# Road Asset Management Systems In Geçitkale, North Cyprus

**Esther Obrasua Akobo**

Submitted to the
Institute of Graduate Studies and Research
in partial fulfillment of the requirements for the degree of

Master of Science
in
Civil Engineering

Eastern Mediterranean University
June 2018
Gazimağusa, North Cyprus

Approval of the Institute of Graduate Studies and Research

Assoc. Prof. Dr. Ali Hakan Ulusoy
Acting Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science in Civil Engineering.

Assoc. Prof. Dr. Serhan Şensoy
Chair, Department of Civil Engineering

We certify that we have read this thesis and that in our opinion it is fully adequate in scope and quality as a thesis for the degree of Master of Science in Civil Engineering.

Asst. Prof. Dr. Mehmet Metin Kunt
Supervisor

Examining Committee

1. Assoc. Prof. Dr. Mustafa Ergil

2. Asst. Prof. Dr. Şevket Can Bostancı

3. Asst. Prof. Dr. Mehmet Metin Kunt

# ABSTRACT

North Cyprus has maintained its major roads which have heavy traffic loads. However, the village road networks are often neglected due to various factors such as lack of asset management and technical know-how at local administration level.

The village of Geçitkale happens to be one of such villages affected and although it is one of the large villages in Famagusta District with a population of 1,253 based on 2011 census is Geçitkale village, the road asset management is very poor. The road system is managed by the municipality and so far there is no inventory of their road network and they are now taking steps to rebuild their database. Geçitkale is home to several archeological features such as the Archangelos Michael Church and İncirli cave.

To provide help in the maintenance of the road asset systems, this research will help create inventory of the Geçitkale region. The R Sweave database will be used to create an inventory for the various road attributes. The attributes include but are not limited to stating the conditions of the roads, overall value of asset, establishment of level of service needed for each road, targeting long term conditions and anticipating future. The development of data collected for each road section was done by importing into the R software and an inventory was generated of all the road attributes.

This method is easily adopted as it is simple, efficient and also caters to the lack of technical know-how as it does not require a skilled engineer.

**Keywords:** Road asset management, Pavement, Road and Geçitkale

# ÖZ

Kuzey Kıbrıs ana yollarını korumuştur. Bununla birlikte, köy yönetim ağları, varlık yönetimi eksikliği ve yerel yönetim seviyesinde teknik bilgi birikimi gibi çeşitli faktörler nedeniyle sıklıkla ihmal edilmektedir.

Geçitkale köyü etkilenen bu köylerden biri olmakla birlikte, Gazimağusa ilçesindeki büyük köylerden biri olmasına rağmen, 2011 nüfus sayımına göre 1.253 nüfuslu Geçitkale köyü, yol varlık yönetimi çok zayıf. Yol sistemi belediye tarafından yönetiliyor ve şu ana kadar yol ağlarının envanteri bulunmuyor ve şu anda veritabanlarını yeniden inşa etmek için adımlar atıyorlar. Geçitkale, Archangelos Michael Kilisesi ve İncirli mağarası gibi çeşitli arkeolojik özelliklere ev sahipliği yapmaktadır.

Bu araştırma, yol sistemlerinin bakımına yardım sağlamak için, Geçitkale bölgesinin çizelgesini oluşturmakta yardımcı olacaktır. R Sweave veritabanı, çeşitli yol özniteliklerine yönelik bir çizelge oluşturmak için kullanılacaktır. Öznitelikler yolların koşullarını, varlığın toplam değerini, her yol için ihtiyaç duyulan hizmet seviyesinin oluşturulmasını, uzun vadeli koşulları ve geleceği öngörmeyi içerir. Her yol bölümü için toplanan verilerin geliştirilmesi, R yazılımına aktarılarak yapıldı ve tüm yol özelliklerinin bir çizelgesi oluşturuldu.

Bu yöntem basit, verimli ve aynı zamanda yetenekli bir mühendis gerektirmediğinden teknik bilgi eksikliğine de hitap ettiği için kolayca benimsenir.

**Anahtar Kelimeler**: Karayolu yönetimi, Kaldırım, Yol ve Geçitkale

To My Parents

# ACKNOWLEDGMENT

A deep gratitude to my supervisor, Dr Mehmet Metin Kunt for his support, input and encouragement during this project.

To my ever present parents, Engr. Iboroma Zab Seddon and Mrs Ibinabo Stella Akobo. Thanks for teaching me to soar.

My forever superwoman and grandmother, Eva Ikiroma. You continue to teach me the true meaning of love and strength.

I am grateful to my siblings Dr. Seleipiri; my power house, Biobele, Josiah, Deborah and Tamunokuro who always support me.

With a special mention to Shedrach, Deinma, Rejoice, EXILES and Zaniar. Thanks a ton!

# TABLE OF CONTENTS

# LIST OF TABLES

# LIST OF FIGURES

# LIST OF ABBREVIATIONS

| | |
|---|---|
| ADA: | Americans with Disabilities Act |
| BOT: | Build-Operate-Transfer |
| DBF: | Design-Build-Finance |
| DBFOM: | Design-Build-Finance- Operate-Maintenance |
| DOW: | Department of Works |
| EPA: | Environmental Protection Agency |
| ERF: | European Union Road Federation |
| GASB: | Government Accounting Services Board |
| GDP: | Gross Domestic Product |
| IMF: | International Monetary Fund |
| LLCC: | Lowest Life Cycle Cost |
| NCHRP: | National Cooperative Highway Research Program |
| PMS: | Pavement Management System |
| PPP: | Public-Private Partnership |
| RAM: | Road Asset Management |
| TL: | Turkish Lira |
| WSDOT: | Washington State Department of Transportation System |

# Chapter 1

# INTRODUCTION

## 1.1 Background

Roads are one of the important financial community assets and offer massive benefits to the society. However, because of asset mismanagement, many road networks are under threat of deterioration (UN Economic and Social Council, 2009).

Until recently, the reporting of fixed assets consisting of roads, buildings, bridges or different infrastructure on accounting sheets was tough due to the report system requested by the government. These assets have been of fixed value, without any consideration for depreciation or actual usability. Sincerely said, the government no longer accounted for the roads in need of repair or if they were truly safe for use, it best mandated that the roads be accounted for with a fixed fee.

Management of the road asset entails the application of engineering and management practices to optimize the kind of service outcome for the most cost-effective financial input. The function of the asset manager is to optimize funding and results within the constraints of finance, service type, and assets. Taking best the pavement and surfacing property into attention, the optimization is carried out through life-cycle control technique. Concerning pavement and surfacing property, the life-cycle control is best effective (Rajeswari, 2014).

A skilled practitioner is needed to perform a few form of needs-evaluation or review against predicted pre-treatment service level, and make changes primarily based on actual overall performance. Maintenance is essential to design, construction, and asset management groups to predict and contain unforeseen or underestimated road conditions. For instance, sudden softening of pavement may be detected which could affect long-term period pavement performance.

In March 2013, the European Union Road Federation (ERF) published a Manifesto on road asset management (RAM), referred to as 'keeping Europe moving – A Manifesto for the long-time period, powerful control of a safe and efficient European road network. Collectively with some crucial facts and figures, the Manifesto highlighted the problem of the shortfall in investments all over Europe for the renovation of the road infrastructure and its dramatic consequences: massive deterioration of the network, higher risks of accidents, issues of congestion, increased noise and a reduced service to society'. The problem is that road infrastructure is frequently no longer seen as a financial asset for society and the economic system, largely because of the shortage of awareness of its value.

## 1.2 Problem Statement

Asset management is a systematized method of upgrading, maintaining and running assets. Numerous companies are making use of asset management concepts as a professional device and tool to assist in outlining the objectives and prioritizing agency services in choice making. Road asset management is centered on the pavement, culverts, pavement markings, traffic signs (Hussain, 2014).

Infastructures provide the most principal land transportation mode. They are like the spine of the economy, usually carrying over 50% of freight and 80% of passengers and in a country, and offering critical connection to massive rural road networks (Ali et al., 2006). Road network is an important public asset in numerous countries. Improvements to road assets convey prompt and typically radical changes in communities via easy hospitals, markets, and schools' accessibility, larger consolation, safety, and general wellbeing; and lesser automobile prices in operation.

Governments are applying extra strain on road authority to enhance accountability for community assets management and the roads performance. Some nations such as Australia, Canada, and the United States undergo systematic accountability and reporting necessities on their asset management (Russell et al., 2014).

## 1.3 Research Questions

- Is there a reliable and structured inventory of the total road assets and their conditions?
- How significant is using the software to develop an effective and efficient model that aids proper road asset management systems?

## 1.4 Objectives and Scope

### 1.4.1 Aims and Objectives

The primary focus of this research is to collect asset data, analyze, and show the conditions of the asset and present a management plan by using the software tools such as R, R Sweave, and LATEX.

Specific research objectives are;

- Data collection procedure including data types and frequency of collection to create a proper inventory of the road assets with its components (i.e. pavement surface, traffic signs, light poles, and sidewalks).
- To establish an easy-to-use database for implementing and updating of the state of the assets.
- To investigate the current conditions of the road assets, which require replacement or maintenance.
- To prepare a report on the road asset conditions, showing deficiencies in each asset.

### 1.4.2 Scope

The presentation of this thesis will follow a two-step approach. The goal of the first step is to develop a simple asset management model (SAMM) to resource short-term planning and viewing of the asset. An evaluation of the road asset management with a focus on condition assessment and infrastructure maintenance priority will offer references and popular structure as to how the simplified model has to be constructed. The next step of the study is the implementation of the simple asset management model.

This thesis includes five chapters that explain the study. Chapter one will give an introduction of the research study by presenting background information on the subject, stating the problems existing and giving an idea to how the study will be a solution with the research questions, objectives and scope. Chapter two is a review of past literatures relating to the subject that explain the adopted management of several road elements in various countries. It also describes municipal asset management,

highlights the challenges present and findings in relation to the project and the case study along with its assets. In chapter three, the methodology of the study is explained. General research approach is shown, the organization of the research including the data collection processes, analysis and integration of the project into the case study are explained. For chapter four, the results and discussions of the topic is carried out. There is commenting on the road asset management model; assessment of the asset conditions, creation of the inventory system, and the priority of the asset. The conclusion chapter specifies the easy adoption of the study and the importance of the study.

Also, there are added figures from the study to help the framework for implementation and further research.

# Chapter 2

# LITERATURE REVIEW

## 2.1 General Information

For proper understanding of the subject that is asset management, the basic theory of the concept is properly reviewed to give a distinct definition of strategic and tactical asset management. Road asset management involves critical tackling for decision makers equipping them with sufficient effective and sustainable tools for road management (Campanaro et al., 2017). This includes an entire inventory of the works and all its elements, outlook of the road network performance and condition, overall value of asset, establish level of service needed for each road based on type and level of road use, planning to achieve objectives and maximize asset value that is cost effective, target long-term conditions, establish investment strategies for overall good asset condition, anticipate future condition and define and implement a Road Asset Management(RAM) plan.

Colby (1999) referring to Government Accounting Services Board (GASB) 34 states that:

> Infrastructure assets are long-lived capital assets that normally can be preserved for a significantly greater number of years than most capital assets and that normally are stationary in nature. Examples of 9 infrastructure assets include roads, bridges, tunnels, drainage systems, water and sewer systems, dams, lighting systems, and buildings except those that are not ancillary part of a network of infrastructure assets, those are not considered infrastructure assets.

## 2.2 Definition of Asset Management

Through time, the value of fixed assets like roads, bridges, and other infrastructures have been left unaccounted for, due to lack of inventory by the government of the existing road authority across various countries for various reasons. Since the maintenance of these assets was not accounted for, the depreciation of these assets began to set in affecting the economy of many countries, from the under developed, developing to even developed countries. Gradually, there has been establishments of various efficient standards and governing road authorities to redefine infrastructural assets and provide accountability. Usually, corporations give asset management definitions based on their structural agenda.

Cesar et al., (2014) described strategic decisions for choosing the best organization to control road preservation and investment program to include the following:

- Can one or several entities manage the structure of the program?
- What should be included in the management structure of the entity or entities in the management of the program?
- How can the investments be managed after setting up the entity/entities?
- Should the introduced entity/entities be committed to the existing assets or a new investment program?

The complexity of the road sector demands a large sum of stakeholders with the existing large and versatile nature of the remodel procedure used to prepare and implement the plan for the transport officiating body. There is, therefore, need for technical expertise.

Jusi et al., (2003) reports on the road network of Papua and New Guinea. The country's department of works (DOW) in charge of road asset maintenance didn't give adequate maintenance requirements to the road networks. This affected the gross domestic product (GDP) and growth of economy adversely due to lack of providence of fundamental access to services like markets, health and education and administration. Also, the rural part had little or no access to services. The DOW now gains funds and guide from the Asian Development Bank with Finland consultant assist and have developed their system for road asset giving solutions to long and short term management of road networks.

