx?m=Investors&m2=Investments>

Turner, Rochelle. (2015). World Travel & Tourism Council. Travel & Tourism Economic Impact- 2015 Morocco. Retrieved from:  
<https://www.wttc.org/-/media/files/reports/economic%20impact%20research/countries%202015/morocco2015.pdf>

Voir, G & Hachette, T. (2002). *Maroc Broche*. Paris, 70-85.

# APPENDICES

## Appendix A: Timeline

Task	Week						
	1	2	3	4	5	6	7
<b>Learn QGIS</b>							
<b>Determine an approach on receiving data for the Global Information System (GIS)</b>							
<b>Assess the structures/ conduct informal interviews</b>							
<b>Analyze/ Input data into the software</b>							
<b>Send and share findings with the Prefecture of Rabat</b>							

## Appendix B: Conversation Guidelines

These questions were guidelines for casual conversation between the interviewer and the interviewee. Questions varied depending on the interviewee's past and how well certain questions fit to their life.

### Version 1

1. Do you live in, work in, or are you just visiting in the Kasbah?
2. Have you lived/worked in the same place the entire time?
3. Why did you choose to [reside, work, visit] here?
4. What are your overall thoughts about the area?
5. Do you have any memories of this area?
6. Do you have any stories in the area that you would like to tell us?
7. Do you have any historical information about this building?

### Version 2

1. What is your name?
2. What is your occupation?
3. Are you currently living/working/visiting the Kasbah?
4. Why did you choose to [reside, work, visit] here?
5. Do you have any stories or memories of this area?

## Appendix C: Attribute Table

Attribute	Structure	Roads	Walls
ID	X	X	X
Name	X	X	
Age	X		X
Creator	X		X
Material	X	X	X
Use	X		
Color	X		
Image	X	X	X