Road which is a physical asset is comprised of various elements including travel way, pavement, alignment, subsurface, crown, curb, gutter, shoulder, structures, signs, sidewalks, paths, utilities, waysides and overlooks amongst others.

Herabat (2003) reports the improvements of roads in rural areas; a national improvement plan has helped to reform the social and economic dominant structures. There was the introduction of sub-sectors. The goal of sub-sectors is to ensure the best social and financial improvement in these regions. Generation of a network for clean connection among the rural regions and venture tiers was used. They involved technological and method gear. The device advanced the bridge, drainage system, pavement, traffic signal, plant life troubles and pavement marking. Advantages of the improved national overall plan is determined from the road user results and efficiency.

### 2.2.1 Pavement

An excellent maintenance plan for road network is one that ensures a consistently high level of structural and functional conditions (Agarwal et al., 2004). The use of

pavement as a road element ensures daily road usage which is important in encouraging economic activities, hence it contributes to economic stability. The pavement quality affects travel and puts road users at safety risk if left in poor condition (World Bank, 2011).

The management of pavement asset is done through evaluating and maintaining the asset at project, network and strategic levels. The success of this asset management is highly dependent on the communication at different decision levels by stakeholders and the management system employed.

Jeff et al., (2016) describes pavement asset management giving an overview of the management processes starting with the establishment of the complex project context, the project preservation process overview (consisting of the data collection and the project prioritization and programming), the preview of the present and foreseen condition of the asset in the networking context, identification of issues facing the pavement management system (PMS) and the solutions to these problems. The Washington State Department of Transportation System (WSDOT) was used.

Most of the financial aspect of the pavement asset maintenance is usually insufficient and this increases the urgency for better performance in risk evaluation, investment prediction trade-offs, and communication at this time for maximum cost efficiency during the finance acquisition.

The primary objective of Pavement management is to manage the Lowest Life Cycle Cost (LLCC), which is the choice of alternative to manage the total cost of asset

ownership throughout life cycle. This involves choosing the right time to rehabilitate pavement life as too early or too late, unnecessary rehabilitation can waste pavement life or cause an increased repair cost, higher fuel and cost of ownership.

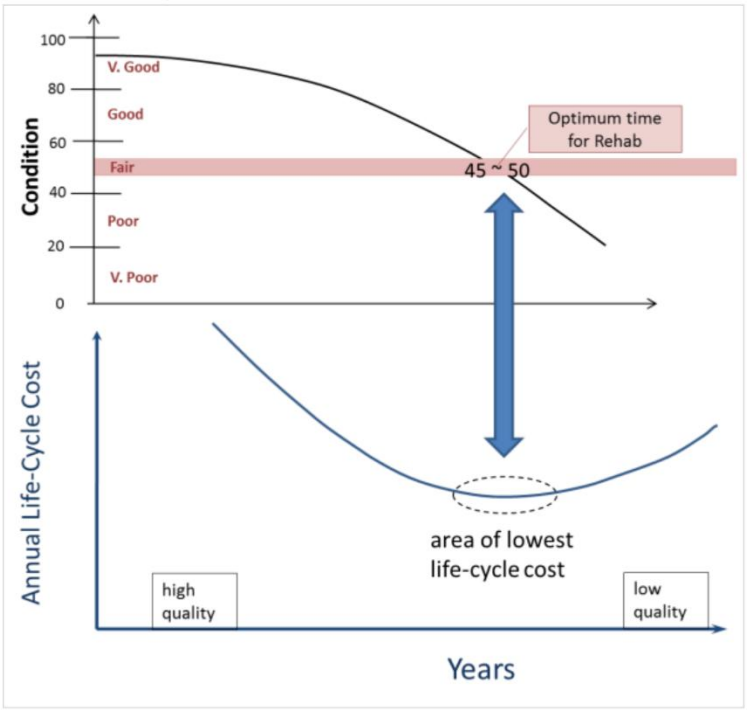


Figure 2.1: Pavement Quality and LLCC (Source: Pavement Asset Management, Jeff et al, 2016)

The direct relationship between Lowest Life Cycle Cost (LLCC) and overall pavement quality is shown in Figure 2.1. An increase in funding higher than LLCC affects the overall pavement quality but the pavement life is considered wasted and vice versa.

The basic requirements of the Lowest Life Cycle Cost framework are determining the minimal accepted pavement performance levels and it can be gotten from the evaluation of:

- Commercial Freight
- Driving Public
- Pavement Structure
- Safety

- Vehicle Operating Cost

This information serves as the primary indicators for conditions including;

- Cracking
- Roughness
- Rutting
- Skid Resistance

These parameters are used to obtain the minimum accepted pavement performance levels, ranging from “Very Poor”, “Poor”, “Fair”, “Good”, and “Very Good”.

Michael (2014) began illustrating the pavement management methods. They advised about the standards and asset control. The National Cooperative Highway Research Program (NCHRP) synthesis subject matter 37-03 was used to divide the other infrastructure property. Site visitors’ alerts, culverts, lighting fixtures, signing, 14 sidewalks, pavement markings are the instructions of asset control. They evaluated a number of the components to the upcoming asset preservation, measuring the asset performance, budgeting methods, asset provider life, and so on. This observation shows the primary know-how on construction management, pavement markings and site conditions provider lifestyles for distinctive materials. The reflect meter was used for asset control, and reliability method.

Including the consideration of external factors interrelated that affect pavement performance including the Construction, Environment, Maintenance, Structure, and Traffic.

### 2.2.2 Traffic Signs

Traffic signs contribute to an important part of the road asset system, little or no road signs on any road is an inadequate road.

The traffic flow in Geçitkale, North Cyprus has a typically hour pattern with peaks usually in the morning, early afternoon, and later in the evening especially on working days. The morning peak is very sharp and short as people are commuting to their jobs or schools. The next peak, in the afternoon is usually shorter than the first and last longer as it is the general lunch-break time of various occupations. The evening peak is almost as high as the morning as people are usually commuting home.

Hussain (2014) explains that signs aid road users by giving clear and easy information and guidance. It helps the authorities facilitate a proper route network for economical operations, control, rules and regulation of traffic and enhance road safety. Roads signs must be efficient by being visible, legible, understandable, interesting to cause right behavior, regular with use, lighting and position.

The road signs are important as they help constitute a safe traffic flow at different times and to various locations reducing accident risk, and promote road safety.

Harris et al., (2012) details traffic sign reflectivity standards. The research paper turned into supplied examining of numerous reflective traffic signs preservation techniques using signal asset management. This approach was coined from data collection and inspection system. For the process to be finished, they had to take 30 eventualities within the annual preservation fee in line with signal and percent of traffic signs. The

simulation outcomes must be better cost in keeping with higher signal preservation. Normally leading to a decrease in the percentage of signs. For a few sign, the use of night time inspection is recommended.

Allen et al., (2017) describes the asset control to assess the street substructure drainage network. It was stated that various places in Canada have elevated heavy industrial vehicles volumes. They are aimed to aid primarily finance-based development, these changes in moisture conditions and heavy loadings influence the failure, and street structure distress. In a number of the instances like gradual shifting and truck turning traffic will increase pressure inside the road structure. Their structural tension impacts are hard with the experimental and mechanized models. Floor penetrating radar, falling weight and deflect meter, powerful mechanized designs are explained through the three case studies.

Joseph et al., (2010) explains the necessity of culverts as an asset and its management. It is more essential to evaluate the underground property for survey and inventory procedure. The numerous Department of Transport System (DOTS) states have been dispatched to the survey concerning the control of culvert issues. The entire twenty-eight replies helped to make plans to create the planning for the survey and stock database software. Numerous organizations did perceive the failure motive for figuring out and inspection process.

Asset management systems also involve the management methods implemented, inventory, system breakdown and the condition assessment method of the project.

Charles (2013) was involved in situation assessment and inventory of project. The location, condition and inventory of the road asset were generated to be effective. They ought to adopt worldwide positioning satellites for correct position of the asset situation (broken or shut off). This assignment became executed for all roadway belongings in the dual carriageway boundary lanes. Sub-contractors and contractors are accumulating results and improvement. The overall technique changed within November 2012. They had to accumulate and eventually compete for inventory toll road property in 3 nations evaluating asset situations and state procedure for asset management statistics.

Smadi (2006) explains infrastructural management systems with reference to the transportation field of civil engineering to aid students plan better strategies for adoption and development of these assets for both agencies and government.

Due to diversity, various governments have failed to notice the administration, financial and feasibility arrangement of the road asset management (Queiroz et al., 2010). They include:

- Decentralization: This is practiced especially in large countries where there are many smaller sectors. The complexity of management for large and diverse road assets give rise to sector divisions for proper monitoring and management. Hence the authority of the road management is delegated to the local governments. For instance, China practices decentralization as the management of road network management, construction and operation, is handled by the local provinces. Whereas, smaller countries remain centralized like Bangladesh, Ghana and Jamaica.

- Public Private Partnership (PPP): Countries government have resulted to other sources of finance for construction of road assets. Some rely on public borrowing like China that is paid back from toll revenues, some borrow from the International Monetary Fund (IMF) or the World Bank while others have opted to award contracts to private agencies. PPP refers to a contractual agreement formed between public and private sector partners, by which the private partners play a greater than traditional role to design, construct, finance, operate, maintain, or renovate a facility or system. PPP models are specific and defined by stages of delivery of project and private expertise, finance and other resources involvement. Common models include Design-Build-Finance (DBF), Design-Build-Finance-Operate-Maintenance (DBFOM), Build-Operate-Transfer (BOT), etc.
- Management System: Transportation policy for road asset networks have been governed by management principles within the widespread ideas, but in a few cases, explicitly required. A lot of those legislation had similarities in terms of both fashionable traits and specific information which either led to powerful implementation of the mandates inside the guidelines or supplied barriers to implementation.

## 2.3 Municipal Asset Management

The adoption of decentralization used in North Cyprus has brought about the municipalities owning and controlling assets found in them.

Fernholz et al., (2007) described Municipal asset management as the procedure of stock, valuation, utilization, vital portfolio surveys, detailing and reviewing of

metropolitan resources and, at times, state properties as a feature of the basic leadership procedure of local governments.

The goal of municipal asset management is to meet a proposed level of service with cost effectiveness throughout the life cycle of the asset.

The reasons why the municipality should be cost effective with respect to these assets are:

1. Road asset contributes as a major investment.
2. Economic growth of the municipality is dependent on maintained road asset (Robert et al., 2013).
3. Efficient maintenance and operation is important for public health and safety.
4. Innovation and productivity in operation of infrastructure is achieved.
5. Primary customer service is improved.

Also, municipal asset management includes the consideration of the various external factors that influence sustaining the asset. They include the political, legal, and regulatory aspects. Like some other systems of government, the advantage administration capacities must be caught on with regards to the social and political condition. The laws and directions will, to a few degrees, mirror these substances.

Civil pioneers, who, with their constituents have created a typical vision and social understanding, regularly have their underwriting and support to fortify or change the benefits administration framework that will streamline asset use in the accomplishment

of open goals. The particular lawful and logical parts of strategy and basic leadership forms are the concentration of this segment.

Kaganova and McKellar (2014) states that practices for good asset management for municipalities worldwide should have shared basic features: Good inventory, institutional structure with clear responsibilities, market-based evaluation, optimizing maintenance of infrastructure, strategic financial planning and transparency.

### 2.3.1 Good Inventory

Proper asset management is centered around understanding what the asset entails. There should be a thorough and refurbished inventory and logical classification. To prepare an effective, well informed, long-term choices for assets, maintaining and developing an in-depth account of the municipality resources. However, in the case of developing countries such as North Cyprus, the municipalities have insufficient asset inventory systems.

### 2.3.2 Institutional Structure with Clear Responsibilities

Lack of clear roles and responsibilities are common for developing countries. A major principle to allocation of a senior manager and a team solely for the management of an asset.

### 2.3.3 Market Based Evaluation

Municipalities should be properly informed on the market-based value of assets financially to prevent undervalued exchange. This is important due to decentralization, where the revenues are generated from the land sales. The municipality can profit from the sale of surplus land and corruption is also tackled since they are sold at market value.

### 2.3.4 Optimizing Maintenance of Infrastructure

Maintenance of assets help the municipality save in the long-term and also aids accountability. In place of erecting new infrastructure, maintenance of the existing ones should be encouraged as it leads to limiting unnecessary expenses as good maintenance leads to less need for frequent repairs over the life cycle of assets.

### 2.3.5 Strategic Financial Planning

For better outcomes in the long-term, it is important to have a strategic approach. The purpose of a good asset management plan is to maintain existing assets, generate efficiency gains, facilitate economic well-being and quality of the public sector.

### 2.3.6 Transparency

This refers to basic, cost effective, and efficient ways to promote asset management and abolish corruption as stated in ISO55001. Disclosing information of asset facilitates public engagement and opinions and puts the government in check as to the management of assets.

A key procedure in resource administration is the risk analysis (Wijnia, 2015). Tending to hazard in foundation decides the ramifications of disappointment from different perspectives. By deciding the ramifications of disappointment, a relative significance chain of command among resources is made. A few assets are at a higher hazard for disappointment because of their debased condition, while a few assets are a higher hazard because of their relationship with higher or more essential administration levels. The accompanying inquiries outline what chance administration looks to reply:

- Are there possible risks?
- What is the probability of risk occurrence?
- What are the risk consequences?

In the event that debased administration is perceived in the framework and the state of a few resources is poor, the likelihood of disappointment is significantly higher. At last, the result of such disappointment gives the last bit of hazard. In the event that an advantage is in poor condition, yielding a high likelihood of disappointment, yet the outcome of disappointment is low, the hazard to the association is likewise low. The outcome is similarly as imperative as the likelihood and with a specific end goal to give an exact risk appraisal, both must be available.

The risk assessment processes include the identification, classification, analysis and assessment and the mitigation of the risk.

A Simple Asset Management Model (SAMM) is needed at different points of the maintenance phases; operational and strategic asset management. Different focus levels require different plans in the asset management process. The road asset management structure has different integrated levels. The decision-making process behind these levels include the strategic, operational and tactical processes (Jeff et al., 2016). Among them, strategic process requires the greatest focus. The levels are reflected in planning variables in diverse capacity. For instance, the quality and type of information needed differ at different levels for the attributes below.;

- Failure consequences
- Planning points
- Set goals
- Asset priority

An expense-based open utility uses asset management to reinforce its execution and improve the level of administration given to clients. This is improved and executed using an expense-based asset management approach. In some organizations, road assets benefit the main goals of the association but does not necessarily improve on them. However, the lack of knowing the relationship between the organization main goals and the benefits of the organization makes it a disadvantage to the administration. There are three stages of road maintenance: protective, restorative, and crisis (ERF, 2013). In protective stage, primary target is to broaden the expectancy of life and function of roads to counteract prompt harms. To achieve the set target, there is an implementation of special treatments on road elements as an approach to back off damage or degradation and further decrease the requirement for restoration. Restorative maintenance involves procedures carried out after pavement damage. It proposes processes following road damage. Restorative maintenance might be required when there is friction loss on the roads, forming of potholes, or noticed cracks and different sorts of distresses. Contrary to the protective stage, restorative maintenance is more of a responsive way to deal with avoiding damage to road surface and repairs required for road network. Crisis maintenance, then again, occurs as a quick need to fix road. A few potholes could attract quick consideration when they influence traffic or prompt mishaps. Much of the time, emergency maintenance are not permanent measures. They are carried out till lasting arrangements can be taken to address the current issue.

## 2.4 Limitations

This research is carried out to provide the municipality of Geçitkale with possible plans to their asset management. It is intended to provide a simple cost effective plan that is easily adaptable. However, there are various challenges which have served as

hindrances for further studies and should be noted for improvement and require future development. These include:

### 2.4.1 Communication Barrier

This was a very critical barrier to the study as firstly, the author was not fluent in the local language and could not have direct communication. Also, due to the distance to the town from the author's location, it was difficult to gather timely information for the study.

### 2.4.2 Out-of-date Management Structure

The road management structure is fairly out of date, as the municipality is a fast growing and their system of managing the road networks remains the traditional method. Also, in the past road accounted for a small percentage of the spending whereas now there is an enormous growing need for road as an asset. However, regardless of the greater asset value of roads, there is still lack of structure.

### 2.4.3 Lack of Inventory

Road as a valued asset has come a long way from the traditional road management and needs to be properly maintained and accounted. The responsibility of the asset rests mostly on the municipality. Although there is somewhat clear designation of the road, the information is outdated and there is a lack of proper inventory on the asset condition.

### 2.4.4 Problem of Human Resource

A very significant problem facing asset management is the human resource constraint. The government suffer greatly from lack of qualified and experienced technical know-how and managers and also have lots of unqualified human resource leading to inadequate asset management.

### 2.4.5 Poor Management Information Systems

An effective road management system entails quality, timely and cost efficient information processes and acquisition. Introducing a road asset management plan has to be strategic and easy to adapt to due to technical, internal and external influences. The application of RAM plan is that it is to be sustainable and should meet the daily needs of the asset.

### 2.4.6 Lack of Financial Resources

A very limiting factor for road asset management is insufficient funds and where there are financial resources, there is inadequate allocation of these finances due to improper asset plans. This is manifested in the form of hastily degrading asset values, increase in congestion of traffic, deteriorating road protection, and worsening environmental pollutants. Many roads are designed and constructed shortsightedly without proper plans for rehabilitation and maintenance.

### 2.4.7 Roads Seen as just a Public Good

Road is often viewed as a state property and so is seen as ‘free’ by the road users. This false view poses a serious problem because even as a public service, it is unlikely to be paid for like other amenities such as electricity and water supply that are easy to be charged for. As there is no stated cost for road, taxes are used as primary finance for the asset budgeting and having other sectors like education, security and health, there is a competition for the available funds.

### 2.4.8 Research Scope

The time allocated for the research was not sufficient in respect to the scope. There is no background information of road asset management using the program model used.

## 2.5 Findings

There are several findings established by this research and a few past reviews. Firstly, the need for enhancement in infrastructure management. The case study research has shown that there is insufficient data and information that has vanquished any hope for an adequate asset management deduction making and in progression, plan. Lack of data created a challenge of identifying and locating the asset elements and also knowing their conditions. Issues arose due to lack of inventory: changes that were made or maintenance carried out on the asset were either not properly documented or not documented at all.

Also, there was absence of readily available tools. The lack of no existing integrated data system. The process of documenting data and information is very difficult due to the absence of an already existing integrated system that aids the recording and reporting of data and information.

## 2.6 Case Study

The municipality of Geçitkale (Greek, Λευκόνοικο; 2,380 inhabitants in 2011) is located in north-west of Famagusta. The Municipality consists of seven (7) villages; which are are Çamlica, Çınarlı, Geçitkale, Mallıdağ, Nergisli, Sütlüce, and Yamaçköy.


Figure 2.2: Map of Geçitkale
(Source: City Population; web [Assessed: 17 Oct 2017])

In Figure 2.2 shows the map of Geçitkale in the Cyprus map, pin pointing the locations of the villages. Geçitkale town has a total kilometer square area of 54.0. It is known as the airport base that is situated in the town and the presence of the Archangelos Michael Church that being conserved by the Technical Committee on Cultural Heritage and UN Development Programme.

Figure 2.3 is the full road network of the Geçitkale municipality streets consisting of the road IDs, names of both the street, avenues and junctions and their location. This was obtained from the municipality.

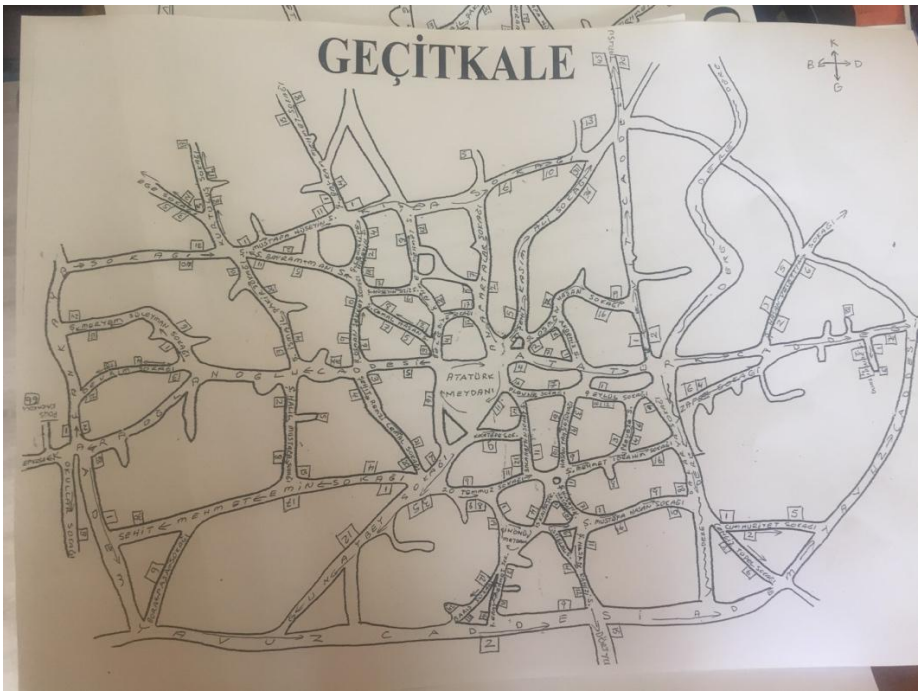

Figure 2.3: Geçitkale Municipality Road Network

The Figure 2.4 shows the front view of the church. The structure was constructed over different times and has no exact date for archaeological purposes.


Figure 2.4: Archangelos Michael Church
(Source: UN Development Programme; web [Accessed: 17 Dec 2017])

It is a twofold aisled church with an anticipating chamber at the south-west corner and an arcade along the south side. Preparatory investigation of the development history demonstrates that the most seasoned part is presumably the chamber in the south-west corner which is by all accounts a medieval structure. Along the entire width of the west side of the congregation, there is, at a moment level, a ladies' display – gynaikonitis- the entrance to which is through a stair – half stone fabricated half wooden - at the southwest side. The congregation is altogether worked with stones and the enormous curve of the south divider is completely secured with frescoes. A work of art of Archangelos Michael, to whom the congregation is dedicated, covers the entire mass of the visually impaired curve.

The United Nations Development Program (UNDP) in affiliation with Technical Committee on Cultural Heritage and the European Commission are currently responsible for the restoration of the church as it shows the history of Cyprus. This history is shared by both the Turkish and Greek Cypriots as the church is an archeological, structural and cultural representation of their heritage. North Cyprus has been a tourist attraction known for its rich legacy dating back from the Byzantine, Lusignan, Venetian, Ottoman amongst other civilizations. The restoration of this church would further show this heritage and increase the options of tourist and positively affect the income and sustenance of the municipality.

This study provides a proper guidance for road users like traffic and road signs leading to the church hence improving the way road users view road and highlight the importance and need of the asset.

Another important archeological treasure to the Geçitkale Municipality is the İncirli cave which is located 2km south of the Çınarlı village. This is the most important geological cave on the island of Cyprus. The fossil cave formed about 200 thousand years ago contains gypsum over 1.5 million years old.

### 2.6.1 Case Study Assets

The data collection included covers 54 streets with total length of 5472 lane km of paved roads in Geçitkale, including Major streets; Avenue and minor streets; Street. This effort was achieved through a cooperative effort of individuals from the municipality and help from some capstone Civil Engineering Department students of the Eastern Mediterranean University.

The Municipality's general Asset Management Strategy is encompassed on accessible information, foreseen benefit levels, development desires, and different assumptions. Assumptions in these things present some unavoidable hazard that the general technique may change after some time as the town advances and grows total information and procedures. Perceiving these uncertainties, the Municipality will create techniques to address each deficiency so the Asset Management Strategy can advance after some time. Risk mitigation methodologies for each of the accompanying are examined underneath:

- Assumptions of Assets
- Data quality of Assets & Mitigation
- Growth (expected vs. actual) of Assets & Mitigation
- Budget Needs of Assets & Mitigation

### 2.6.2 Assumptions of Assets

Assumptions have been made to fill information gaps and have been noted where implied. Similarly, with assumptions, some assumptions may not represent a sufficiently substantial level of the benefits and could possibly bring about surprising cost expenses if not repaired as it poses a risk.

### 2.6.3 Data Quality of Assets & Mitigation

The information gotten and gathered to the study for different viewpoints were given by both the municipality and manual study and estimations to precisely mirror the administration lives of the essential segments of the assets (i.e. condition, execution, or expected maintenance information for any of the elements (i.e. pavement area, road lights, and so on.). Given the level of the information, huge risks exist in the component asset life achieving the finish of their separate administration lives. This acquaints critical trouble with build up a yearly spending that precisely would mirror the required resource substitution/restoration cost required.

**Mitigation:** An examination program of advantages ought to be built up to use the new work process structure and fabricate the current database. Execution of the recently constructed database, the report ought to be looked into and check whether the new information produces critical changes to the asset management procedure.

### 2.6.4 Growth Levels of Assets & Mitigation

Development figures are not ensured, and keeping in mind that exertion must be made to guarantee that administrations are given if the development is met, development can be more noteworthy or lesser at that point expected gauge. This can conceivably make a surplus or shortfall of accessible funds.

**Mitigation:** It is proposed that the development of the Municipality ought to be looked into on a yearly premise to decide whether the figure is precise, and if conceivable the financial plans ought to be balanced in like manner.

### 2.6.5 Budget Needs of Assets & Mitigation

The need for a substantial and consistent budget poses as a very important factor of road asset management. The budget need in this way have never been estimated in earlier years and the desire of each level of budget according to the road elements has not been built up. Improving documentation for budget need is important to better mirror the level of duty from the municipality. The municipality receives annual budgets for road development, but due to the lack of proper inventory has not effectively maintained the road network. This contributes to the road deterioration as risk exists if a higher or lower desire than what is conceivable for the road network is presented out of assumption with respect to the present levels of funds.

**Mitigation:** It is proposed that to address this issue, there should be a proper inventory of the road network showing its conditions, objectives built up in the primary year of using the inventory ought to be monitored alongside the cost, to give the best proposal and effective use of funds. In the event that the cost of the road network is too high to keep up the objective, the level of priority within the road network is implied and balanced out.

# Chapter 3

# METHODOLOGY AND ANALYSIS

## 3.1 Introduction

There are various types of research methodology. For proper and effective description of these methods, there has to be classification of the aim of the study, the reasoning behind the study, processes involved and the possible outcome of the study.

In the case of classification based on aim for conducting the study, there can be analysis, description, exploration or prediction of the research. For the logic or reasoning behind the study, it entails giving a distinct perspective that is different from the norm either by deducing or inducing the study. In processes involved in the study, there is the information on the collection and analysis of the data, either qualitative or quantitative analysis. Lastly, for the possible outcome of the research, there is either a solution presented to a stated problem of to contribute to a general knowledge.

## 3.2 Research Approach

Study approaches occur in three stages under cogitate levels: deductive, abductive and inductive approach. Nonetheless, an analyst can begin with a hypothesis that is produced from writing, and outlines a system to test the hypothesis, at that point a deductive approach is received; if the exploration begins with information accumulation to create a hypothesis, at that point an inductive approach is embraced; at long last, the abductive approach is a blend of deductive and inductive (Saunders et al., 2012). The table 3.1 explains a briefing on the various levels.

Table 3.1: Approaches of Research (Saunders et al., 2012)

| | Deduction | Induction | Abduction |
|---|---|---|---|
| Logic | In a deductive inference, when the premises are true, the conclusion must be true | In an inductive inference, known premises are used to generate untested conclusions | In an abductive inference, known premises are used to generate testable conclusions |
| Generalisability | Generalising from the general to the specific | Generalising from the specific to the general | Generalising from the interactions between the specific and the general |
| Use of data | Data collection is used to evaluate propositions or hypotheses related to an existing theory | Data collection is used to explore a phenomenon, identify themes and patterns and create a conceptual framework | Data collection is used to explore a phenomenon, identify themes and patterns, locate these in a conceptual framework and test this through subsequent data collection and so forth |
| Theory | Theory falsification or verification | Theory generation and building | Theory generation or modification; incorporating existing theory where appropriate, to build new theory or modify existing theory |

This research conducted falls under the abductive approach as it contains both literary reviews and the collection and compiling of data from the case study.

This approach is useful to this research as it allows proper and detailed study of the topic. It also involves the use of the software which helps the sensitivity of the study and reduces various human errors that may arise, resulting in a more efficient find and result.

After the data collection and compilation was entered into R, the R Sweave was used to compute, analyze and prepare reports (Appendix A and B) using the R language. The data when compiled in excel is saved in ".csv" file format for spread sheet. The file is then imported into R data console and the summary of the data was requested. The first product of the input in R is the creation of inventory. Figure 3.1 is a flowchart showing the processes involved for inventory creation in R.

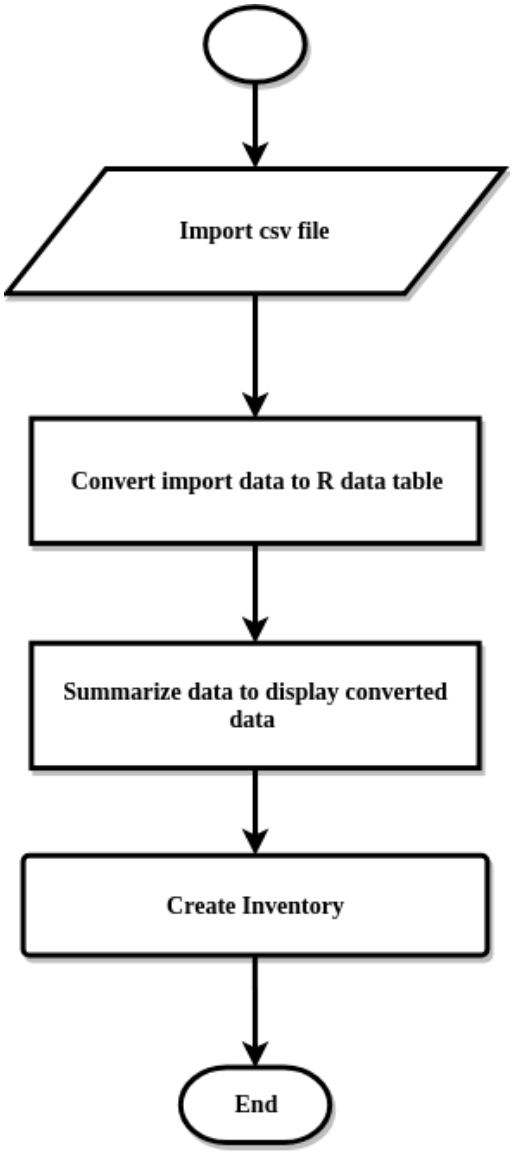


Figure 3.1: Flowchart Showing the Processes Used in Creating Inventory in R

From the creation of inventory, there are other processes that follow. These include the report generation showing the various individual attributes. Appendix A showed

the advantage of adopting municipal asset management and the strategies employed in asset management. It was divided into three sections, each assessing the needs of the municipality. The first section showed information about the Geçitkale municipality and its goals. The next explained the goal, and importance of asset management especially in the Geçitkale context. It also listed benefits of asset management, which involved improved emergency response, proper planning for future repairs and/or replacement, knowledge of asset location, condition and value. Lastly, the strategies considered in implementing asset management was described.

Appendix B consisted of a summary report which included the conditions and values of the assets. The needed road attributes such as traffic signs, street lights, sidewalks and pavement management. Again, the road categories (avenues and streets) were displayed in various tables by the length and existence of sidewalk. The total avenues and streets with their various lengths were displayed on tables. Tables showed the streets that had no sidewalk, had one and two sidewalks respectively, the summary of the road categories (numbers of streets, average width, average length, total width and total length) and summary of sidewalks (total length, total area, average width, total width, numbers of streets with no sidewalk, one and two sidewalks).

Figure 3.2 is a flowchart illustrating the generation of the various reports displayed in Appendix A and Appendix B from start to finish.

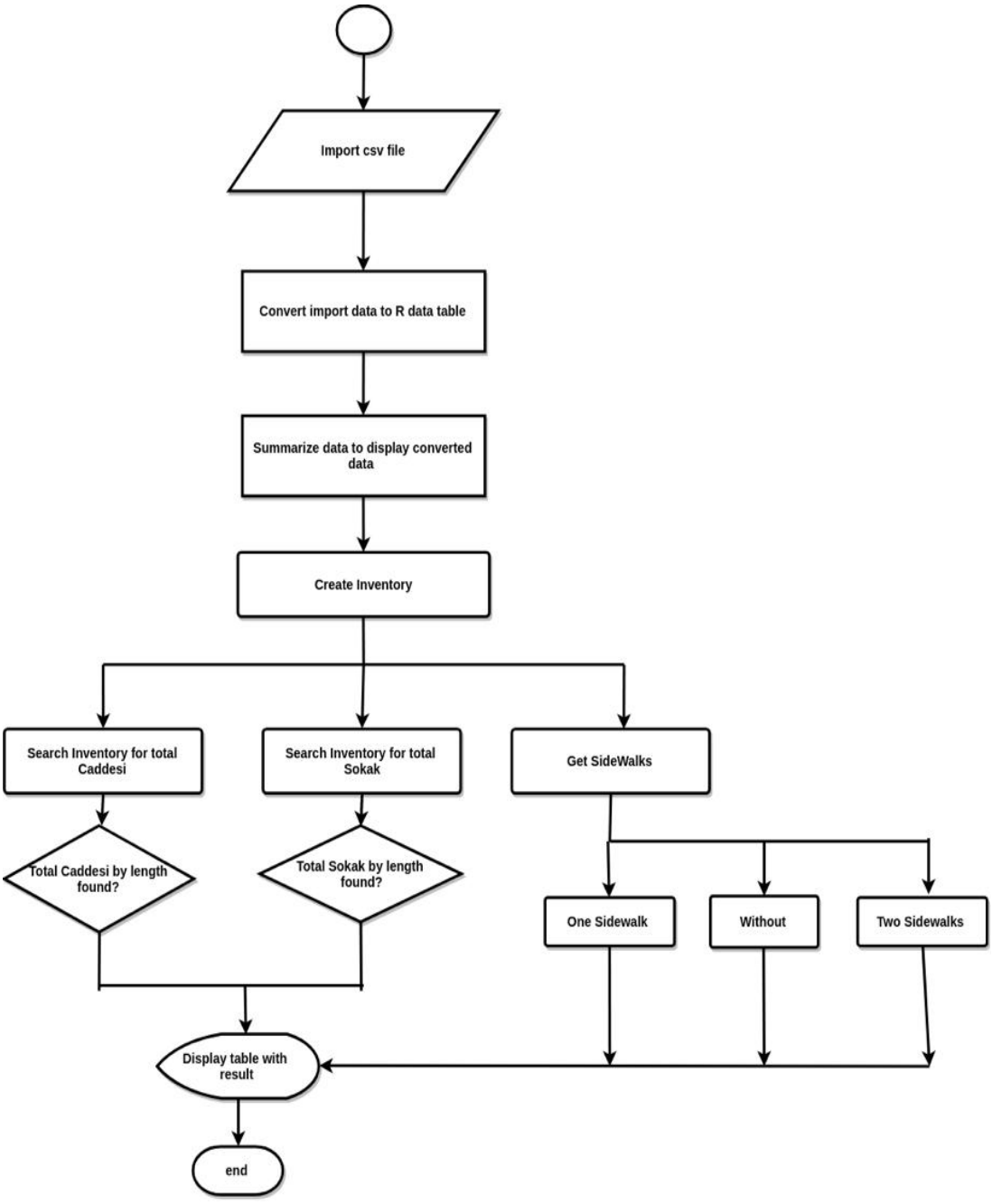


Figure 3.2: Flowchart Illustrating the Generation of the Reports

## 3.3 Research Organization

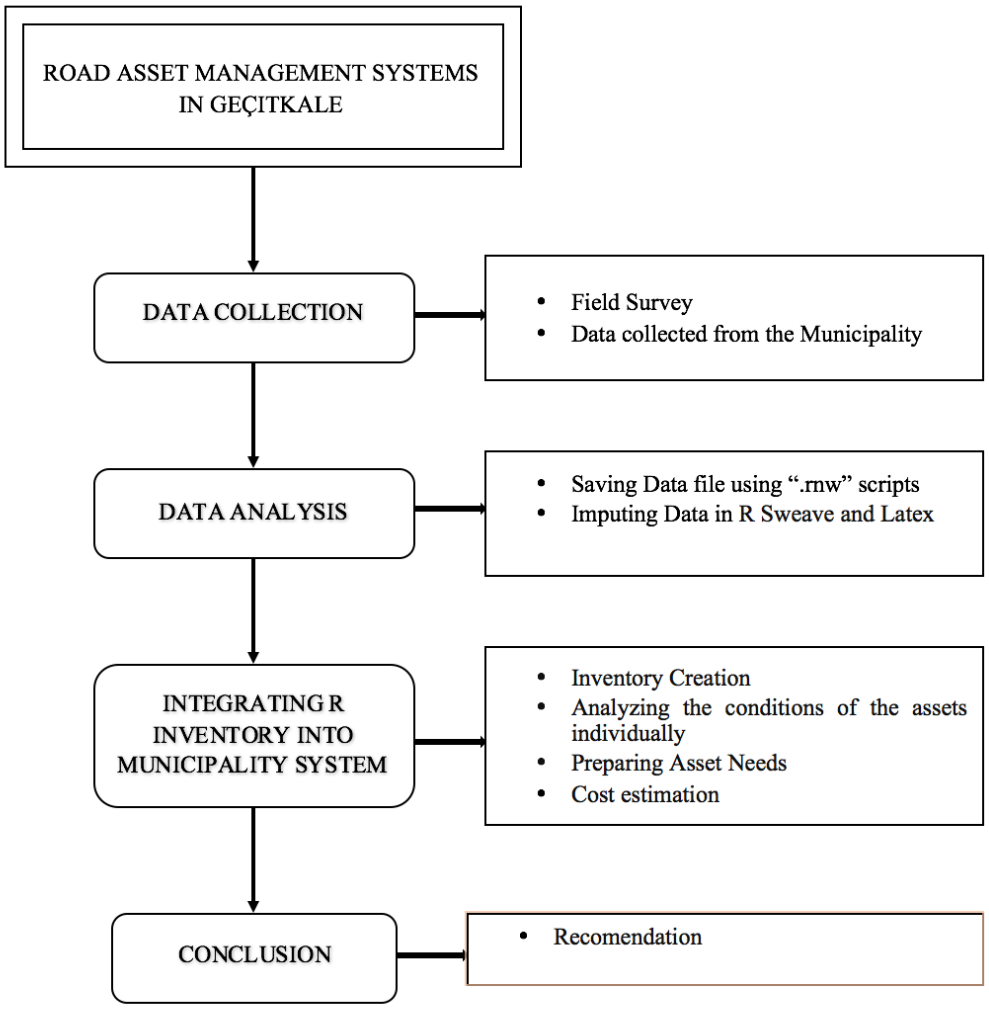


Figure 3.3: Research Organization

Figure 3.3 describes the organization of the research showing the summary of the various steps carried out at each stage of the study. It flows through the data collection, analysis and integration stage and to the conclusion of the study which involves the recommendation for the study.

## 3.4 Data Collection

The method of data collection adopted here is the observation method according to Denscombe (1998). This method implements a direct first hand observation of events and collecting of data. This was carried out systematically as there was the qualitative and quantitative analysis.

There are two stages in the collection of information. The first stage was the data collected from the municipality and field Survey and Documentation. The second stage is the inputting of the data to the R Sweave and Latex database for analysis.

Data collection was collected according to the inventory, pavement conditions, and road activity data groups. For inventory, the road network consisting of having a road ID, geometry of road categories (average width, average length, total width and total length), and the summary of sidewalks (total length, total area, average width, total width, numbers of streets with no sidewalk, one and two sidewalks).

The pavement conditions were accounted for in respect to the thickness, width, length and surface defects. The strategy of the road asset management was also considered with respect to the budget allocation and lack of skilled personnel.

Figure 3.4 shows the open street map of Geçitkale village and points out that due to lack of proper infrastructure asset management. There is no information about the street names which limits accessibility to the village for people especially tourists and also does not provide enough information for asset management.


Figure 3.4: Open Street Map of Geçitkale
(Source: OpenStreetMap; web [Accessed: 17 Dec 2017])

The collection of information was done by the author with assistance from the Municipality. The municipality provided the name and the length of some of the street. A survey of the acquired streets was conducted by the author alongside an official from the Municipality and representative of the Civil Engineering Department, taking down the width of the pavements, presence of traffic lights, traffic signs, and sidewalks. The necessary modifications were made to the information provided.

Figures 3.5a and b and 3.6 show different roads in Geçitkale. Figure 3.5a and 3.5b shows the streets leading to the Archangelos Michael Church from different areas of the village.

Figure 3.5 (a): Road Leading to the Archangelos Church in Geçitkale

Figure 3.5 (b): Road Leading from the Archangelos Church in Geçitkale

Figure 3.6 shows a street intersection in Geçitkale with several existing road attributes that are not in optimum condition. They include two stop signs at the opposite sides of the road, a light pole and a traffic mirror.


Figure 3.6: Road with Existing Traffic Signs at an Intersection in Geçitkale

## 3.5 Data Analysis

Asset management systems for the most part do the data analysis which includes:

- Interpret data condition accumulated on the individual asset.
- Identify the "perfect" solution.
- Prioritization of solutions against design
- Prioritize maintenance against spending plans.

The investigation of information could be economic, specialized and distinctive in nature. The table 3.2 shows the various investigation of information in respect to asset management. These include the technical and economic analysis.

The first stage is the technical analysis, it consists of the obtaining of the asset conditions, reasons for maintenance of the assets (mostly done according to the level of priority), the age of asset and how it influences or relates to the deterioration and the frequency in the road network use.

The economic type of analysis is more cost management oriented, the budget required is calculated, the budget breakdown is done and fund is allocated to the assets in need, unit prices are gotten, maintenance, miscellaneous and total costs and budget are accounted for. This research is mostly on the technical analysis type as it shows the condition of assets, maintenance strategy, and asset priority for maintenance.

Table 3.2: Analysis of Asset Types (Saunders et al., 2012)

| Type of analysis | Analysis |
|---|---|
| Technical | Condition of asset<br>Causes of maintenance<br>Age and degradation of asset.<br>Use of network |
| Economic | The budget required<br>Budget allocations (*e.g.* Budget breakdown)<br>Variations in unit prices<br>Deviations between out-turns and estimated costs<br>Maintenance costs of assets<br>Total costs and budget |

There were various steps involved in developing the methodology used to obtain the reports. They include:

1. Collected Data was put into Microsoft Excel.

2. Data was imported from excel and run into the R Script.
3. R Sweave package was installed and activated in R.
4. The command for creation of documents was imputed using the report format to make a pdf document.
5. The report was run in R Sweave and the reports were produced in a ".rnw" file.

### 3.5.1 R

R is a computing language and environment for statistical computing and language. It is similar to S language but with a different implementation. R gives a wide assortment of measurable (straight and nonlinear demonstrating, traditional factual tests, time-arrangement examination, characterization) and graphical procedures, and is exceptionally extensible. Figure 3.7 shows the key steps carried out in the R language for the project.

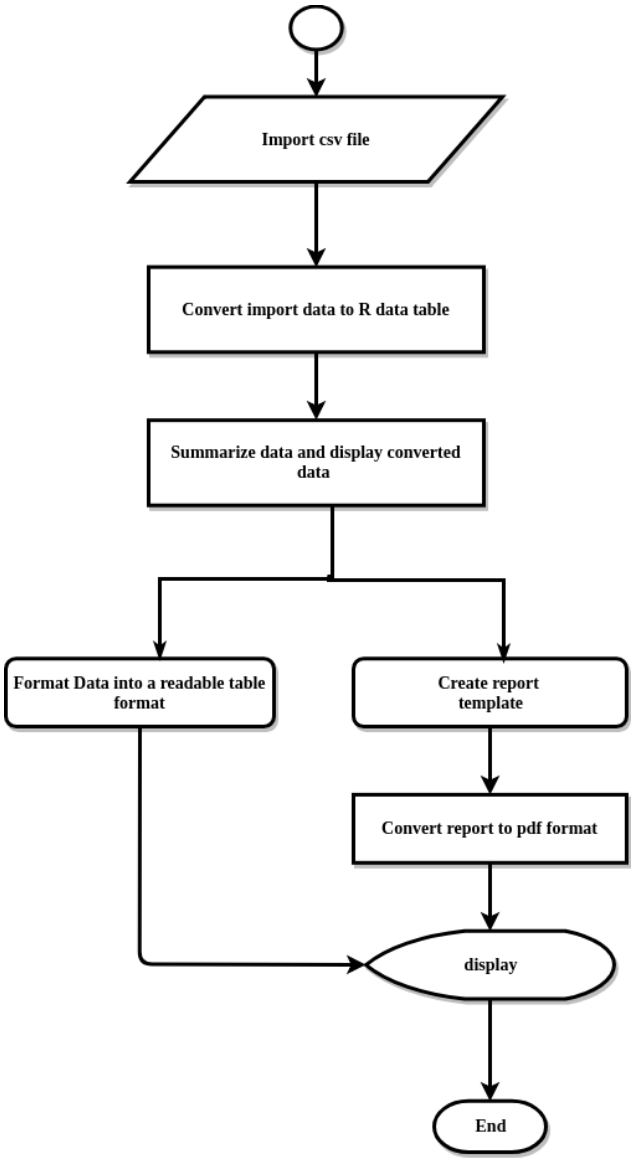


Figure 3.7: Key Steps in R

Extraordinary care has been assigned control over the defaults for the minor outline decisions in illustrations, however the client holds full control. One of R's qualities is the simplicity with which much composed production quality plots can be created, including numerical images and formulae where required.

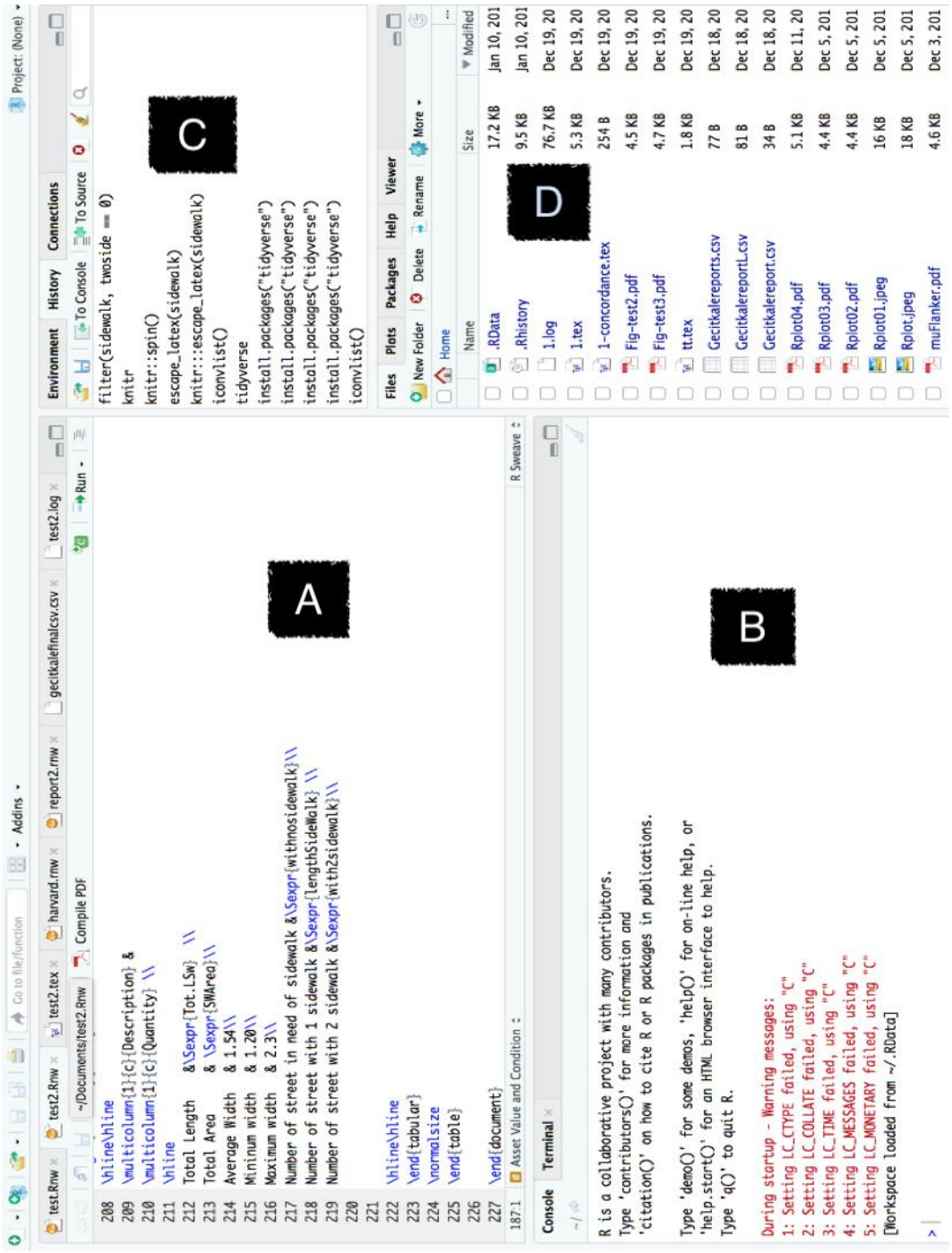


Figure 3.8: RStudio

Figure 3.8 shows various commands that are imputed into the RStudio to create a table used in the report formed. The RStudio consists of four portions labeled A, B, C and D as seen in the figure. The Part A is the Source bar and shows the tabs and information that is to be run and/or compiled to pdf in the Sweave package. The types of file stored here include the ".csv", ".rnw", ".tex" The template of a report is shown partially here, viewing how a table is formed and the parameters to be displayed in the table. Part B consists of the console and the terminal. The console consists of the platform where the R language is written and the summary is produced. The terminal shows the information about where the data is stored. Part C consists of the environment, history and connection tabs. The environment contains the all data and values descriptions and quantities put into the software. The history has all the entries put into the R Console according to the dates put in. Part D has the files, plots, packages, help and viewer tabs. The files section shows every file and document in the system being used for easy access. The plots display graphs, figures and tables drawn in the R-console section (B). Packages show the in-built and downloaded r-packages installed in the RStudio. Help contains easy ways to understand R language better; it has online resources, manuals, references and other miscellaneous materials and the Viewer shows the viewing of the Scripts.

## 3.6 Integrating the R Inventory Database into the Municipal System

This chapter is directed towards the integration of the created R system into the municipal environment. The implementation of this language is easy and in long-term helps the municipality save up on cost, time and ensures the quality of assets. The integration of this language triggers improvement in the behavioral change towards road assets, showing its significance in the aspects of;

- Inventory Creation
- Analyzing the conditions of the assets individually
- Preparing Asset Needs
- Cost estimation

A very important and one of the first steps to consider in asset management is the problem of inventory. The lack of inventory in the municipality hugely contributed to the poor road maintenance.

R language compiled the inventory of the whole Geçitkale Road network exported from Microsoft Excel in ".csv". There were two set of data obtained. The documents obtained first were from the municipality. The figure below shows the file conversion from excel to RStudio.

Figure 3.9 illustrates the reading of the imported .csv file, the change of the assets that were unaccounted for to zero to help R know the needed attributes and the general summary of the “gecitkale1” file.

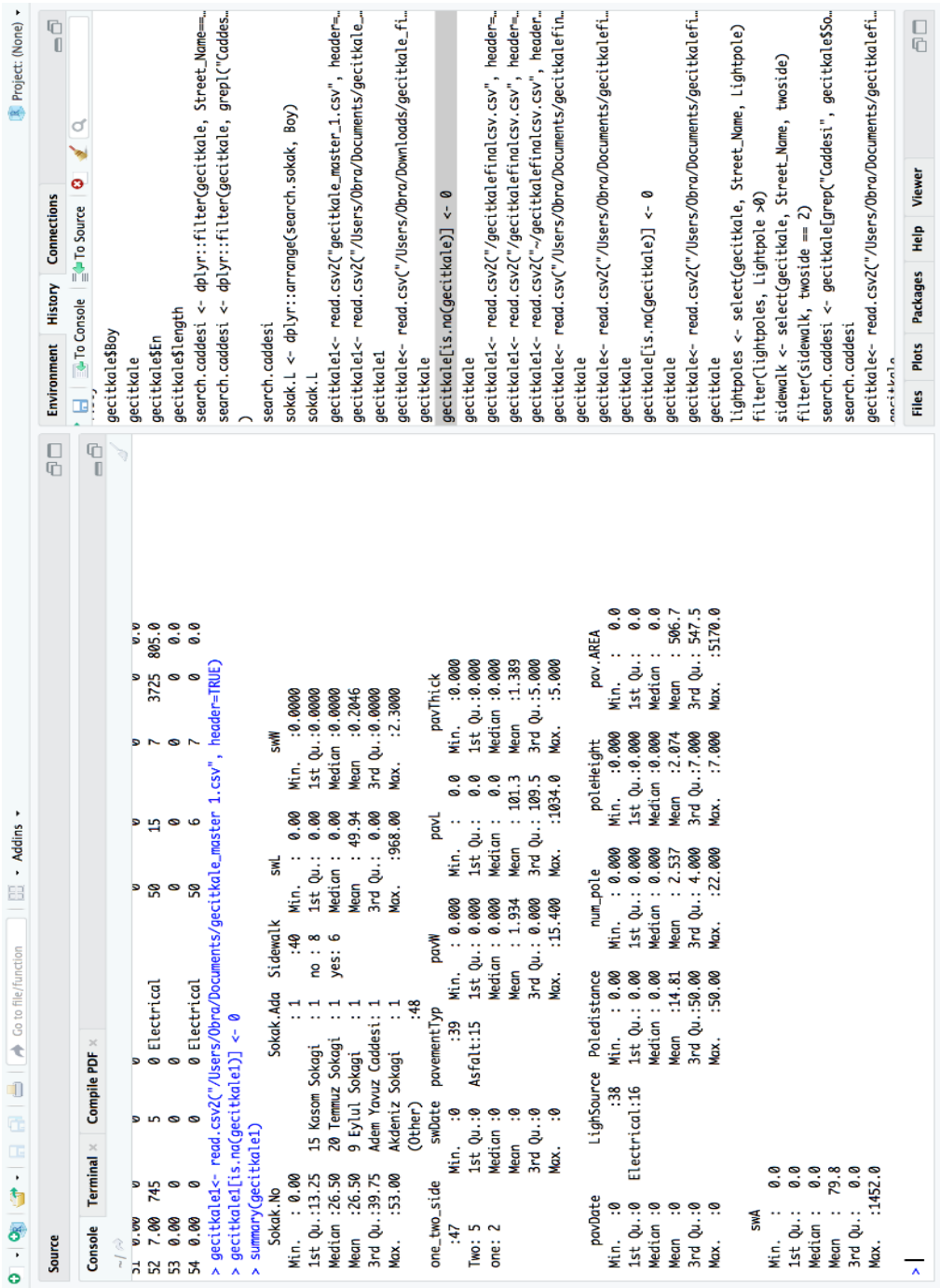

Figure 3.9: Initial Data Summary RStudio

It showed the number of streets, maximum lengths of the streets, sidewalk (width, length, one or two sided, area), pavement information (type, width, length, thickness, area), lighting (light source, number of poles, height).

The command was then imputed into the R, and the summary was printed out by R. However, there was a further research carried out by the Author that included a final data acquisition. The obtained result is displayed in Figure 3.10.

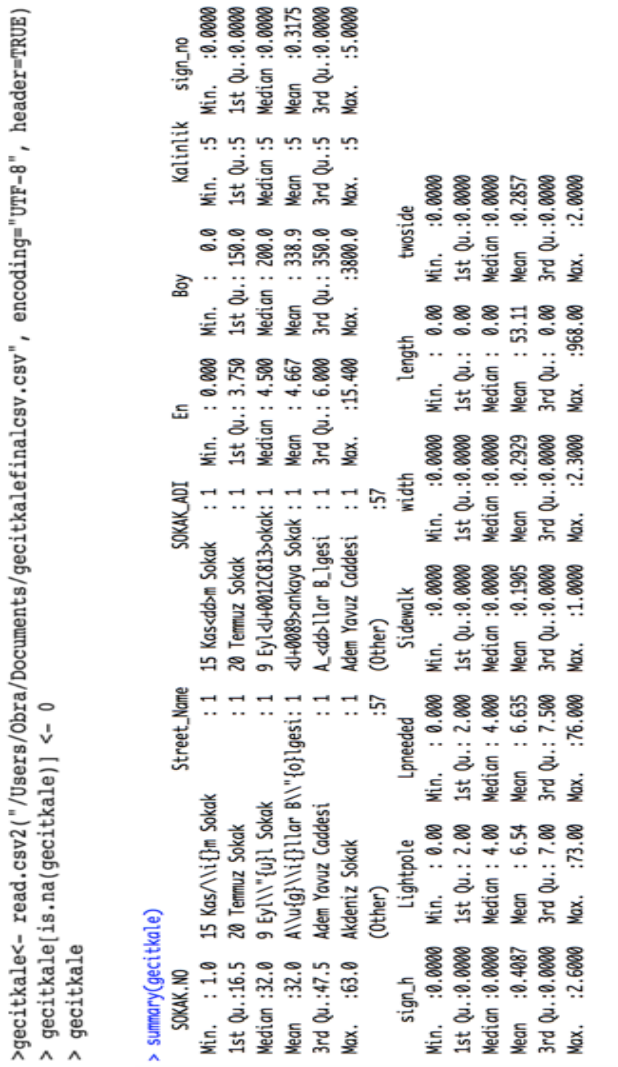


Figure 3.10: Final Data Summary from RStudio

## 3.7 Cost Management

In order to fully understand the application of R, a scenario is created. For proper cost management on streets in Geçitkale, cost assumptions have to be made.

For any sum allocated for the municipality road asset management, the asset priority must first be considered. This involves having decisions based on the factors considered for the class which include:

- Streets in need of emergency maintenance
- How many traffic signs are needed?
- Degree of road pavement surface damage
- Availability of sidewalks
- Presence of traffic lights
- Location of road in relation to basic amenities or sites.
- Traffic flow in the municipality
- Type of vehicles
- Frequent usage

The classes for the cost management consideration are:

a. Traffic Class 1: This refers to the streets or avenues with a higher level of priority in relation to the services it offers. For instance, the road leading the the municipality and the school should have a higher priority as there is frequent use of the road and it helps access amenities. Also, the roads leading to the Archangelos Michael church and cave should have high priority as it helps accessibility to the sites. The avenues are as important as there locations are vital for road users access to the municipality.

b. Traffic class 2: This class of roads have a lesser degree of accessibility and use. For example, 100,000 TL is allocated to the municipality for the repairs. For regular yearly maintenance, at least one percent (1%) of the funding goes to the avenue pavements, that is the longer roads. The figure 3.11 shows the commands inserted in R to obtain the value of the 1% of the total pavement area by searching for just the avenues according to their names, creating the total pavement area of the avenues and dividing the set value "Tot.PACadde" by 100 which rounded up to 310.50 $km^2$.

```
> search.caddesi <- gecitkale[grep("Caddesi", gecitkale$SOKAK_ADI), ]
> search.caddesi
> Tot.PACadde<- sum(gecitkale$En*gecitkale$Boy)
> Tot.PACadde/100
```

Figure 3.11: Proposed Budgeting for Geçitkale

Also, the cost analysis in relation to cost and tenders of some works in the Geçitkale municipality were obtained. Table 3.3 shows an example of the cost estimation proposed for some of the roads in need of repairs in the municipality. Nine streets are mentioned but only two are chosen for cost estimation according to their level of importance. The area of sidewalk, excavation volume, needed asset, resource to be considered, unit cost of the resources and price (resource multiplied by the unit cost) were shown.

Table 3.3: Pavement Cost Estimate for Geçitkale Municipality

| Street name | Side walk $m^2$ | Excavation $m^3$ | Work needed | Metre | Unit cost TL | Metre x TL |
|---|---|---|---|---|---|---|
| Atatürk Caddesi | 468 | 468 | sidewalk | 495 | 33 | 16335 |
| Barış Sokak | 27 | 0 | excavation | 226 | 6 | 1356 |
| Çankaya Sokak | 238 | 0 | Total | | | 17691 |
| Ecevit Caddesi | 140 | 0 | | | | |
| Karaoğlanoğlu Caddesi | 440 | 226 | | | | |
| Plevne Sokak | 30 | 30 | | | | |
| Selahattin Sonat Sokak | 85 | 42 | | | | |
| Şht. Hasan Kanizi Sokak | 67 | 67 | | | | |
| Şht. Kasım Ali Sokak | 260 | 0 | | | | |

# Chapter 4

# RESULTS & DISCUSSION

The improved model is created to upgrade and maintain operations by producing a foolproof model of the infrastructure. There are several improvements in asset management of infrastructure for local agency.

First, a standard database was designed for routine data collection. Second, an analysis procedure is developed to simplify the infrastructure asset reporting. Finally, the entire reporting system is implemented in this software to minimize human interference and the errors that may be caused by that.

This model is intended to fill the holes that exist at the most reduced level of the association, empowering the correspondence of hazard to skilled workers who work with the framework consistently. Taking key focuses that produce this sort of model, the idea is limited to the accompanying ideas:

- Asset condition Assessment
- Inventory
- Asset Priority

## 4.1 Asset Condition Assessment

The knowledge of the state of advantages is a basic part of deciding if to repair or supplant a benefit and is an instrumental information point in resource stock. Hao et al. (2012), presumed that proactive cautioning of looming disappointment might be

accomplished through the standard evaluation of covered foundation, prompting diminished operational hazard (Hao et al., 2012). Surveying an asset's condition intends to assess its status to perform to its composed level (Grigg, 2006). It is helpful in figuring danger to the related infrastructure, levels of service or an organization's central goal. The execution of condition appraisals presents different issues in the business, abridged by time duty and relative error of information. No strategy for foreseeing disappointments will ever be 100 percent exact. However, offices can enhance the uprightness of condition data utilizing the data that previously exists among records and faculty inside the association.

## 4.2 Inventory

The premise of any viable resource administration program rotates around a strong stock. Stock is the foundation of condition appraisal, venture prioritization and sustainment choice help (Grigg, 2010). In an ideal situation, utilities should utilize records wherever accessible keeping in mind the end goal to reinforce the exactness of their advantage inventories. Where records are missing, utility-finding procedures ought to be utilized to decide endpoints write and profundity if conceivable. Hao et al. (2012) take note of that finding covered foundation without far-reaching and exact maps, and in addition, deciding the state of this covered framework is exceptionally hazardous.

The absence of coordinated sustainment administration frameworks in the road asset portion prompts challenges in precisely gathering and logging information with respect to foundation area, execution, and criticality. Without dependable information, deciding an exact framework stock of what office claims and where it is found are

almost unobtainable. Adjustment of innovation and information hones is basic to the adaption of asset management, as it shapes the foundation of the choice help process.

Building up a precise resource enlist with the proper level of detail is one of the more troublesome errands of asset management. The Environmental Protection Agency (EPA) prescribes gathering the accompanying known data about the framework:

- Age
- Condition
- History of Service
- Useful Life

As the advantage administration process repeats, devotion will be enhanced as more helpful data is added to the stock.

## 4.3 Asset Priority

Asset Priority is the third part of the road infrastructure asset management model. Knowing the level of priority of road assets help set focus for asset management and help with imparting partners the consequences of specific choices. Administration levels can identify with street quality, ecological measures or different models. It is critical that associations provide for their administration levels to what is essential to them. An imperative point that is common in the writing is that, levels of administration are frequently centered around what engineers do and not what is given to the client. This makes a misconception of what the advantage does and how that means, what the client gets.

The significance of administration levels through a few inquiries to be postured to resource chiefs include:

- What do the stakeholders and clients request in the aspect of frequent asset use?
- What do the controllers require?
- What is the real execution?
- What are the physical abilities of these benefits?

In outline, priority of the asset gives focus to execution and makes the procedure of asset management client driven. One of the key focuses that can be drawn from the asset priority is that it straightforwardly influences the level of hazard related with an advantage. Some administration levels may convey more weight than others, for example, administrative necessities or taking care of flame stream requests. The weight in which the service level holds straightforwardly relates to the level of admissible hazard that might be taken with resources that fall inside that frequent use of the asset. Along these lines, a connection is drawn between levels of administration and hazard administration.

# Chapter 5

# CONCLUSION

Integration is turning into commonplace amongst local municipalities that exercise asset control. Integration performs a crucial position in supporting asset control, it unites the aims of the local municipalities into one normally viewable platform. Integration via information is generally one of the most vital components of an asset management program.

From the past literature reviews on the various asset managements, the need for a simple and efficient road management system for individual road elements is necessary especially for local municipalities. Municipal asset management is seen to be a very effective adoptive strategy that explores factors that affect asset sustenance. These include external attributes like politics, legal, government system and regulations.

The case study, Geçitkale municipality has very little resources and strategy for road asset management. There was no initial inventory for the road network, the conditions of the assets and asset needs were not determined, and lack of technical know-how which has led to deterioration of the road assets.

The use of the software R, R Sweave and LATEX (which are easy to use) is suggested to create road inventory showing the various road attributes; such as road signs,

pavement, traffic signs, sidewalk and light poles, the conditions of the assets were analyzed individually from the inventory formed and a report on the asset needs was provided. Data from the municipality was collected and a field survey of the road network was carried out. The data was then imputed with the ". rnw" script into R and an inventory was formed. Also, a cost estimation required for the maintenance of the asset was presented.

This is the first adaptation of the road asset management system in the Geçitkale context. It also is an efficient system to understand road as an asset and effectively manage and/or restore its attributes. Also, the interface is easy to use and the creation of the inventory database will help the municipality implement it smoothly. This adoption is sensitive due to the assumptions made. For instance, the lack of past infrastructural asset inventory, past developments have not been accounted for which can influence asset prioritization.

Also, for the implementation of the management plan. The municipal staff have to undergo some hours of training in R to be able to understand and effectively use it.

However, this study can easily be adopted by other municipalities and has the potential to provide an improved and well-coordinated road asset strategy and management.

For future works, in other to maintain and successfully adopt the road asset management, there should be the following:

- The annual spending of the municipality should be monitored for the first few years and adjustments should be done accordingly.

- There should be a traffic volume count for about three weeks to understand the traffic flow patterns to be used in the management plan.
- There should be a system to put the road names, sites and locations on google or open street maps for easier identification and access.
- Road users should be educated on the value and importance of road as an asset.
- There should be a routine check-up of the road attributes and their condition.

# REFERENCES

ADA Standards for Accessible Design (2010). Retrieved from https://www.ada.gov/regs2010/2010ADAStandards/2010ADAStandards_pr.pdf. [Accessed: 17 December 2017].

Agarwal, P., Animesh, D. & Chakroborty, P. (2004). A Rational Approach for Prioritisation of Highway Sections for Maintenance. Paper presented at the Sixth International Conference on Managing Pavements, India, pp. 1–12.

Akofio-Sowah, M. A., & Kennedy, A. A. (2014). A Critical Review of Performance-Based Transportation Asset Management in United States Transportation Policy. IRF, 6.

Allen, D. H., Little, D. N., Soares, R. F., & Berthelot, C. (2017). Multi-scale computational model for design of flexible pavement–part I: expanding multi-scaling. *International Journal of Pavement Engineering*, *18*(4), 309-320.

Ali C. T., & Burçak Ö. (2016). Northern Cyprus Economy Competitiveness Report. Retrieved from http://www.ktto.net/wp-content/uploads/2017/03/KTTO2016-2017-eng.pdf

Anjuman, T. (2009). Evaluation of an Online Intelligent Transportation System (ITS) Asset Management System World Bank (2011). Construction and maintenance. Retrieved from

http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTTRANSPORT/EXTROADSHIGHWAYS/0,,contentMDK:20596514~menuPK:1476380~pagePK:148956~piP K:216618~theSitePK:338661,00.html [Accessed: 11 Oct 2017].

Archangelos Michael Church in Lefkonoiko/Geçitkale (2012). Retrieved from http://www.cy.undp.org/content/dam/cyprus/docs/PFF%20Projects/Archangelos%20Michael%20Project%20Sheet-en.pdf [Accessed: 17 November 2017].

Burki, S. J., Perry, G., & Dillinger, W. R. (Eds.). (1999). Beyond the center: Decentralizing the state. World Bank Publications.

Campanaro, A., & Masic, J. (2017). Municipal asset management in China's small cities and towns.

European Union Road Federation, ERF (2013). Road Asset Management.

Fernholz, F., & Fernholz, R. M. (2007). A toolkit for municipal asset management. *Duke University, March*.

Geddes, R., Gongera, K., & Solutions, C. D. (2016, April). Economic Growth through Effective Road Asset Management. In International conference on transport and road research, 15th–17th March.

Gregory, C. S. (2014). The development of a simplified asset management model for fixed US Air Force installations (Doctoral dissertation, Colorado State University).

Grigg, N. S. (2006). Condition Assessment of Water Distribution Pipes. Journal of Infrastructure Systems, 12(September), 147–153. doi:10.1061/(ASCE)1076-0342(2006)12:3(147).

Grigg, N. S. (2010). Asset Management for Infrastructure. In Economics and Finance for Engineers and Planners - Managing Infrastructure and Natural Resources (pp. 229–242). American Society of Civil Engineers.

Hao, T., Rogers, C. D. F., Metje, N., Chapman, D. N., Muggleton, J. M., Foo, K. Y., & Saul, a. J. (2012). Condition assessment of the buried utility service infrastructure. Tunnelling and Underground Space Technology, 28, 331–344. doi:10.1016/j.tust.2011.10.011.

Harris, E. A. (2007), Analysis of Traffic Sign Asset Management Scenarios, transportation research board journals.

Herabat, P., Satirasetthavee, D., & Amekudzi, A. (2003). Web-based rural road asset-management system. *Transportation Research Record: Journal of the Transportation Research Board*, (1855), 105-111.

Hussain, T. (2014). Development of traffic sign asset management system in indian context (Doctorial dissertation).

Jeff U., David L., & Tim R. (2016). Pavement Asset Management. Retrieved from https://www.wsdot.wa.gov/NR/rdonlyres/E93CF754-0452-4FDE 92BA02A7BC4CB98A/0/WSDOTPavementAssetManagement2816.pdf [Accessed: 13 Oct 2017]

Jusi, P., Mumu, R., Jarvenpaa, S., Neausemale, B., & Sangrador Jr, E. (2003). Road Asset Management System Implementation in Pacific Region: Papua New Guinea. *Transportation Research Record: Journal of the Transportation Research Board*, (1819), 323-332.

Kaganova, Olga & Mihaly Kopanyi. (2014). "Managing Local Assets." In Municipal Finances: A Handbook for Local Governments, edited by C. Farvacque-Vitkovic and Mihaly Kopanyi, 275-324. Washington, DC: World Bank.

Kenley, R., Harfield, T., & Bedggood, J. (2014). Road asset management: the role of location in mitigating extreme flood maintenance. Procedia Economics and Finance, 18, 198-205.

Makinde, O. O., & Oluwasegunfunmi, V. (2014). Comprehension of traffic control devices amongst urban drivers–a study of Ado-Ekiti, Ekiti State, Nigeria. European Journal of Engineering and Technology, 2(1), 9-19.

Männistö, V., & Inkala, M. (2003). Road Asset Management Research Program in Finland. In 2 nd European Pavement and Asset Management Conference.

Michael J. Markow, (2008), pp. 78–86, Current Asset Management Practices Applied to Pavement Markings, transportation research record.

Occupational Safety and Health Administration. (2013). Safety and health management systems: A road map for hospitals.

Pannapa Herabat, Paper No. 03-4251, Web-Based Rural Road Asset-Management System, transportation research record.

Pavement interactive (2012). Retrieved from http://www.pavementinteractive.org/ [Accessed: 16 Oct 2017].

Perrin Jr, J., & Dwivedi, R. (2006). Need for culvert asset management. *Transportation Research Record: Journal of the Transportation Research Board*, (1957), 8-15.

Queiroz, C., & Kerali, H. (2010). A Review of Institutional Arrangements for Road Asset Management: Lessons for the Developing World.

Rajeswari, B. (2014). Road Asset Management: Evolution and Techniques.

Russell, K., Toby, H., & Juliana, B. (2014). Road asset Management: the role of location in mitigating extreme flood maintenance.

Seeboo, A. (2008). Proposed highway asset management framework with an emphasis on economic impact analysis. Iowa State University.

Smadi, O., & Akili, W. (2006). Infrastructure Asset Management Education: active learning and engagement-based practices. *Transportation Research Record: Journal of the Transportation Research Board*, (1957), 16-18.

TRNC State Planning Organization (2016). Retrieved from https://www.citypopulation.de/php/cyprus-north.php?adm2id=322 [Accessed: 17 Oct 2017].

Tender process for the conservation of the Archangelos Michael Church in Geçitkale has begun. Retrieved from http://pio.mfa.gov.ct.tr/en/tender-process-for-the-conservation-of-the-archangelos-michael-church-in-gecitkale-has-begun/. [Accessed: 17 Dec 2017].

United Nations Economic and Social Council (2009). The Transport Situation in Africa.

Wijnia, Y., & John, C. (2015). The Asset Management Process Reference Model for Infrastructures.

Yang, C. (2013). Highway asset management (Doctoral dissertation, University of Nottingham).

# APPENDICES

# Appendix A: Report 1

Annual Report

Esther Obrasua Akobo

26 Dec

## Contents



## 1 The Geçitkale Municipality

The town of Geçitkale has a population of approximately 2,380 people as at 2011. It is located in North Cyprus with a total area: 54.0 km2. The Municipality consists of seven villages, which are; Çamlica, Çinarli, Geçitkale, Mallidag, Nergisli, Sütlüce and Yamaçköt. The Municipality is committed to improving resident?s quality of life; encouraging tourism, establishing long term development strategies and providing a nurturing environment for new and future business.

## 2 Municipal Asset Managment

The Geçitkale Municipality rated the condition of the road asset. This data collection included 0 meters lane miles of paved roads in Geçitkale, including Major streets; Caddesi and minor streets; Sokaki. This effort was achieved through a cooperative effort of individuals from the municipality government with help from Engineering Students and their Supervisor who is a Transportation Engineer of Eastern Mediterranean University

The goal of municipal asset management is to meet a proposed level of service with cost effectiveness throughout the life cycle of the asset.

The reasons why the municipality should be cost effective with respect to these assets are:

1. Road asset contributes as a major investment.
2. Economic growth of the municipality is dependent on maintained road asset

3. Efficient maintenance and operation is important for public health and safety
4. Innovation and productivity in operation of infrastructure is achieved.
5. Primary customer service is improved

Also, municipal asset management includes the consideration of the various external factors that influence sustaining the asset. They include the political, legal, and regulatory aspects. Like some other systems of government, the advantage administration capacities must be caught on with regards to the social and political condition. The laws and directions will, to a few degrees, mirror these substances. Civil pioneers, who, with their constituents have created a typical vision and social understanding, regularly have their underwriting and support to fortify or change the benefit administration framework that will streamline asset use in the accomplishment of open goals. The particular lawful and logical parts of strategy and basic leadership forms are the concentration of this segment.

The Goals of the Municipalitys Operation and Maintenance (O&M) Activities are as follows:

- To ensure infrastructure assets are being maintained in a reliable and sustainable manner that is suitable for the road users.
- Reducing the risk of failure which is directly related to meeting regulatory requirements and road users satisfaction.
- Maximize value by determining lowest sustainable cost alternatives for maintenance over asset lifecycle.

There are many benefits of asset management and once the principals are incorporated by the Municipality, some of the results will be immediately apparent while others will take time to implement. Some of the benefits of asset management are as follows:

1. Better operational decisions
2. Improved emergency response
3. Ability to plan and pay for future repairs and replacements
4. Increased knowledge of the location of assets
5. Increased knowledge of which infrastructure assets are critical to the Municipality
6. Additional efficient operation of asset
7. Better communication with municipal users

## 3 Asset Management Strategy

The Municipalityś overall Asset Management Strategy is surrounded on available data, anticipated service levels, growth expectations and other assumptions. Assumptions in these items introduce some unavoidable risk that the overall strategy may change over time as the Town evolves and develops more complete data and processes. Recognizing these uncertainties, the Municipality will developing strategies to address each source of risk so that the Asset Management Strategy can evolve over time. Risk mitigation strategies for each of the following are discussed below:

- Data quality
- Levels of Service
- Growth Levels *expectedvs.actual*
- Assumptions

### 3.1 Data quality

The data provided and collected for the report for various aspects were given by both the municipality and manual survey and measurements to accurately reflect the service lives of the necessary components of the assets (i.e. condition, performance, or intended maintenance data for any of the components (i.e. pavement area, street lights, etc.). Given the level of the data, significant risk exists in the component asset life reaching the end of their respective service lives. This introduces significant difficulty to establish a yearly budget that accurately would reflect the required asset replacement / rehabilitation cost required.

Strategy to address:

An inspection program of assets should be established to utilize the new workflow structure and build the existing database.

Implementation of the newly built database, the report should be reviewed and see if the new data produces significant changes to the asset management strategy.

### 3.2 Levels of Service

The levels of service present a risk, since no previous levels of service were established for the Municipality. The Levels of Service therefore have never been measured in previous years and the expectation of each level of service has not been established. Adjustment is expected in the early years of levels of service to better reflect the level of commitment from the Town, but risk exists if a level of service is set at a higher expectation then what is possible at the current levels of funding.

Strategy to address:

It is suggested that to address this source of risk, the targets established in the first year of utilizing the Levels of Service should be reviewed along with the cost to provide the levels of service. If the cost of the level of service too high to maintain the target should be adjusted or alternative strategies to accomplish the level of strategy should be investigated.

### 3.3 Growth Levels

Growth forecasts are not guaranteed, and while effort has to be made to ensure that services are provided if the growth is met, growth can be greater or lesser then expected forecast. This can potentially create a surplus or deficit of funding available.

Strategy to address:

It is suggested that the growth of the Municipality should be reviewed on a yearly basis to determine if the forecast is accurate, and if possible the budgets should be adjusted accordingly.

### 3.4 Assumptions

Assumptions have been made in the report to fill data gaps and have been noted where undertaken. As with any assumption, risk exists in that the assumption made not account for a large enough percentage of the assets and could potentially results in unexpected costs if not corrected (i.e. year of installation assumed, when the asset is past its expected service life, and due to the degradation of the asset, effecting surrounding assets).

Strategy to address:

It is suggested that an inspection program should be developed utilizing the information provided herein to eliminate the largest assumptions. The new findings should then be used to adjust the report findings, correcting the asset management strategy if required.

# Appendix B: Report 2

## Summary Report

Esther Obrasua Akobo

June 7, 2018

## 1 Asset Value and Condition

The Geçitkale Village has 6 main streets with total road length of 8600 meters and 54 regular streets with a total length of 12000 meters.

Maintaining and operating the transportation infrastructure are key activities of the Geçitkale Municipality.

Emerging needs include:

Street Lighting: Out of a total of 53 streets recorded only 16 are have electrical street light poles. Numerous street lights are now reaching the end of their useful life and will need to be replaced. Most of them are in poor or very poor condition and can stop working at any time. These lights, in addition to the ones that are reaching the end of their life will need capital replacement funds to replace them. Street lights are important for the safety of the neighborhoods and for those who use the transportation system especially at night.

Signs: Traffic signs are made up of several components. Several traffic signs are in poor, very poor condition or are not there and without additional resources, the condition will continue to decline. For instance, the Geçitkale School has no traffic signs(ie posting signs for school speed limits, school crossing signs, and school bus stops) before it showing the presence of a school or the speed bump present after the school. Traffic signs in poor condition are more prone to increased trouble calls, causing safety problems. Traffic signs in optimal condition ensure that there is synchronization of traffic flow, which results in congestion reduction.

Pavement Management: The Municipality has a total recorded Pavement Area of 100532.5 meters and total road length of 63 meters. Pavement condition and performance target are expected to change following the implementation of management practices and tools.

Sidewalk Network: ADA required that City public facilities be designed and constructed so that they are accessible to all people, including those with disabilities. Only 4% of the sidewalk system in Portland has corners with curb ramps that meet current ADA-accessible standards. In total, nearly 40% of corners have accessible corner ramps. PBOTs goal is to construct at least 700 new corners per year. The total sidewalk Area is 4309.1 meters.

| | SOKAK.NO | Street_Name | Boy |
|---|---|---|---|
| 1 | 21 | Eczacı Yusuf Kuman Caddesi | 0 |
| 2 | 20 | Ecevit Caddesi | 800 |
| 3 | 27 | Karaoğlanoğlu Caddesi | 1000 |
| 4 | 8 | Atatürk Caddesi | 1100 |
| 5 | 4 | Adem Yavuz Caddesi | 1900 |
| 6 | 15 | Cumhuriyet Caddesi | 3800 |

Table 1: Total Caddesi

1

| | SOKAK.NO | Street_Name | Boy |
|---|---|---|---|
| 1 | 23 | Erdal Palu Sokak | 0 |
| 2 | 31 | Mimar Mehmet Vahip Sokak | 0 |
| 3 | 38 | Şair Orhan Veli Sokak | 0 |
| 4 | 39 | Şair Özker Yaşın Sokak | 0 |
| 5 | 62 | Yazar Yaşar Kemal Sokak | 0 |
| 6 | 1 | 15 Kasım Sokak | 50 |
| 7 | 3 | 9 Eylül Sokak | 50 |
| 8 | 6 | Akdeniz Sokak | 100 |
| 9 | 19 | Dumlupınar Sokak | 100 |
| 10 | 34 | Preveze Sokak | 100 |
| 11 | 37 | Şair Fikret Demirağ Sokak | 100 |
| 12 | 49 | Şht. Hüseyin Aziz Sokak | 100 |
| 13 | 50 | Şht. Hüseyin Hasan Sokak | 100 |
| 14 | 11 | Belediye Sokak | 150 |
| 15 | 12 | Bora Paşa Sokak | 150 |
| 16 | 13 | Cemaliye Hüseyin Sokak | 150 |
| 17 | 26 | İstiklal Sokak | 150 |
| 18 | 29 | Kocatepe Sokak | 150 |
| 19 | 33 | Plevne Sokak | 150 |
| 20 | 36 | Salahattin Sonat Sokak | 150 |
| 21 | 43 | Şht. Cemal Hasan Sokak | 150 |
| 22 | 47 | Şht. Hasan Tahsin Sokak | 150 |
| 23 | 10 | Barış Sokak | 200 |
| 24 | 16 | Cumhuriyet Sokak | 200 |
| 25 | 40 | Şht. Ahmet Mehmet Sokak | 200 |
| 26 | 41 | Şht. Bayram Mani Sokak | 200 |
| 27 | 44 | Şht. Eray Mehmet Sokak | 200 |
| 28 | 51 | Şht. İsmail Süleyman Sokak | 200 |
| 29 | 57 | Şht. Mustafa Hasan Sokak | 200 |
| 30 | 58 | Şht. Mustafa Hüseyin Sokak | 200 |
| 31 | 59 | Şht. Osman Hasan Sokak | 200 |
| 32 | 61 | Şht. Remzi Cemal Sokak | 200 |
| 33 | 2 | 20 Temmuz Sokak | 250 |
| 34 | 42 | Şht. Bayram Mehmet Sokak | 250 |
| 35 | 45 | Şht. Halil Mustafa Sokak | 250 |
| 36 | 48 | Şht. Hasan Velettin Sokak | 250 |
| 37 | 55 | Şht. Mehmet İbrahim Sokak | 250 |
| 38 | 60 | Şht. Osman Şevket Sokak | 250 |
| 39 | 63 | Zafer Sokak | 250 |
| 40 | 7 | Anafartalar Sokak | 300 |
| 41 | 46 | Şht. Hasan Kanizi Sokak | 300 |
| 42 | 52 | Şht. İsmail Şakir Sokak | 300 |
| 43 | 53 | Şht. Kasım Ali Sokak | 300 |
| 44 | 18 | Devrim Sokak | 350 |
| 45 | 35 | Sakarya Sokak | 350 |
| 46 | 28 | Kışla Sokak | 400 |
| 47 | 30 | Kurtuluş Sokak | 400 |
| 48 | 32 | Okullar Sokak | 400 |
| 49 | 56 | Şht. Meryem Süleyman Sokak | 400 |
| 50 | 24 | Günaybey Sokak | 450 |
| 51 | 14 | Cengiz Topel Sokak | 500 |
| 52 | 54 | Şht. Mehmet Emin Sokak | 500 |
| 53 | 22 | Ege Sokak | 600 |
| 54 | 17 | Çankaya Sokak | 650 |

Table 2: Total Sokak

| | Street_Name |
|---|---|
| 1 | 15 Kasım Sokak |
| 2 | 20 Temmuz Sokak |
| 3 | 9 Eylül Sokak |
| 4 | Adem Yavuz Caddesi |
| 5 | Ağıllar Bölgesi |
| 6 | Akdeniz Sokak |
| 7 | Anafartalar Sokak |
| 8 | Barış Sokak |
| 9 | Belediye Sokak |
| 10 | Bora Paşa Sokak |
| 11 | Cemaliye Hüseyin Sokak |
| 12 | Cengiz Topel Sokak |
| 13 | Cumhuriyet Caddesi |
| 14 | Cumhuriyet Sokak |
| 15 | Devrim Sokak |
| 16 | Dumlupınar Sokak |
| 17 | Eczacı Yusuf Kuman Caddesi |
| 18 | Ege Sokak |
| 19 | Erdal Palu Sokak |
| 20 | Günaybey Sokak |
| 21 | İnönü Meydanı |
| 22 | İstiklal Sokak |
| 23 | Kışla Sokak |
| 24 | Kocatepe Sokak |
| 25 | Kurtuluş Sokak |
| 26 | Mimar Mehmet Vahip Sokak |
| 27 | Okullar Sokak |
| 28 | Preveze Sokak |
| 29 | Sakarya Sokak |
| 30 | Şair Fikret Demirağ Sokak |
| 31 | Şair Orhan Veli Sokak |
| 32 | Şair Özker Yaşın Sokak |
| 33 | Şht. Ahmet Mehmet Sokak |
| 34 | Şht. Bayram Mani Sokak |
| 35 | Şht. Bayram Mehmet Sokak |
| 36 | Şht. Cemal Hasan Sokak |
| 37 | Şht. Eray Mehmet Sokak |
| 38 | Şht. Halil Mustafa Sokak |
| 39 | Şht. Hasan Tahsin Sokak |
| 40 | Şht. Hasan Velettin Sokak |
| 41 | Şht. Hüseyin Aziz Sokak |
| 42 | Şht. Hüseyin Hasan Sokak |
| 43 | Şht. İsmail Süleyman Sokak |
| 44 | Şht. İsmail Şakir Sokak |
| 45 | Şht. Mehmet İbrahim Sokak |
| 46 | Şht. Meryem Süleyman Sokak |
| 47 | Şht. Mustafa Hüseyin Sokak |
| 48 | Şht. Osman Hasan Sokak |
| 49 | Şht. Remzi Cemal Sokak |
| 50 | Yazar Yaşar Kemal Sokak |
| 51 | Zafer Sokak |

Table 3: Street without sidewalk[3]

| | Street_Name | twoside |
|---|---|---|
| 1 | Çankaya Sokak | 1.00 |
| 2 | Ecevit Caddesi | 1.00 |
| 3 | Plevne Sokak | 1.00 |
| 4 | Salahattin Sonat Sokak | 1.00 |
| 5 | Şht. Kasım Ali Sokak | 1.00 |
| 6 | Şht. Mustafa Hasan Sokak | 1.00 |

Table 4: Street with one sidewalk

| | Street_Name | twoside |
|---|---|---|
| 1 | Atatürk Caddesi | 2.00 |
| 2 | Atatürk Meydanı | 2.00 |
| 3 | Karaoğlanoğlu Caddesi | 2.00 |
| 4 | Şht. Hasan Kanizi Sokak | 2.00 |
| 5 | Şht. Mehmet Emin Sokak | 2.00 |
| 6 | Şht. Osman Şevket Sokak | 2.00 |

Table 5: Street with two sidewalk

Table 6: Road Categories

| Class | Number | Avg. width | Avg. Length | Tot. Length | Tot. Area |
|---|---|---|---|---|---|
| Cadde | 6 | 7.9 | 900 | 8600 | 31050 |
| Sokak | 54 | 7.9 | 900 | 12000 | 61362.5 |

Table 7: Sidewalk

| Description | Quantity |
|---|---|
| Total Length | 3346 |
| Total Area | 5243 |
| Average Width | 1.54 |
| Mininum width | 1.20 |
| Maximum width | 2.3 |
| Number of street in need of sidewalk | 51 |
| Number of street with 1 sidewalk | 6 |
| Number of street with 2 sidewalk | 6 |